2. Flagship Projects

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

2.1.1 Rationale and scope

Through development of more productive and resilient agroecosystems and landscapes, safeguarding and effective use of tree genetic resources (TGR) provide opportunities to improve livelihoods and support the environment[1,2]. The many benefits generated by trees depend on their genetic constitution, to: bridge production gaps and ensure profitability; increase availability of nutrient-rich tree foods and other novel products in markets; and enhance environmental services and resilience, at farm and landscape levels. The role of TGR in the support of tree products (e.g. fodder, food, fuel, medicine and timber) and services (e.g. carbon sequestration, ecosystem restoration) has however often been undervalued, with past neglect borne in inefficient and/or failed tree plantings programs, with trees not properly matched to site and agroecosystem, to production requirements and market needs, and to the provision of important services.

Deforestation, landscape degradation, narrow agricultural intensification and dietary homogenization are acute problems, yet mechanisms to respond effectively to these challenges are currently often lacking and are exacerbated by climate change. Tree cultivation can help meet increased demands for food, timber, fuel, etc. and provide environmental services, but often low and sometimes unreliable yields are significant disincentives to cultivation. Only when these issues are addressed can trees successfully compete with other production options in agricultural landscapes, to support farming system diversification, the livelihoods of growers and consumer choices.

Large genetic gains are possible in a range of important traits through tree domestication[3,4] if more efficient means to carry this out are adopted to meet the context-specific requirements. High quality tree planting material must also be delivered to growers if yield gaps are to be addressed, but this is currently a consistent constraint in agroforestry adoption as well as in other tree planting initiatives, e.g. restoration programs. Concerted efforts to address delivery constraints for annual crops have resulted in significant improvements in up- and out-scaling of production in recent years, including through private sector involvement, but with the exception of a few perennial commodities, similar progress has not been made for trees[5].

The newly constituted Flagship 1 is designed to help remedy these problems. It addresses issues of under-recognition of the importance of TGR in developing productive and sustainable agricultural landscapes; the past lack of coordination of relevant research and development efforts; and the current lack of tools and support mechanisms for effective action. Activities on **safeguarding** genetic diversity, **domestication** and planting-material **delivery** are co-located in a single flagship, in contrast to FTA Phase I where activities were in Components 1 and 2. Through this integration and by drawing on recent methodological advances, appropriate safeguarding, domestication and delivery approaches will be mainstreamed, providing a route to increased impact.

The enabling environment is now favorable. The findings of the first *State of the World's Forest Genetic Resources* report (SOW-FGR)[6] published in 2014 with the active participation of FTA staff brought TGR safeguarding issues to wider public attention, which has been reinforced by global and national action plans for TGR conservation[7], and by prominent concerns of the dangers of small founder tree planting populations in increasing susceptibility to tree diseases globally. Second,

community genetic[8] research has recently revolutionized our understanding of the important roles of TGR in supporting environmental service provisions, indicating important genetic traits for enhancing positive species interactions in agricultural systems and supporting sustainable intensification through higher land equivalent ratios (LER). Third, climate shifts and more variable weather patterns have reestablished the importance of diversity breeding, which considers production traits that are enhanced by diversity and uses local landscape-level deployment approaches to maintain variation[9]. Fourth, a greater focus on the nutritional quality of human diets has highlighted the greater role that nutrient rich tree foods could play if the massive extant genetic variation within their genepools was translated into productivity, quality, efficiency and profitability gains[10], taking advantage of modern methods to do so (Figure 1). Fifth, renewed investments in large-scale afforestation and reforestation[11,12] rely for their success on access to appropriate tree planting material[13], and provide new opportunities to realign and optimize existing delivery systems in need of reform.

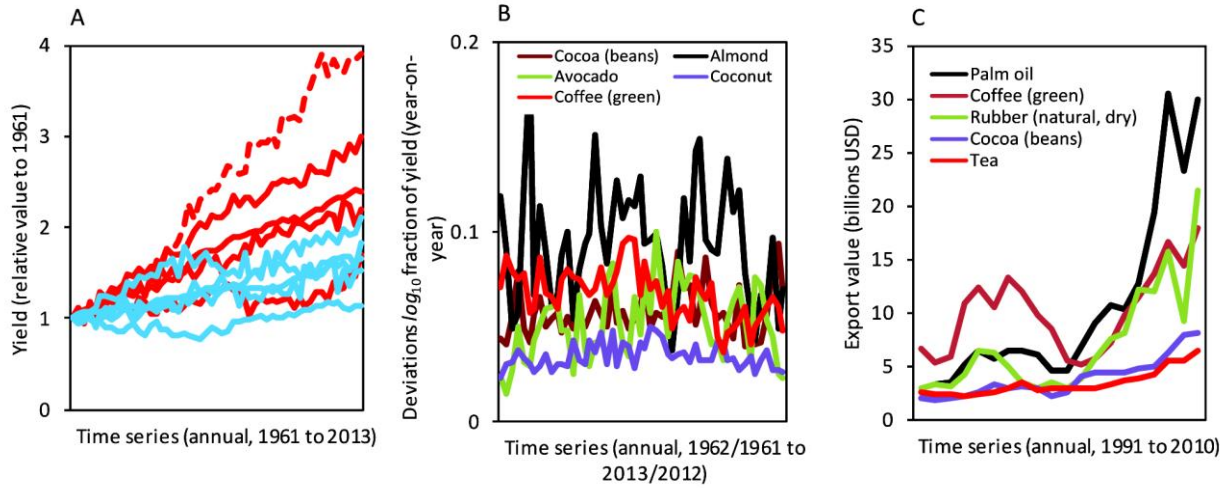


Figure 1. Supporting data for Flagship 1, extracted from FAOSTAT databases. A, Yield time series for 10 crops with large increases (red) or decreases (blue) in their relative contributions as human foods over the last 50 years[14]. The red dashed line is the exceptional case of oil palm. Most crops with a large increase in relative importance have doubled in yield over the period. This suggests a threshold for new or 'orphan' tree crops to successfully compete in, integrate in, and diversify, agricultural landscapes; B, Yield stability time series (as A) for 5 fruit tree crops with a degree of dependence (> 10%) on animal pollinators[15]. Stability may be achieved through alterations of reproductive systems through selection and breeding, and through the use of particular propagule types. Proper placing of species in the right production systems and landscapes is essential; C, Export values over a 20-year time series for five tree commodity crops that have undergone formal breeding. Data indicate high monetary values, varying absolute values and a trend to increased values, justifying domestication investments in new, and further investment in existing, tree crops.

2.1.2 Objectives and targets

Objectives

Availability of 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 and lost opportunities besides threatening TGR. Flagship1 is addressing these challenges through scientific research within three Clusters of Activities (1. Safeguarding Diversity; 2. Tree Domestication; and 3. Delivery Systems) by developing effective and affordable methods, technologies, gender-responsive guidelines, decision-support tools and proofs of concept in partnership with relevant institutions and networks. It is hypothesized that by applying optimal combinations of TGR safeguarding measures specific to ecological, geographical and societal contexts, by using new and available tree domestication approaches and by developing context-specific delivery systems for the best available planting materials, that livelihoods and productive and resilient agroecosystems will be supported.

Outcomes

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 1. These outcomes will contribute to Sustainable Development Goals 2, 13 and 15.

Table 1. Outcomes by windows of funding

Outcomes	Amount needed (million USD)	W1/2 (%)	W3 (%)	Bilateral (%)
1. Managers and policy makers adopt effective monitoring methods, tools and practices to mitigate threats to valuable tree genetic resources, 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. Agricultural and horticultural research partners adopt cost-effective domestication approaches for priority tree species, based on impacts and maximizing efficiency, and considering trade-offs involved in intensification	23	19	0	81
3. National governments, extension services and private partners adopt cost-effective and equitable tree planting material delivery pipelines, with 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%

Targets

By 2022, for safeguarding diversity, Flagship 1 will contribute to supporting the implementation of global and regional strategies for genetic resource conservation in Latin America and Africa, while biodiversity of 10 globally-important and 100 regionally-important food or income-generating tree

species will be supported *circa situm*. Tools and approaches for reducing the impacts of threats such as illegal logging and over-grazing in five target countries will be in place. On-line status and threat assessment tools for 100 species in Latin America and 100 in Africa will be used by managers to develop national conservation strategies. Effective, efficient and equitable approaches and policy recommendations for genetic conservation will be developed for 10 priority species in target countries in each of three continents. Training materials, characterization methods, policies and indicators of status and threats will have been adopted in 10 nations. For domestication, guidelines and decision-support, tools on domestication approaches will be adopted by national research partners in at least 10 countries, with national and private sector breeders, on user-prioritized species. In addition, genomic data and assembled germplasm collections/panels will be used in the breeding strategies for five important food crops. Stakeholders will be testing at least ten more potential 'varieties' of trees across agro-ecological zones, while public and private partners will be engaged in tree domestication activities to reach identified needs with incipient cultivars for at least three more tree species. For delivery systems, national extension partners, private companies and others involved in agroforestry and restoration initiatives in 10 nations will have adopted best practices for sourcing available planting material and will have established new breeding seed orchards for 20 tree species globally, to meet demands for higher quality planting material. Policy makers will have incorporated appropriate certification standards into tree planting material delivery systems in five countries, while farmers will have adopted user-friendly online decision support tools to support tree planting choices in conjunction with market information services in five countries. National extension partners including tree seed centers and NGOs will have determined and adopted improved context-specific delivery approaches to deliver priority tree species to farmers in 10 countries, with the roles of the various actors that are involved properly aligned. Changes in policies and strategies by national governments and implemented by national extensions services will have resulted in entrepreneurial suppliers becoming more engaged in delivering seed/seedling inputs (supplying at least 20 percent more material than 2016 levels) in five countries.

Within the timescale of the program, we estimate the number of smallholders benefiting directly from Flagship 1 activities in terms of improved access to resources through safeguarding as more than 500,000, with more than one 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 delivery systems to be in the order of two million or more, while more than 10 million, will benefit from more effective restoration supported by improved delivery. A longer-term indicative value of interventions in economic terms and with effects amplified through wider adoption of the theory of change is estimated at an annual benefit following program intervention of ~US$ 230 million in today's prices. This does not account for reduced losses in genetic diversity through safeguarding activities, which would increase the value of the intervention further.

<u>Links to IDOs and SDGs</u>

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 2 along with allocations of Flagship 1 investments.

Table 2. Investments by sub-IDOs

Sub-IDOs	Amount needed (million USD)	W1/2 (%)	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 labour 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

2.1.3 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, national agricultural, forestry and horticultural research institutions, policy makers, national planning agencies, global and local conservation organizations, and local authorities are better able to define priorities, select methods and improve practices and policies for TGR safeguarding, and more widely and effectively apply new approaches 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 their domestication (*outcome*). The more efficient and inclusive delivery system options and delivery support tools for tree planting materials – 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 input suppliers, including women and youth enterprises, to provide growers, including farmers and restoration practitioners, with a range of more productive and/or site-matched tree germplasm (*outcome*). Through co-research with national partners, a better understanding of how, when and where domesticated resources and appropriately chosen germplasm contribute to the provision of environmental services, including through restoration initiatives, provides sustainable management guidelines for adoption through national policy makers and reveals important domestication and site-selection traits (*outcome*). Improved planting material inputs increase the range, yield and quality of tree products (e.g. food, fuel, timber) available for rural women and men and their households, supporting their incomes and diets, and enhancing the success and resilience of restoration initiatives (*impact*). As farmers and traders integrate improved tree products into value chains, peri-urban and urban consumers benefit through increased supply of e.g. nutrient rich food tree crops and reduced unit production costs, and hence enhancing the dietary diversity as well as lower consumer prices that are important in low-income nation markets (*impact*).

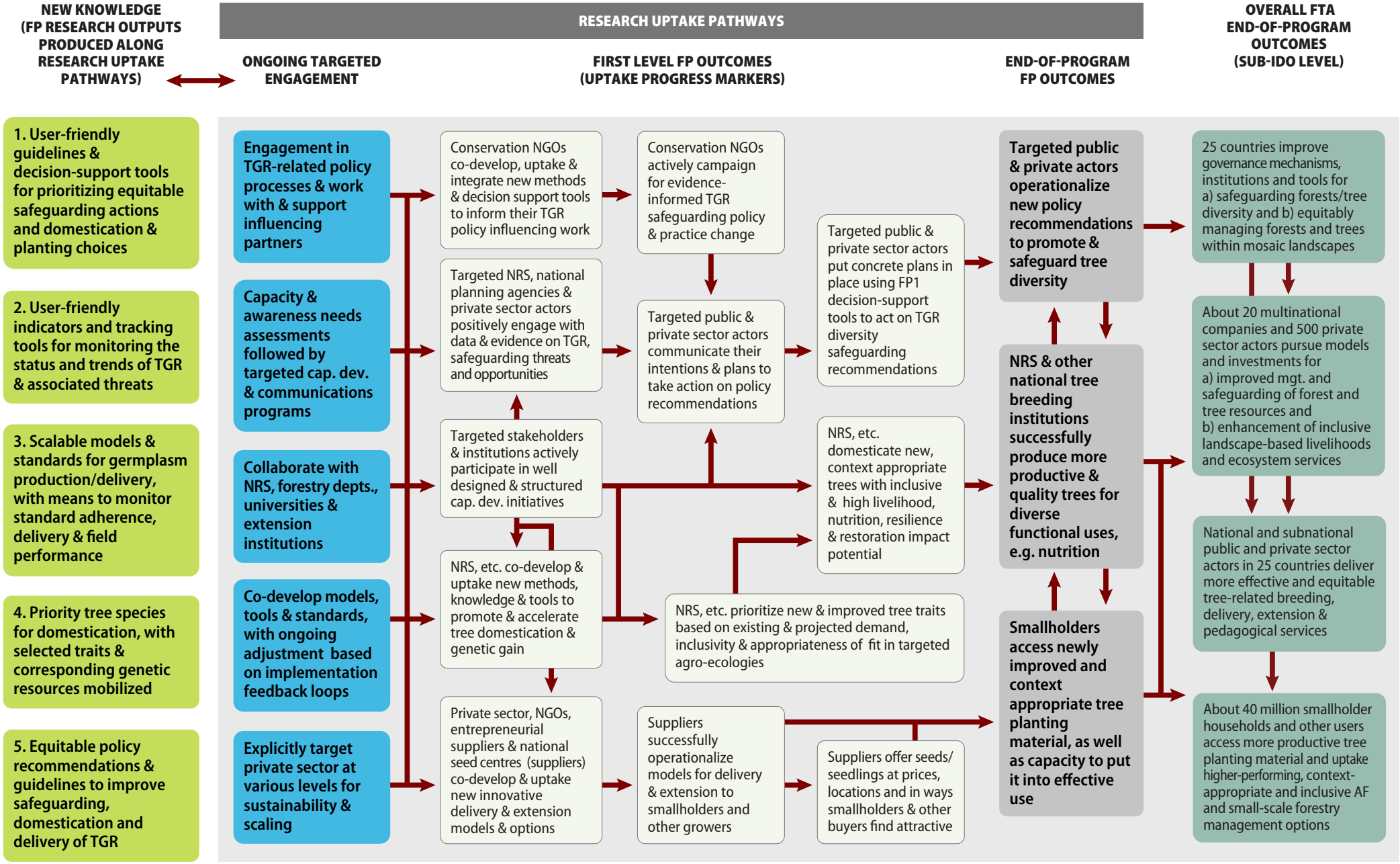


Figure 2. Theory of change for Flagship 1

Reaching impact through linkages with other FTA Phase II flagships, CRPs and platforms

Flagship 1 realizes impact through interactions with other flagships within FTA Phase II, and with the CGIAR CRPs and platforms more widely, summarized in Table 3 and Figure 3, and discussed further in section 2.1.7.

Table 3. Summary of linkages 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)	- Provides traits that support sustainable intensification and improve livelihoods in different production systems	- Feedback on, and testing of, important domestication traits in a systems context; appropriate delivery options for different production systems
	FP3 (value chains)	- Provides planting material that produces high-quality products and useful services that have market value	- Selection/prioritization of valuable species/traits for domestication and delivery; integration of planting material into product/service markets
	FP4 (landscapes)	- Planting material matched to landscape niches, supporting restoration and contributing genetic-level landscape resilience	- Appropriate context for genetic diversity safeguarding approaches and planting-material delivery options, for different landscape configurations
	FP5 (climate change)	- Productive and diverse site-matched and 'future-proofed' tree germplasm with adaptive capacity and greater mitigation opportunities (e.g. carbon sequestration and biofuels)	- Feedback on important tree traits for adaption and mitigation (e.g. level of plasticity required in the context of variable weather patterns); new trait combinations for novel environments and land-use transitions
	SP1 (impact and inclusion)	- Provide indicators, tools and capacity training to monitor and evaluate safeguarding, domestication and delivery impacts	- Information on the effectiveness of Flagship 1's activities that guide future research directions and support mainstreaming within FTA Phase II
CRPs	A4NH	- Provides nutritious, productive and site-matched tree foods aligned with the prioritized needs of communities and (with FTA II Flagship 4) matched with their landscapes	- Information on important dietary needs that prioritize the relevant traits for food tree domestication
	CCAFS	- Tools for future tree-site matching based on tree traits	- Model development to study tree distributions and help describe tree-planting-material delivery systems to meet future location-specific climates
	PIM	- Policy concerns based on TGR case studies	- Framework for dealing with tenure, ownership and governance
	Livestock	- Appropriate domestication tools and delivery systems for forages	- Interactions in mixed livestock production systems that determine important traits for tree domestication; constraints for safeguarding
	All AFS CRPs	- 'Portal' for learning between FTA II and other AFS CRPs on domestication and delivery; models for genome-environment marker-assisted selection based on *in situ*-adapted wild populations; lessons for annual 'orphan' crops delivery	- Models for domestication and germplasm delivery
Platforms	Big data	- Genomic information; species, vegetation and risk assessment maps; modeling approaches to support analytical capability	- Data sets and methods for comparative analysis of genomes, distributions and interactions
	Genetic gains	- Models for genome-environment association analysis based on *in situ*-adapted wild populations	- Models for advanced genomic methods in domestication

	Component	Contributions of FP1 to…	Contributions from flagship, CRP, platform to FP1…
	Genebanks	- Work on *in situ* and *circa situm* genetic resource conservation approaches complements and explores interactions with genebank activities; identifies gaps and supports the provision of material to enter *ex situ* genebanks; feedback, perspectives and context for technical resources on ABS of TGR (Policy Module)	- Characterization allows prioritization in conservation decision making *in situ* and *circa situm*, as well as in the choice/availability of candidate material for domestication; raw material for domestication; phytosanitary support ensures planting material health in delivery systems; framework for dealing with ABS of domesticated tree resources (Policy Module)

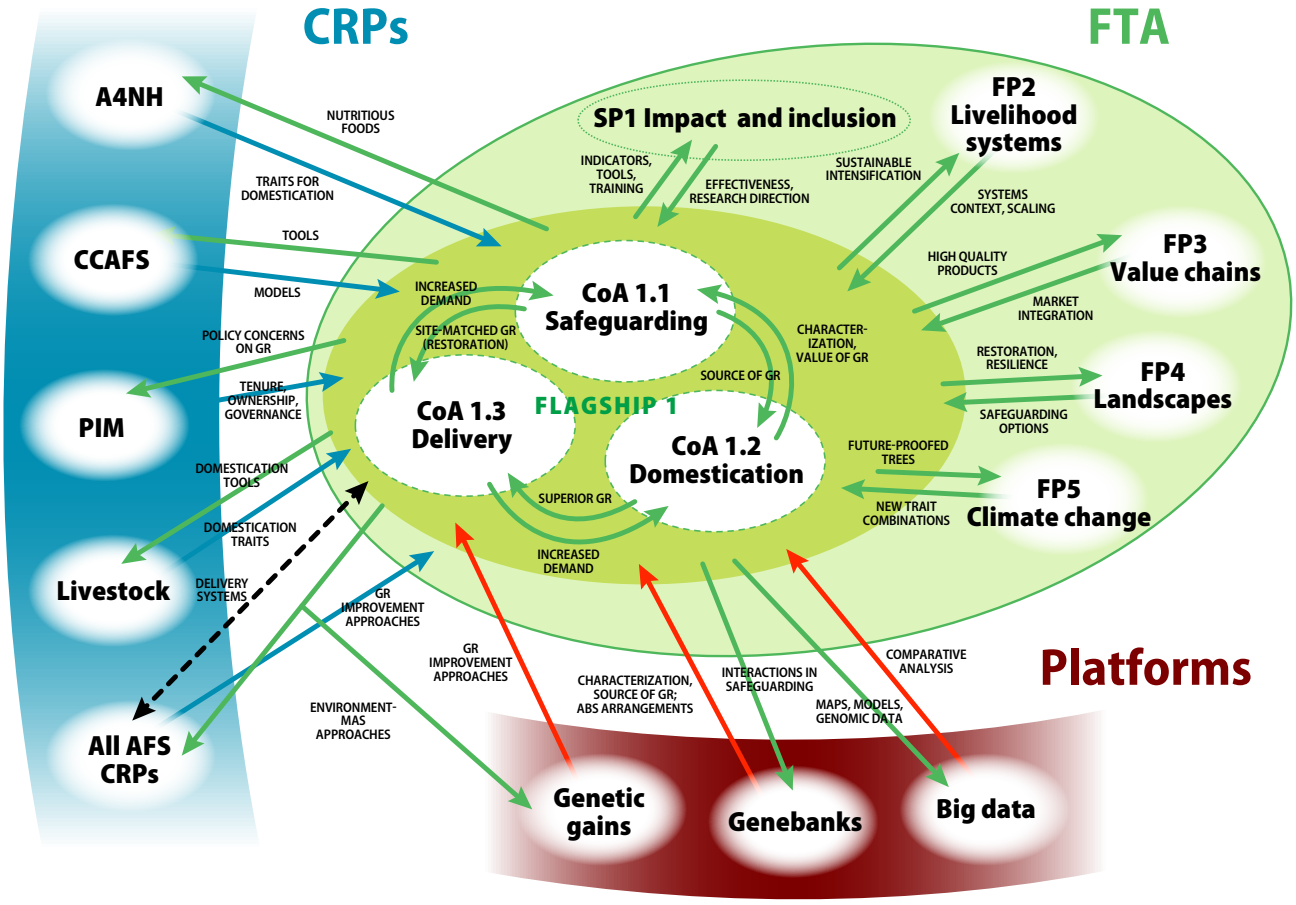


Figure 3. Linkages with other FTA Phase II flagships, CRPs and platforms, including nested linkages between Flagship 1 clusters

Developing a theory of place for Flagship 1

To realize impact, the development of a theory of place for Flagship 1 in conjunction with other FTA Phase II flagships, especially 2 and 4, is crucial. Our theory of place is illustrated in Figure 4. Geographic foci of CoA 1.1 are biodiversity hotspots, regions where important TGR are threatened, a range of different landscape configurations, and areas where landscape management is targeted by other flagships (for coordinated assessment and intervention, especially with Flagship 4. Addressing productivity gaps through CoAs 1.2 and 1.3 in conjunction with Flagship 2 is particularly important in humid tropical forest heartlands, while addressing farm- and landscape-level resilience through these clusters is especially important in sub-humid tropical clonal forest systems. Tackling gaps in both production and resilience through Flagship 1

activities is especially crucial in dryland areas. CoA 1.1 activities tend to cover wider geographic ranges, often based on regional geospatial datasets. They are at lower intensity than CoA 1.2 activities, which focus on priority species determined by local women and men, market needs and other important factors such as 'researchability'. CoA 1.2 activities also generate models for wider application[16]. Like CoA 1.1, CoA 1.3 builds on regional geospatial datasets. Other crucial elements for CoA 1.3 are the choices of locations for 'proof of concept' testing, which relate to planned impact expansion under other flagships, and the locations of other large-scale agroforestry/restoration initiatives. Flagship 2 and 4 activities are therefore of particular importance. Part of CoA 1.3's purpose is to facilitate the availability of the right tree planting material in the right place at the right time, taking into consideration the impacts of anthropogenic climate change and other trends on shifting production domains. It not only considers the priority species of CoA 1.2, but a wider range of trees that includes a diverse portfolio of species for restoration. The different landscape configurations researched by Flagship 4 provide a framework for different planting-material delivery systems in different settings, helping to develop more appropriate context-specific models in CoA 1.3, bounded by landscapes/landscape transitions.

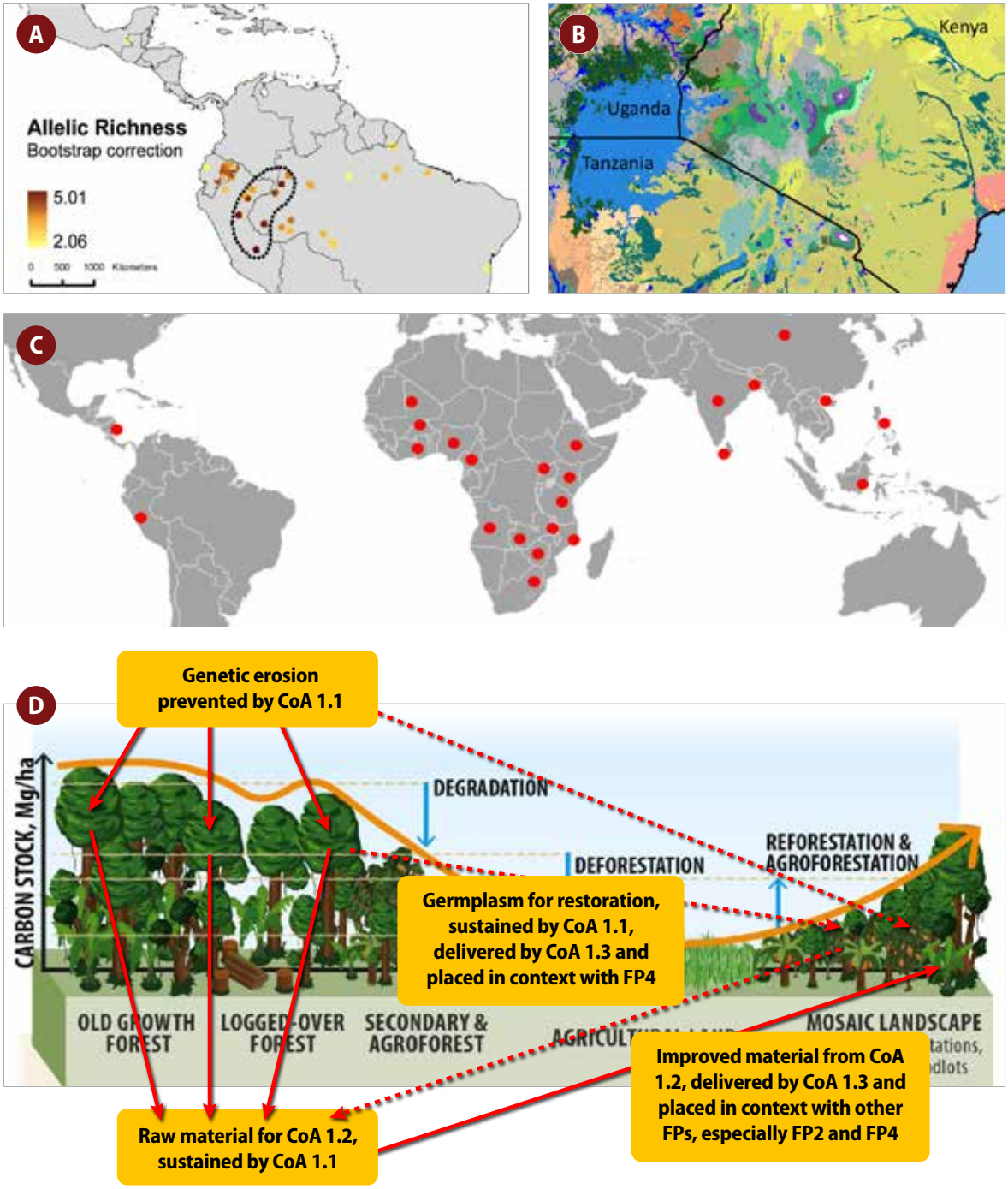


Figure 4. Elements of the theory of place for FP1. A, Genetic diversity hotspots in cocoa in the Amazon based on simple sequence repeat molecular markers, indicating priorities for safeguarding purposes (dashed enclosure; CoA 1.1); B, High resolution vegetation map for East Africa[17] (extracted snapshot) informing what trees should be planted where in the region for delivery purposes (different colors indicate different vegetation types; CoA 1.3), guiding agroforestry plantings and restoration 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 other FTA Phase II flagships; C, Countries with tree domestication activities (CoA 1.2) under FTA I are indicated by red circles. An emphasis in several African countries reflects particular emerging opportunities for domesticating new tree foods; D, Placing the three Flagship 1 CoAs within the context of the forest transition curve of FTA shows linkages among CoA.

2.1.4 Science quality

Flagship 1 is interested in combining relevant novel approaches with well-established methods when this is able to address issues of importance, to support impact, and to address specific knowledge gaps. The

starting point is a range of important tools, research studies and syntheses produced by Flagship 1 researchers under FTA Phase I Components 1 and 2. For safeguarding, a number of innovative spatial datasets were derived and disseminated, including MAPFORGEN[18] and the Vegetationmap4africa[17]. Work on genetic diversity indicators (e.g. 'quality' and 'value' attributes) also revealed more practical and affordable measures[19]. Phase I also led to a greater understanding of the possible positive and negative interactions between TGR safeguarding and past and contemporary land- and resource-use patterns[20], which can be used to better guide conservation and sustainable use options[21]. For domestication, a wealth of experience in methods was obtained[10]. *Allanblackia*, a new domesticate, reached the market with food oil[22] and an effective and novel public-private collaborative approach was developed for its domestication, aspects of which approach are being applied to other species. Experience was gained in participatory tree domestication approaches to achieve positive outcomes for livelihoods, nutrition and the social standing of participants, their households and communities[23]. Research also indicated the factors that constrain or enable equitable participation of women in domestication. For delivery, the characterization of current planting-material delivery systems has led to the development of more effective approaches for stakeholders to align objectives and work together positively to reduce transaction costs for suppliers, farmers and other growers in providing and obtaining planting material[5]. Good options include the integration of planting material delivery models with tree product markets. Participatory domestication, which integrates domestication with planting material delivery and with product markets through rural resource centers[9], is an effective approach[24]. Extension services are a particular bottleneck in the adoption of appropriate delivery systems, especially in the context of restoration activities[2] and needed climate-change responses.

In Phase II, outputs and outcomes from Phase I are extended in scope based on newly developing approaches and knowledge (cf. lessons learned, section 2.1.5). Innovative tools and approaches in FTA Phase II Flagship 1 include the following:

- The use of advanced, in-house-developed, geo-spatial methods of threat mapping and gap analysis in combination with local 'gendered' knowledge to determine safeguarding priorities (building e.g. on the Vegetation4africa[17] and MAPFORGEN[18].
- The in-house development of novel hand-held media tools (e.g. smartphone applications) of high resolution vegetation maps to guide where to conserve and/or plant trees, supporting safeguarding activities and the appropriately targeted delivery of tree planting material, including verification (right tree, right product/service, right production system/landscape)[25].
- New thinking on appropriate safeguarding approaches that challenges 'conventional wisdom' on the benefits of cultivation, questioning and testing the linkages between safeguarding settings in different environmental, social, etc. contexts, to determine when *ex situ*, *circa situm* and *in situ* methods are complementary and when they are conflicting[26].
- The use of in-house next generation sequencing and genomics facilities, in collaboration with other institutions and global bioinformatics support, to facilitate new approaches for the domestication of priority trees, including perennial African 'orphan' crops[27]. Genomic information will be combined with interpolated environmental data sets for marker-assisted selection to support environmental adaptation, including to anthropogenic climate change, considering also important caveats in interpretation.
- The integration of genomic results with well-proven in-house-developed participatory domestication/evaluation methods that consider consumer and private sector concerns in the development of tree products and services. Genomic approaches will also be integrated with diversity breeding methods to best support productivity, other ecosystem services and farming system resilience.
- The development of new ensemble climate modeling approaches for determining probability-based delivery/suitability domains for tree planting, considering future climates. Implementation will be through advanced statistical packages made available to the wider ecological-research community through R[28].
- Option testing of inclusive and context-tailored entrepreneurial support models for tree-planting-material delivery systems for smallholders and restoration practitioners, with the use of Before-After-Control-Impact experimental designs that have not yet been applied to the sector[19].

- The development of flexible and resilient approaches to supply planting material for landscape restoration in the context of anthropogenic climate change, based on considerations of both genetic and species suitability, phenotypic plasticity and emerging knowledge of current practices in the restoration sector[29].

Competitive advantage

As is clear from lists of references that have involved current members of Flagship 1 as authors (see endnotes), the program brings together groups of leading researchers who are global experts, supporting the adoption of appropriate scientific approaches and high research quality. A recent publication highlight is a special edition of Forest Ecology and Management on TGR edited by Flagship 1 staff, containing some of the most downloaded articles for the journal in the past year, and many flagship-staff-co-authored papers[30]. Another is the SOW-FGR[6], the development of which was at FAO's request supported by Flagship 1 scientists in the form of data collection, advice, review, writing of chapters and of five supporting thematic studies, one of which has been downloaded from the Internet more than 8,000 times to date[29]. Statistical software co-authored by one Flagship 1 team member has now been cited more than 7,000 times in the scientific literature[31]. The critical mass of expert scientists in different disciplines involved in Flagship 1, with their experience in different geographic areas and in working with different types of stakeholders, collaborate with well-established partners to determine a unique competency within the global research community. Over several years, strong links have been built with a range of agricultural, forestry and horticultural research institutions of global and national excellence, as well as with development agencies and practitioners, and private companies. This supports the progression of research into impacts. Flagship 1 teams have also provided important contributions and leadership in policy discussions on genetic resources in national and international fora, meaning that they have influence in developing and supporting the adoption of appropriate national and global polices that support impact (e.g. with FAO[7]). In addition, through its close connection with a wide range of research and development networks and initiatives at different scales, Flagship 1 understands the context for research presented by both the needs of local communities and globally determined priorities. The teams have the expert knowledge to meet these demands, while having an understanding of the detailed biological characteristics of trees needed to underpin effective research on them. Important *ex situ* collections of priority trees that are housed by the Genebank platform, but that involve Flagship 1 scientists, also enhance characterization and domestication research.

2.1.5 Lessons learnt and unintended consequences

Combining safeguarding, domestication and delivery research into one flagship is a means to effectively apply lessons learned from FTA Phase I. Some of the key lessons learned:

Safeguarding: combining varied information sources will allow rapid out-scaling of spatially explicit safeguarding tools. Genetic diversity indicators need to be combined with 'option' values of TGR i.e. integrating value analyses with threat and distribution information for safeguarding priorities. Interactions between safeguarding methods need to be explored further with reference to a range of landscapes (with Flagship 4), for appropriate reward systems.
Domestication: experience gained in domestication methods, including the participatory approach, needs to be extended in FTA Phase II in combination with other novel techniques. Lessons in working with the private sector[32] on domestication to be more widely applied, for integration with other production components in farming systems, for up- and out-scaling (increasing quality and reach of tree product integration) through focused joint research with Flagship 2. Lessons need to be shared with public and private partners and applied to a wider range of tree products and services. Role of women in domestication will allow gender imbalances and skewed benefits to be addressed further.
Delivery: lessons on effective stakeholder interactions need to be appropriated to realize 'proofs of concept' and then impacts (with Flagships 2 & 4). Integration of delivery models into value chains with tree product markets is required (with Flagship 3). The participatory domestication approach which supports delivery requires scaling out and a wider understanding is needed across contexts[33] with attention to strengthening the currently weak extension services.

Potential unintended consequences to avoid:

- Policy measures to safeguard TGR, including ABS arrangements put in place to benefit local communities and host nations, and high valuations for the option value of biodiversity, limiting access to resources for research.
- Domestication and market expansion results in a trend to monoculture, rather than the intended agroecosystem diversification.
- Enhanced delivery of planting material results in new assemblages of species that interact negatively rather than positively, causing declines in productivity and resilience.
- Increased profitability due to domestication results in the clearance of forests for tree cultivation and/or reduced attention to management of natural resources as a less important source of product.
- Tree domestication of once wild resources positively supports farmers livelihoods', but disadvantages the landless very poor who harvested resources from natural forests but outcompeted by more efficient cultivation.

Examples of collaboration to avoid these potential consequences include: encouraging open ABS arrangements that support communities but do not unduly hamper innovation, with the Genebank platform Policy Module; resisting trends to monoculture by exploiting genetics to maximize LER in mixed production systems, with Flagship 2; and the amelioration of forest clearance by Flagship 3's work on value chain certification schemes and Flagship 4's work on rewards for environmental services, which include consideration of the landless poor.

2.1.6 Clusters of activity (CoA)

Flagship 1's work on safeguarding genetic diversity (CoA 1.1), tree domestication (CoA 1.2) and tree planting material delivery (CoA 1.3) is designed to provide methods and tools developed through work on model species and production systems that can be applied to many different tree species and situations. In parallel, more intensive work on a smaller range of key tree species realizes direct impact through up- and out-scaling of the relevant technologies on these trees. The safeguarding activities of CoA 1.1 help describe, and support the availability of, the TGR that are the raw material for tree domestication activities undertaken in CoA 1.2. Similarly, these same well-described and safeguarded resources are important sources of site-matched planting material for restoration activities that are supported through the delivery pathways developed as part of CoA 1.3. At the same time, domestication research under CoA 1.2 helps to characterize important genetic traits and patterns of intra-specific variation that are important for safeguarding activities in CoA 1.1. Domestication activities define 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 provides superior (product/service-, site- and landscape-matched) planting materials that are 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 activities in CoA 1.2 and of germplasm sources that are 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 5.

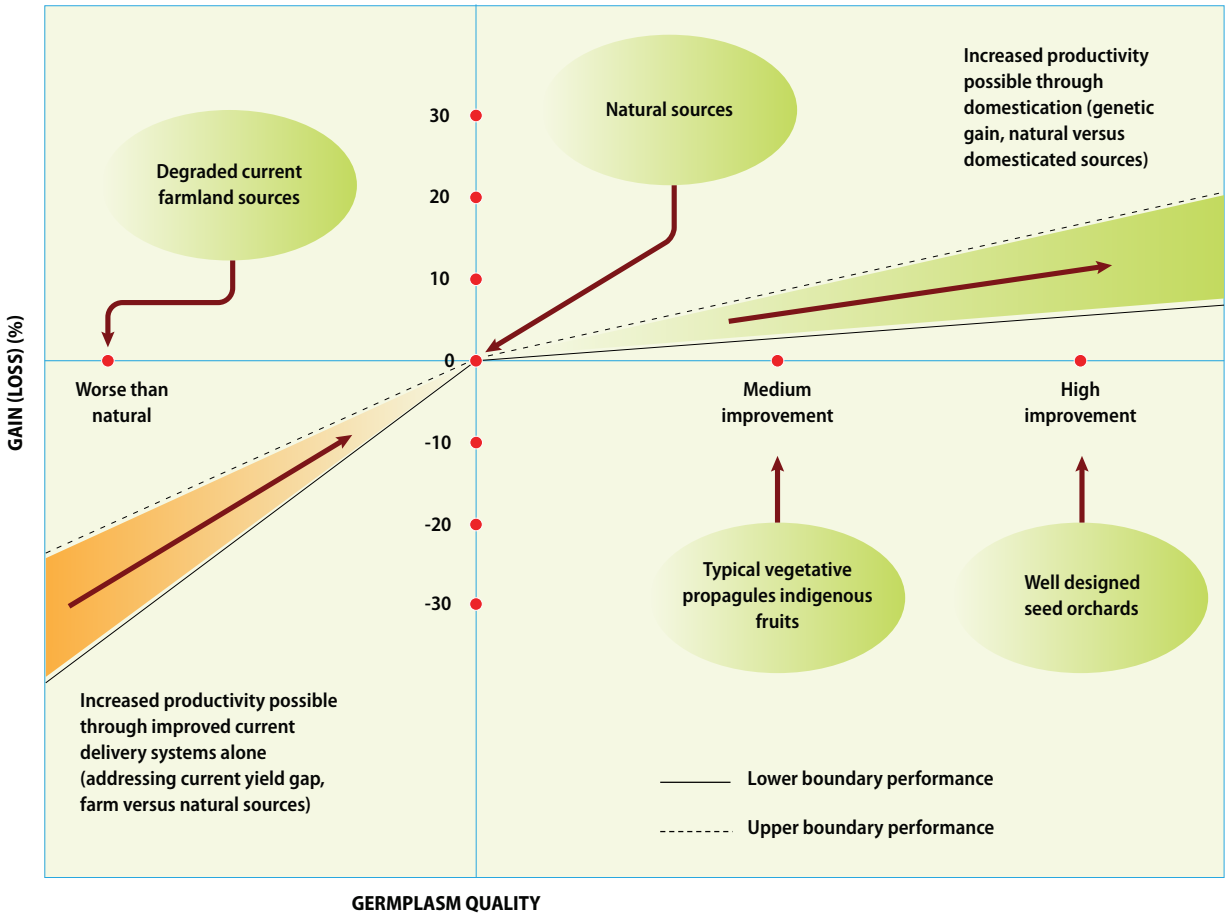


Figure 5. Schematic illustrating the gains in performance available through changes in the planting material sources used by smallholders. Initial productivity gains are frequently possible just by improvements in delivery systems that allow sub-optimal degraded material (compared to existing natural, unimproved) sources to be replaced on farmland (= a productivity gain that addresses the current yield gap without any deliberate genetic improvement). Further gains are then supported by domestication activities (= genetic gains), with the possible gains varying by domestication approach and intensity. The diagram

illustrated that all productivity gains depend on appropriate planting-material delivery systems being in place.

CoA 1.1 Safeguarding diversity

The research of CoA 1.1 will build upon existing knowledge, science, and current national and international safeguarding initiatives. It will develop new and innovative methods to ensure the development and dissemination of appropriate and efficient conservation and sustainable use methods that benefit women and men, and their households, in different ecosystems, and in various national and regional settings. Research will include analyzing, spatially characterizing and mapping patterns of diversity and threats that affect the wellbeing of rural people in forest and farm landscapes. The research will also resolve questions regarding conventional wisdom, such as the assumption that the cultivation of timber and tree commodities is sufficient to safeguard their genetic resource base. Research will determine the conditions when such wisdom holds, based on production systems, landscapes and tree biology. Economic analyses of options will compare the value of land use for genetic safeguarding with other options, for example where wild relatives of tree crops are conserved compared to clearance for agriculture. The knowledge generated will allow the benefits of safeguarding to be shared more equitably among actors, such as forest harvesters and tree planters.

CoA 1.1 assumes that demonstrating the value of TGR for improved livelihoods, restoration and domestication will support safeguarding activities in collaboration with farmers and other stakeholders; that more efficient tools and approaches to support safeguarding including through the sustainable extraction of products, can be devised from an understanding and description of model species and the context of systems; and that policies and legal instruments implemented to provide for ABS do not need to perversely result in an inability to carry out the characterization of germplasm that supports safeguarding priorities. We hypothesize that genetic diversity can be monitored by application of adequate indicators, and that methods for safeguarding can be adjusted in response to indicator development. We also hypothesize that an optimal combination of safeguarding measures can be identified in specific ecological, geographical and societal contexts, considering trade-offs between the measures applied. Finally, we hypothesize that regulatory frameworks and incentive schemes in favor of safeguarding as part of integrated genetic resource management programs can be designed.

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 forest, farm and other settings, to identify gaps and support the development and implementation of appropriate safeguarding activities?
2. Safeguarding combinations: what are the 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, to support sustainable resource management?
3. Stakeholder engagement: how can stakeholders be convinced and supported 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?

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 TGR availability and the value of genetic diversity for products and ecosystem services; 2. Nationally and regionally endorsed actions plans and networks for TGR safeguarding; 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 in safeguarding activities; and 5. Policy briefs, reward systems, strategies and guidelines for appropriate targeting and 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

Greatly accelerated and better targeted genetic gains can be achieved by combining traditional methods for selection such as multi-locational field trials with novel genomic, phenomic, informatic and modeling approaches. Diversity breeding and participatory domestication are also approaches to support impact, with the latter showing promise for being gender-responsive when involving both women and men farmers, to ensure the interests of both are represented.

The recent reduced costs of genomic techniques mean that they can be applied to a wider range of new and 'orphan' crops, allowing the use of these species to be revisited in farming systems. Most wild trees tested in genomic studies evolved *in situ* and are adapted to their environments. This means that environmental datasets based on their sample locations are of particular value in genome-environment association studies to identify markers linked to adaptive traits. Research is concerned not only with traits directly connected to tree products such as yield and nutritional quality for fruits, growth rate and stem straightness for timber, and protein content and palatability for fodder tree species, but also with traits that contribute to environmental and cultural/social service provision, and with the 'interaction traits' between different components of production systems.

CoA 1.2 assumes that a key factor that supports the integration of new tree crops in agricultural production systems is an increase in productivity and/or product quality; that sufficient genetic diversity is present within tree species to realize large genetic gains (and thence production gains, once material is delivered to growers through CoA 1.3); that communities have already or can obtain land and tenure rights that allow them to reap the benefits from improving their production systems through better tree germplasm inputs; and that policies and legal instruments implemented to provide for ABS do not need to prevent access to TGR to support genetic improvement activities. We hypothesize that it is possible to apply a range of context-specific domestication approaches and to determine their relative cost-effectiveness. We further hypothesize that domestication approaches are available that contribute effectively to farm- and landscape-level resilience through the adequate management and deployment of genetic diversity. Finally, we hypothesize that the protection of small farmers' intellectual property will enhance the local development of tree 'cultivars' of documented quality, and facilitate their diffusion through formal and informal channels (facilitated by CoA 1.3).

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

Research is concerned with exploring the utility and implementation of appropriate delivery systems and the constraints that must be addressed for tree planting programs to reach impact.

CoA 1.3 assumes that smallholders and other planters will demand higher quality planting stock when the benefits of this material have been demonstrated to them and/or when appropriate certification and traceability schemes are in place, increasing adoption and the products and services thereby achieved, while providing market opportunities for germplasm suppliers; that better institutional organization of the different types of stakeholders (collectors, producers, traders, NGOs, government, certification agencies, etc.) involved in delivering tree planting materials can reduce the transaction costs for farmers and other growers in obtaining suitable material; and that policies, legal instruments and certification schemes, implemented to provide for ABS, to protect breeders' and farmers' (see CoA 1.2) rights and to control planting material quality, provide a supportive environment for delivery and do not significantly increase transaction costs in obtaining material. We hypothesize that context-specific characterization of germplasm delivery systems can be made for tropical trees to allow for an adequate assessment of their efficiency. We further hypothesize that among the wealth of differently organized input supply systems that are currently applied, it is possible to identify those that may work best in a given context, and to further increase their efficiency. Finally, we hypothesize that it is possible to produce context-specific recommendations for delivery systems, enabling high potential for increasing productivity and farm- and landscape-level resilience.

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 labor 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).

2.1.7 Partnerships

Crucial partnerships to bring about change for CoA 1.1 include with conservation organizations such as regional and global networks (e.g. APFORGEN, LAFORGEN, CacaoNet, COGENT, INGENIC, ICCO); civil society; and national research organizations (to characterize diversity and develop policy and action plans). Partnerships are also required with government agencies such as Treaty-competent authorities (to co-develop and implement policy change); and inter-governmental actors such as FAO and CBD including the secretariats of the International Treaty on Plant Genetic Resources for Food and Agriculture and the Nagoya Protocol (to inform policy makers). For CoA 1.2, important partners include the private sector, such as Mars Inc., Nestle, Unilever, the Cocoa Research Association and SMEs (to set priorities, access genomic and informatic resources, and open new – and reinvigorate old – markets). Also important are partnerships with organized farmer groups, including women's self-help groups; national and international agricultural, forestry and horticultural research centers; public and private breeders; and regional research hubs such as BECA. Partnerships with international research organizations such as the World Vegetable Center and advanced research institutions, e.g. UC Davis and JHI (for genomic breeding and community genetic research approaches) are crucial. For CoA 1.3, important partners include national tree seed centers (to support other suppliers with 'starter' germplasm); national and international (e.g. CARE, VI) NGOs and government extension services (to implement appropriate delivery options); and government and international agencies such as FAO, OECD, IUCN and WRI (to develop and implement policy changes, and to specifically support restoration objectives). Also essential for CoA 1.3 are partnerships with the private sector (especially local entrepreneurial suppliers); and national and international research institutions such as the University of Copenhagen (for decision-support tools and to negotiate with inter-governmental actors on policies and certification). Across all three clusters, stronger partnerships with international research organizations including CATIE and CIRAD are required, while collaboration with African Women in Agricultural Research and Development (AWARD) will support the integration of gender issues in research and practice, and in strengthening the capacities that underpins the gender-responsive research required to achieve equitable and sustainable impacts.

With respect to the impact pathway (Figure 6), Flagship 1 recognizes many partners and many different interactions between them that are required to bring about change, and that 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 between them. For example, subsidies that support NGO involvement in delivering tree planting material to growers may be a dis-benefit to local entrepreneurial involvement. This requires joint definition of problems, co-development of appropriate solutions, and local and national policy decisions to reach a proper balance.

Problem statement
The potential of tree genetic resources to enhance production and resilience is grossly underexploited. Furthermore, ongoing genetic erosion threatens to constrain future actions, while mechanisms for delivering appropriate germplasm and information to users are poorly developed and constitute an impact bottleneck. Responses are complicated by the multiplicity of taxa and competing priorities, as well as a generalized lack of awareness, coupled with limited capacity to act even on agreed national and global targets.

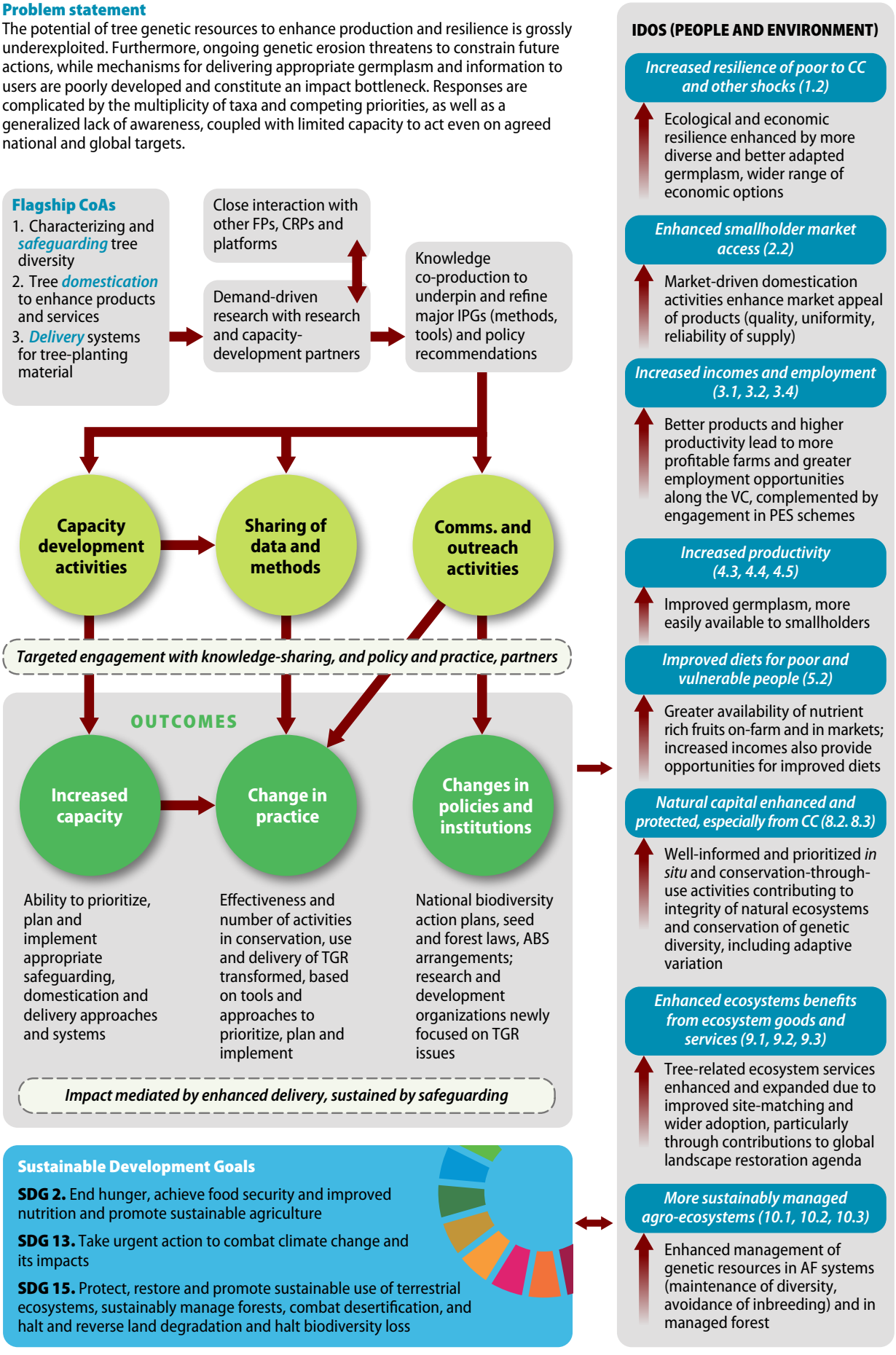


Figure 6. Schematic description of Flagship 1's pathways to impact

The intensity of linkages with other FTA Phase II flagships, CRPs, Platforms and other partners varies. In some cases, required is a 'state of awareness' of content of other programs and reciprocal relevant

information sharing to support decision making. Elsewhere, interactions represent reciprocal, co-adaptive research linkages and joint work programs. As a conduit of appropriate planting material and delivery options, and of associated knowledge on use and management (e.g. propagation methods), Flagship 1 is essential for targeting, developing and delivering the productive and resilient trees promoted by all other FTA Phase II flagships, and its activities must therefore be determined by interaction with them all. Co-investment in the development of research objectives and joint implementation ensures that reciprocal benefits are obtained (Table 3).

2.1.8 Climate change

Flagship 1 has an essential role in responding to anthropogenic climate change in both an adaptation and mitigation context. Safeguarding TGR provides the option value to respond to change, while diversity breeding provides more resilient and adaptive tree planting material that is supplied through climate-responsive delivery systems for agroforestry practices and restoration initiatives. Joint research with Flagship 5 (climate change) 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 tree distributions and 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 provides reciprocal benefits to CCAFS.

2.1.9 Gender

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. Commitment to gender will begin with a particular focus on recruiting, retaining and building the capacity of woman scientists in the Flagship 1 team (e.g. through the AWARD post-doctoral fellowship program) and training team members in gender-responsive methods. In CoA 1.1, the involvement of women (as well as the involvement of young adults, which is essential to ensure the future development of agricultural practices that make the most of TGR) in setting safeguarding priorities will be based on their particular knowledge, uses and future needs. Participatory demand-driven research will build on local skills and will foster 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 will be 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 will be supported through tested approaches that address the structural constraints that limit their participation[34]. 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 will include attention to appropriate credit schemes and financing instruments that are particularly important to enable poorer women to participate individually or as collectives. A key research component 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.

2.1.10 Capacity development

Engagement with partners to develop research and innovative capacities is essential for Flagship 1. Partnership with AWARD will enable development of capacity within the flagship on gender-responsiveness (CapDev Element 5). 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 (CapDev Element 4). This will support the integration of new research approaches in African 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). 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].

2.1.11 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 will be 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 will provides a framework for dealing with tenure, ownership and governance, while the Genebank platform Policy Module will provide 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 program provide ABS models for newly domesticated trees and lesser-used species whose use is being intensified, indicating pitfalls and advantages of particular arrangements.

2.1.12 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 will be 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 delivery systems (see Table 4 and CVs indicated for management staff in appendices). 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 4. Flagship 1 CoA leadership

Flagship Leader: Ramni Jamnadass (ICRAF)			
CoA	**Lead**	**Primary CGIAR partner(s)**	**(Other) Primary non-CGIAR partner(s)**
1.1 (safeguarding)	Bioversity International (Judy Loo)	ICRAF, CIFOR	University of Copenhagen
1.2 (domestication)	ICRAF (Zac Tchoundjeu)	Bioversity International	University of Copenhagen
1.3 (delivery)	University of Copenhagen (Lars Graudal)	ICRAF, Bioversity International	-

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

2.2.1 Rationale and scope

Our central hypothesis is that food security, nutrition and income for 100 million people in smallholder households in Africa, Asia and Latin America can be significantly increased through better management of the tree and forest resources underpinning their livelihood systems. Recent global assessments suggest that there is 10 percent or more tree cover on over 43 percent of agricultural land (about a billion hectares) that is home to 900 million people[1], and that 28 percent of household income is derived from forest resources for smallholders living at the forest margin[2]. This flagship program will increase the contribution that trees and forests make to smallholder livelihoods (Sub-IDO 3.2) by developing more productive tree management options (Sub-IDO 9.2), helping smallholders capture more value from the sale of products (Sub-IDO 3.3), and ensuring more equitable management of tree and forest resources (Sub-IDO 9.1) – especially by and for women (Sub-IDO B.1) and young people. This will increase access to diverse, nutrient-rich foods (Sub-IDO 5.2) and increase livelihood opportunities for people in smallholder households, with a focus on those who are socially and economically marginalized (Sub-IDO 3.2).

Research on tree management options and associated markets is combined with work on policy and institutions to ensure impact at scale. Our central focus is at the household level, and we develop and apply a novel 'research in development' paradigm together with development partners, to tailor options to suit the highly variable range of contexts in which smallholders can benefit from better tree and forest management (Figure 1). Options may comprise combinations of technologies, market and extension interventions, and policy instruments, which often interact with one another in the achievement of livelihood improvements.

The flagship has been reorganized from Phase 1 to comprise five research clusters (section 2.2.6). This enables integrating research to be carried out on livelihood systems analysis, synthesis and scaling, so as to structure work across four major tree production practices that underpin smallholder livelihoods. These are: timber, food and fuel production and marketing; tree-crop commodities (coffee, cocoa, oil palm and rubber); trees in support of sustainable intensification; and silvopastoral systems. The integrating research adopts a transdisciplinary systems approach, including a focus on institutions and policy conditions for success and scaling. This allows us to tackle grand challenges through focused research, to close yield gaps and sustain productivity gains in specific production practices, while effecting system intensification through managing interactions at the livelihood level and in the enabling environment that conditions it.

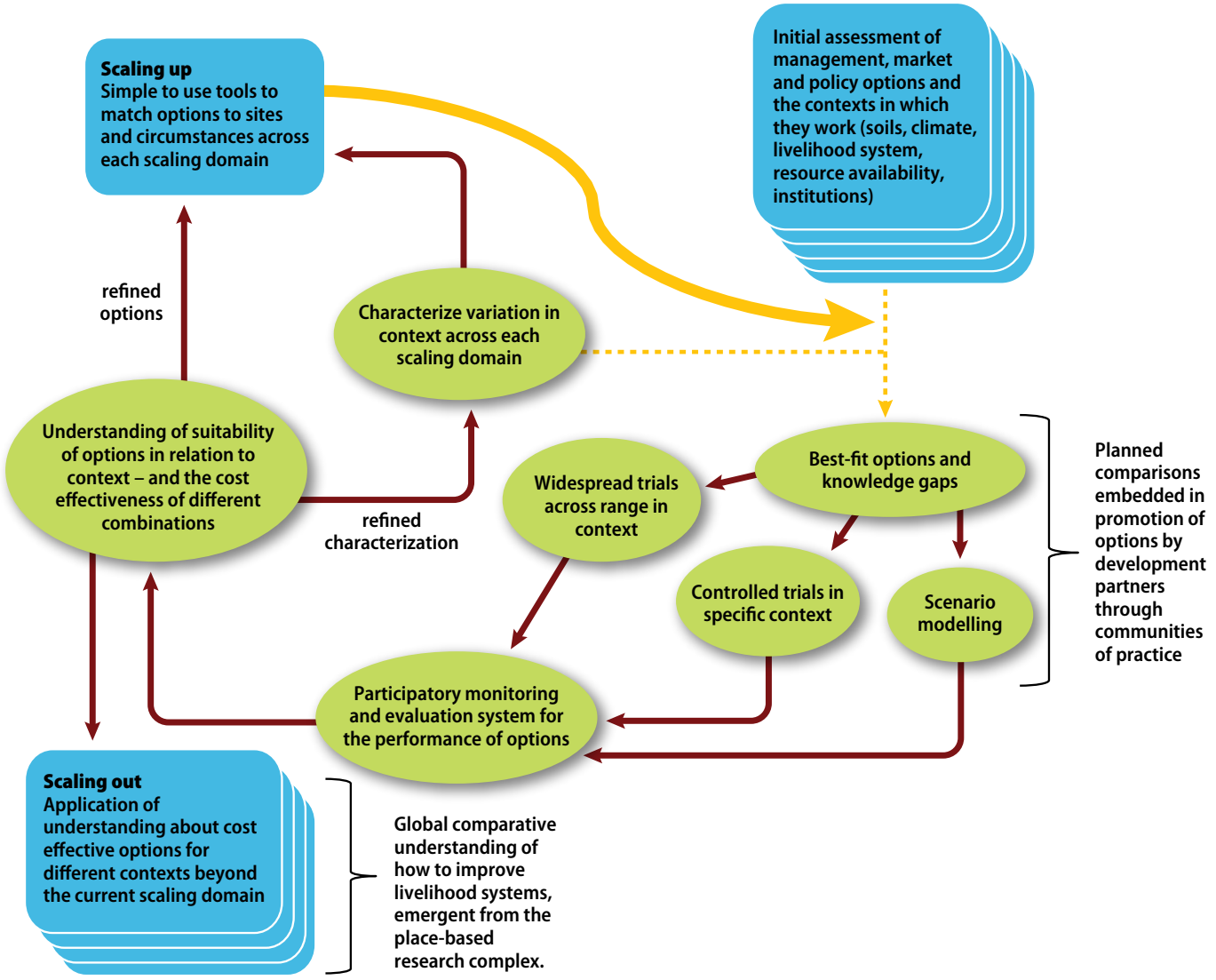


Figure 1. The research 'in' development (RinD) approach (adapted from Coe et al. 2014[3]) that embeds research within development practice by considering options in relation to context (Coe et al. in press[4]) and systematically evaluating options across ranges in context through coupling planned comparisons with innovations in data collection from widespread farmer trials.

In terms of grand challenges, our focus is on the nexus of meeting rising livelihood requirements for food, water (including that required to produce food) and energy (including that required to cook food) as populations increase, while halting and reversing the widespread land degradation that threatens future productivity, in the knowledge that avoiding degradation is much less expensive than restoration. Trees are pivotal resources in addressing these multiple and interacting goals. We tackle the fundamental production and environmental protection issues in the context of needing to increase smallholder income through better market access and function, enabling households to effect exits from poverty. Both production and market options are constrained and can be enabled by socially differentiated access to resources mediated by policies and institutions, with particular requirements to increase women's power over decisions about natural resource management, marketing and income. In this way, we simultaneously address hunger, poverty and environmental protection with a focus on managing trade-offs and synergies amongst them.

2.2.2 Objectives and targets

The flagship aims to develop forest and agroforestry options, comprising innovations in management, markets and policy associated with the tree cover utilized by smallholders. We anticipate that this will lead to greater and more resilient food security and income for 100 million people, representing about 11 percent of the population living in our target area. That is, it will benefit people in targeted developing countries living in areas where tree cover on agricultural land is 10 percent or more, or at forest margins. A key innovation in our approach is the application of systems research at the scale of the impact that we intend to make. This results in operating across large-scale domains by embedding research within development through strategic partnerships with development organizations (Figure 1, section 2.2.1).

Better management of trees by smallholders acts on livelihoods through increased production of food and products that are sold, system intensification through producing fuel and fodder close to home, freeing up cash and labor for other intensification options, and avoiding and reversing land degradation by maintaining and restoring soil health and increasing the efficiency of water and nutrient use. This is coupled with improving value capture by producers from as-yet poorly developed markets for many forest and agroforestry products, and is enabled through policy reforms to remove barriers to people (especially women) deriving benefit from, and controlling production and income from, trees and other forest resources. These impacts of trees on livelihoods interact strongly, so that understanding and addressing trade-offs and synergies associated with the adoption of innovation options is fundamental to successful development outcomes.

Making impact at scale through enhancing smallholder tree and forest management requires innovation in the ways that research and development address fine-scale variation in context. Context includes social, economic and ecological factors that determine the suitability of different innovations. The flagship, therefore, devotes a quarter of the budget to the development and application of novel methods for conducting research across large-scaling domains in concert with development partners (Table 1). These resources have huge leverage since they directly act upon the development funds of partner organizations, which are an order of magnitude larger than those available for research, and are the only way sufficient resources can be mobilized to conduct research at scale. This co-learning approach ensures that research outputs can be scaled up and out to impact 11 selected Sub-IDOs (Table 2) elaborated further in relation to each CoA in section 2.2.6. A further quarter of the budget is devoted to research on system intensification, including the role of trees in sustaining soil health, leading to higher productivity and greater food security for 20 million people (Outcome 2.4). This involves close collaboration with other agri-food system CRPs because trees have an impact on the yield of staple food crops and livestock (see Figure 3, section 2.2.3). About 20 percent of the budget focuses on research on increasing production and value capture from smallholder tree-crop commodities (cocoa, coffee, rubber and oil palm), aiming for 25 percent higher income for 20 million people (Outcome 2.3). The remaining 30 percent of the budget is equally focused on improving diets and increasing income from smallholder production and sale of food, fuel, timber and other products targeting five million people (Outcome 2.2), and improving productivity and animal welfare of silvopastoral systems across 15 million ha, and avoiding or reversing degradation of over 5 million ha (Outcome 2.5). We adopt a gender-transformative approach across the flagship research portfolio (Table 2) with about 10 percent of the budget focused specifically on increasing the control that women have over production and income from trees and forests (Outcome 2.2).

Table 1. Outcomes by windows of funding

Outcomes	Amount needed (million USD)	W1/2 (%)	W3 (%)	Bilateral (%)
1. Improved food security and livelihood opportunities for 100 million people in smallholder households 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	24	0	76
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	24	0	76
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	24	0	76
4. Increased access to diverse, nutrient rich food for 20 million people through closing yield gaps by trees in agricultural systems improving and maintaining soil health as well as intensifying system interactions (fodder and firewood) and directly contributing to production, reducing and reversing land degradation and increasing the resilience of smallholder livelihoods	25	24	0	76
5. Closing yield gaps through improved pasture management and animal husbandry on over 15 million ha and 1 million animals and contributes to reducing and reversing land degradation on over 5 million ha	15	24	0	76
Total	**100 million**	24%	0%	76%

Table 2. Investments by sub-IDOs

Sub-IDOs	Amount needed (million USD)	W1/2 (%)	W3 (%)	Bilateral (%)
3.2 Increased livelihood opportunities	15	24	0	76
3.3 Increased value capture by producers	7	24	0	76
5.2 Increased access to diverse , nutrient rich food	10	24	0	76
8.1 Land degradation minimised and reversed	10	24	0	76
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 agro-ecosystems and communities	6	24	0	76
B.1 Gender-equitable control of productive assets and resources	10	24	0	76
C.3 Conducive agricultural policy environment	10	24	0	76
D.3 Increased capacity for innovation in partner research organizations	5	24	0	76
D.4 Increased capacity for innovation in partner development organizations and in poor and vulnerable communities	5	24	0	76

2.2.3 Impact pathway and theory of change

The ultimate beneficiaries of livelihood systems research are the 100 million smallholders who take up options generated by the research to improve their livelihoods. Our theory of change (Figure 2) rests on three main tenets: 1) that current management of tree cover on farms and at forest margins can be improved to achieve higher and more sustainable yields, leading to better food and nutrition security; 2) that smallholders, and particularly women, can achieve higher returns from tree and forest products through better marketing and processing, thereby increasing income; and 3) that people (especially women, young people and other marginalized groups) can participate more in, and benefit more from, utilizing tree and forest resources, if policies, legislation and institutions affecting their use are made more conducive to this end. Development of international public goods (IPGs) associated with specific options are set out in section 2.2.6, which describes the clusters of activity.

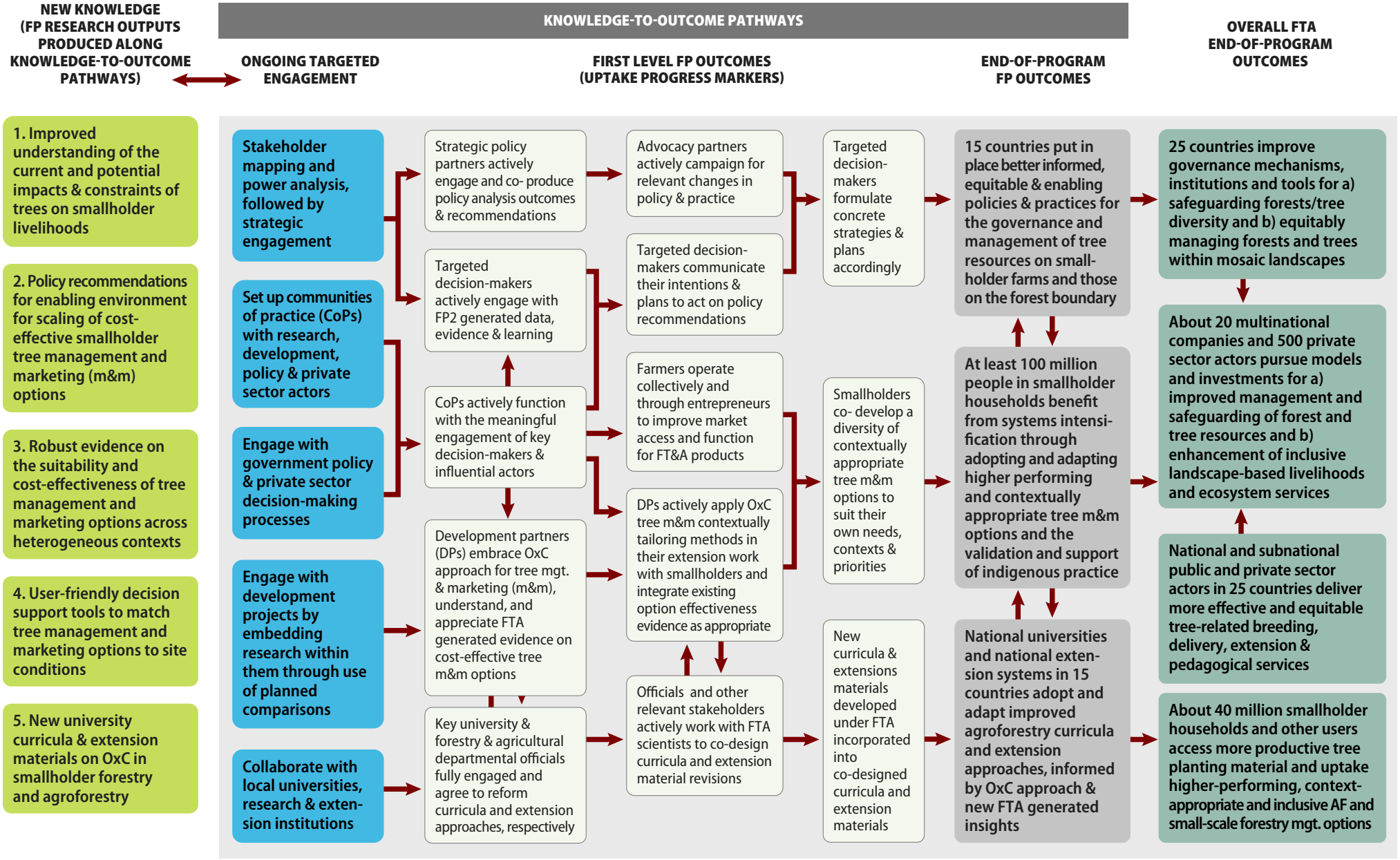


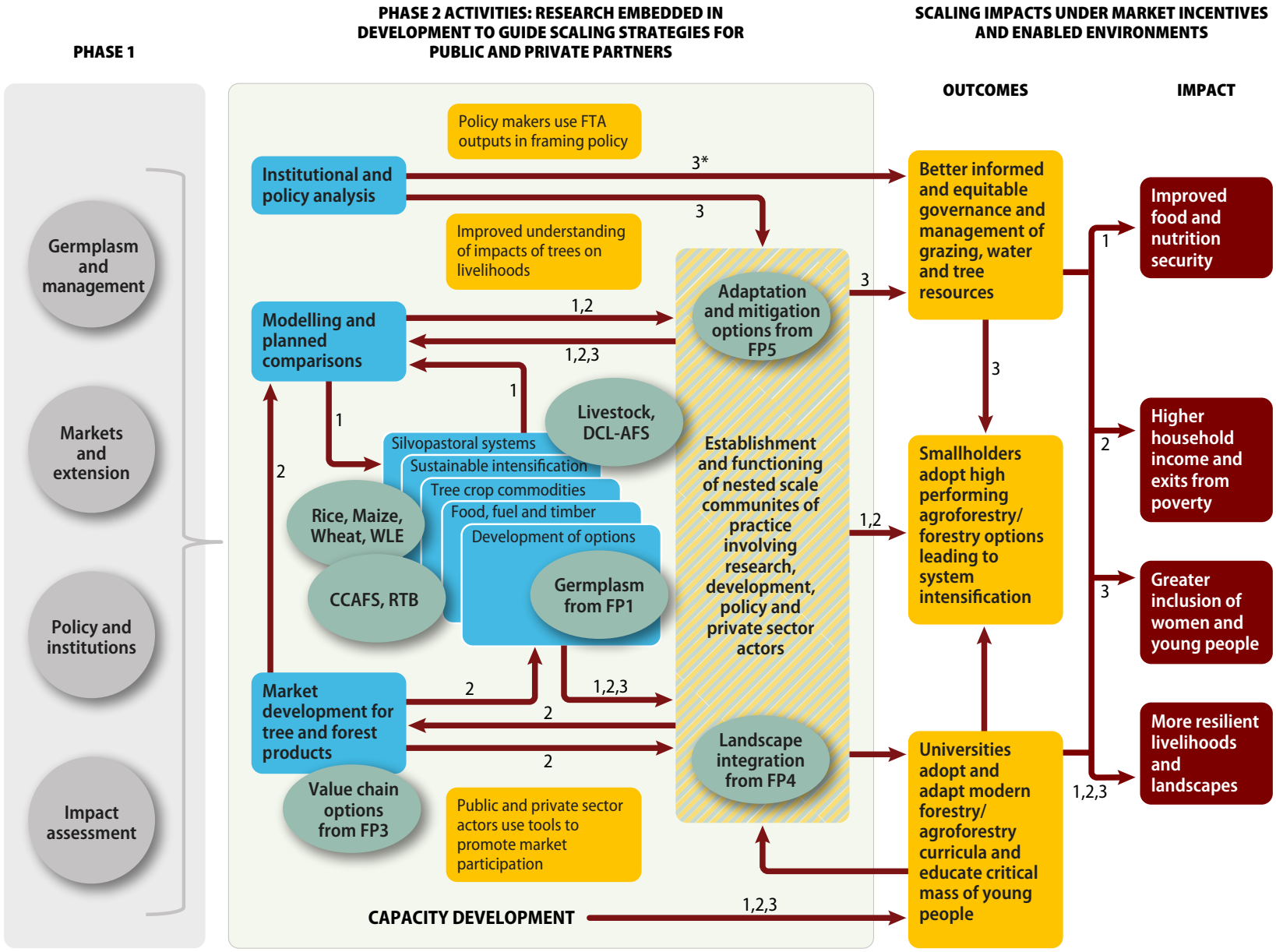
Figure 2. Flagship 2 theory of change

Analysis of development practice reveals that current forest and agroforestry options available for smallholders, while benefitting some people, are i) not comprehensive in terms of the contexts they cover (leaving some people without appropriate options for improvement), ii) are often promoted outside their appropriate contexts (revealing gaps in our understanding about matching options to context) and iii) require an appropriate enabling environment, especially for marginalized people to benefit from them (and for perverse outcomes to be avoided). Research can address these constraints and, therefore, improve smallholder livelihoods through better use of tree and forest resources, if the research is conducted in a way that ensures its relevance across contexts.

A major route to smallholder uptake is via embedding research within development through multi-stakeholder communities of practice (Figure 3). This involves both research and development partners changing the way that they work, to use planned comparisons of ranges of options across ranges in context to efficiently learn, with smallholders, about what works where and for whom (Figure 1). It uses knowledge-based system methods to combine high-end science with local knowledge[5]. This is a major shift from only promoting what is considered the best-bet option in any instance and requires new capacity among development partners in identifying options for different contexts and designing and learning from planned comparisons. Options include market, policy and institutional interventions that are also taken up directly by private and public actors with whom we engage. Specific research areas and outcomes are elaborated in sections 2.2 and 2.6.

Achieving change requires us to forge and sustain new partnerships with development organizations, the private sector and policy makers (section 2.2.7). We have identified and sought to manage risks associated with these interfaces, that are critical for our research outputs to deliver impact (Table 3). We start from a sound base of partnerships established in Phase 1 and manage risks associated with partners failing to either engage or deliver through a six-point strategy:

1. ongoing communication with, and monitoring of, communities of practice to identify potential problems before they emerge and seek to avoid them developing;
2. 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;
3. focusing on the quality of partnerships that we establish, in terms of reciprocity, efficiency and effectiveness;
4. selecting some quick win routes to impact at the outset so that early successes, as achieved in phase 1 piloting, sustain the partnerships that are established;
5. persisting and continuing to innovate where challenges in establishing and sustaining partnerships arise, learning from experience and trying new approaches where necessary; and
6. linking, innovation in partnerships with development organizations and the private sector, to policy processes and publicity, creating incentives around success.



* See Table 3 "Details of the three major impact pathways in Figure 3" for details on numbering.

Figure 3. Diagrammatic representation of three major livelihood systems impact pathways (details, including risks and assumptions and their relationship to research activity are given in Table 3.

Table 3. Details of the three major impact pathways in Figure 3

ToC pathway	Key assumptions	Key risks	Behaviour change required	Capacity development required
1	Management options are generated that increase yield (and total factor productivity) sufficiently to significantly improve food and nutrition security That development partners will collaborate in trialling a sufficient range of options across a sufficient range of contexts so that options can be matched to appropriarte context That generic understanding about how contextual factors and combinations of them affect sutability of options can be derived from planned comparisons	Development partners fail to engage across a sufficient range of context for a sufficient time for context specific results to be produced	Development partners to embed planned comparisons in their developent practice and learn from monitoring and evaluating their performance	Awareness that current best bets are not always appropriate Design and analysis of planned comparisons Use of evidence in deision making
2	Market development (including adding value through processing) results in sufficeintly higher smallholder income for people to exit from poverty Private sector partners are willing to engage in market development Appropriate conditions exist or can be developed for smallholders to co-operate in leveraging markets	Private sector partners do not sufficiently engage in market development with smallholders	Smallholders to operate collectively to leverage market opportunitiies Private sector partners to engage with smallholders in market development	Skills to develop and run insitutions amongst smallholders Market information and development skills amongst smallholders How to develop and sustain positive linkages with smallholders amongst private sector actors
3	Barriers to access to critical resources (land, trees and their products) by marginalized groups exist and can be removed or eased through policy reform Smallholders can be incentivized to adopt more sustainable management of resources Long-term improvements in environmental impact of agriculture can be achieved without reducing short-term productivity	Policy changes are not made despite evidence of their effectiveness because of vested interests	Policies are implemented at a resolution fine grained enough to reconcile trade-offs between production and other ecosystem services Policy makers use evidence in negotiatimg policy formation and implementation	Spatially explicit evaluation of trade-offs and synergies amongst impacts of land use change on ecosystem services by policy makers and implementers

2.2.4 Science quality

The science quality of the flagship arises from our commitment to innovation. We adopt a novel research-in-development paradigm (section 2.2.1) and will deliver high-impact journal papers coupled to blogs, policy briefs and development action that translate high-impact science into high-impact outcomes on the ground. In this proposal we illustrate science quality mainly through the articulation of the research clusters (section 2.2.6), which innovate on the basis of a clear articulation of past developments in each field and partner with advanced research organizations such as a number of universities and CSIRO to ensure that we continue to harness frontier research during implementation (section 2.2.7). In articulating the research clusters, we are able to use previous flagship outputs, so that we build our new research on a sound foundation of past success coupled with important learning – from Phase 1 and the wider research community – that informs the innovations that we propose to take forward in Phase 2 (section 2.2.5). We expose our science to scrutiny not only through peer-reviewed publication and by presenting ideas and results at international meetings, but also by adopting a co-learning approach through which we obtain iterative feedback from stakeholders on the saliency and legitimacy of our research from its early stages.

Key areas of innovation include the development and application of the 'research-in-development' approach that addresses fine-scale variation in context across large-scale domains (CoA 2.1)[6]. This involves the use of planned comparisons with large sample sizes requiring novel data collection methods that make use of recent developments in ICT[7]. Together with CSIRO, we have developed the capacity to model tree-crop interactions within the Agricultural Production Systems sIMulator (APSIM) modeling framework[8] and will extend this from the few tree species (*Eucalyptus* sp., *Grevillea robusta* and *Gliricidia sepium*) and crops (maize and wheat) initially built into the simulator in Phase 1 so as to embrace tree diversity as well as a broader range of crops, including rice and dryland cereals (CoA 2.4) across a broad range of conditions in collaboration with the MAIZE, WHEAT, RICE and DCL-AFS CRPs. This is vital, to address the increasingly clear preferences of farmers to have more trees, and more tree diversity on farms[9] and in farming landscapes[10] that can confer higher productivity and resilience[11]. Together with universities in the UK and the US, we will apply the latest advances in genomics to better understand how trees improve soil health through 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[13] to test hypotheses about non-responsiveness in soils and how trees affect soil health through fostering functionally balanced soil biota. 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[14], by developing and applying spatially explicit negotiation support tools. Building on the Polyscape[15] approach developed in Phase 1, we couple this with sustainable agricultural intensification dashboards designed to be used to bring evidence to bear in multistakeholder platforms where policy decisions are made[16]. We plan to continue to innovate in using systematic approaches to local knowledge acquisition, building on recent advances in statistical analysis of farmer rankings of tree attributes[17] to combine local and scientific knowledge in developing more diverse and inclusive agroforestry options[18]. We will apply a new unified theory of empowerment[19] together with advances in understanding vulnerability[20] and equity[21] to address constraints in realizing effective and equitable governance of tree and forest resources.

2.2.5 Lessons learnt 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 2, we reconcile place-based research with the production of generalizable IPGs, using a novel research-in-development (RinD) paradigm (Figure 1). We found in Phase 1 that conventional approaches to prioritizing tree species and management practices for scaling addressed neither the inclusive needs of socially differentiated actors nor fine-scale variation in conditions, and led to narrowing tree diversity at larger scales. In Phase 2, 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. 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 feedback learning from large scale planned comparisons of tree promotion approaches to inform FP1 research.

In Phase 1 we identified a need for hard evidence on the cost effectiveness of intervention options to inform investment decisions to effect scaling. We address this in Phase 2 through nested-scale planned comparisons. In Phase 1 we established that trees on agricultural land are associated with larger abundances of soil organisms[22]; we build on this in Phase 2 using genomic approaches to understand how different tree species, density and diversity affect functional profiles of soil organisms and impact soil health.

In Phase 1 we analyzed how tree product markets, culture and policies have differential effects according to gender[23]; we will build on this in Phase 2 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[24]; addressed in Phase 2 by developing novel GIS applications at resolutions able to inform negotiation-support. In Phase 2 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.

Intended and unintended consequences: improveming 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 itself. During this process, we take steps to manage risk inherent in the partnerships involved (see section 2.2.3) and to monitor winners and losers. A significant part of our research portfolio looks at who benefits from innovations in policy and practice and what can be done to ensure that intended beneficiaries are reached. Examples from Phase 1 include understanding perverse impacts of forest policy on regenerating trees on farm and of partial devolution of forest authority on vulnerability[25] and empowerment[26] of smallholders. We have also explored issues of equity in distribution of benefits from carbon payment schemes and what is required for social safeguards to result in positive outcomes for smallholders[27]. We now direct the program at producing research outputs that can support negotiation of desirable outcomes through bringing evidence to bear on them.

2.2.6 Clusters of activity (CoA)

The flagship comprises five research clusters. An integrating cluster on livelihood systems analysis, synthesis and scaling, structures and integrates work across four other clusters, that each focus on a major set of tree production practices, underpinning smallholder livelihoods (Figure 4).

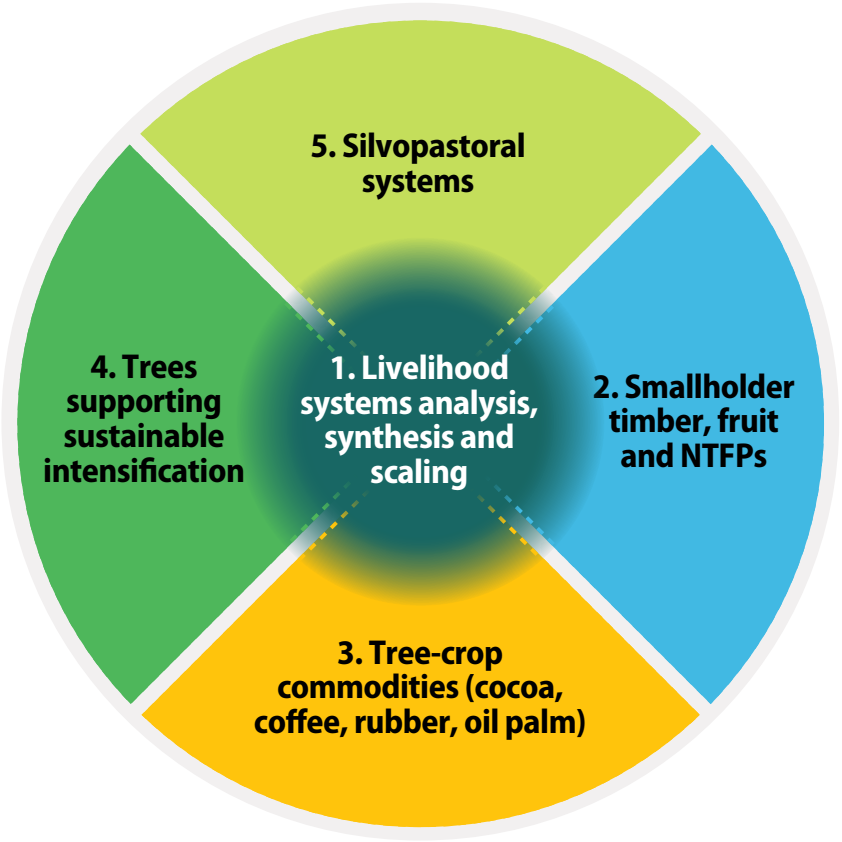


Figure 4. The five research clusters in the FTA Livelihood Systems Flagship.

CoA 2.1 Livelihood systems analysis, synthesis and scaling

We hypothesize that making impact at scale for smallholders through improved management and marketing of trees and their products requires addressing the fine scale variation in context that conditions suitability of options. Secondly that, where trees are incorporated in agricultural systems, gains from system intensification (managing interactions amongst livelihood system components) are likely to be greater than those from tree products alone, and that outcomes will be derived from emergent practice amongst complex groups of stakeholders, that can be guided through negotiation support rather than determined by prescriptive approaches.

Research questions: How can we most efficiently, effectively and equitably co-develop design principles for matching options that improve the use of trees and forests by smallholders (comprising technologies, extension methods and market interventions, and policy and institutional instruments) to the fine-scale variation in the context of smallholder livelihood systems? This requires us to understand how contextual variables condition the suitability of options, and to embed participatory action research within a systematic frame. How can scientific information be used to support negotiation among stakeholders bridging farm to local landscape scales to manage impacts of land use change on ecosystem service

provision? What are the political and institutional conditions that allow for household and smallholder success in terms of livelihood improvements, including ways to scale up results from interventions? How can tree crops help build critical livelihood assets (human, social, natural, physical and financial capital), and how do asset endowments and dynamics vary across and within households according to gender and age? How can access to and control over these assets by women and young people be improved?

The opportunities for livelihood benefits from better management of tree and forest resources vary. Rural livelihoods generally comprise agricultural and nonagricultural elements and forest elements at the forest margin, which all need to be understood in developing appropriate options to improve food security and income. This cluster develops and applies approaches, methods and tools aimed at identifying opportunities for change, trade-offs and negotiation among them (e.g. Polyscape[28]). This includes specific attention to social inclusion with a focus on gender and young people. 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. 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[29]. We use anthropological and 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-scale domains (Figure 2). Planned comparisons, employing large N trials and crowdsourcing of data, using recent advances in information and communication technology, are combined with controlled trials and modeling. 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 through better connecting smallholders to markets and developing markets for key tree and forest products. Specifically for timber we hypothesize that future timber supplies will increasingly come from farm grown sources, and that farmers can benefit from this by improving silviculture, harvesting and marketing. For charcoal we hypothesize that demand from growing urban populations will increase and that developing sustainable production is more viable than imposing controls that are rarely effective, and if so, tend to displace the problem. We further hypothesize that 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 (for example, in furniture manufacturing, drying fruit, or making jam and juice) and contribute substantially to many smallholders' incomes and food security. In this cluster, we look at enhancing smallholder livelihoods through better production and marketing of these products on farms and

investigating the impacts of different forms of forest management on livelihood outcomes[30]. This contrasts with Flagship 4, which looks at forest management from the perspective of managing, maintaining and regenerating 'forests' for multiple purposes. We collaborate across flagships 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[31]. Forest legislation often mitigates against farmers exploiting timber in managed fallows at forest margins or regenerating trees on farms. Trees on farms are an increasingly important source of timber, with huge potential for productivity and profitability gains through better management practices and market development. We are researching how smallholders can get improved access to lucrative and legal timber[32] and fruit markets through opportunities for 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[33]. A major thrust of research surrounds the social aggregation of smallholders in various institutions, and associated private-sector engagement, that can improve market opportunity 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 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 form the basis of smallholder livelihoods. Cocoa and coffee alone cover 20 million ha and are the mainstay of over 30 million smallholder households. There is a hotly contested debate around the need to intensify production and how to do this without aggravating environmental and social disbenefits, 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 food security of smallholder farmers[34]. 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[35]. Yield gaps for coffee vary at the fine scale in relation to soil condition and farmer practices, with trees having the potential to buffer anticipated climate change effects[36]. 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 closing yield gaps through sustainable intensification involving attention to agronomic management, including planting material, pruning and fertilization (Sub-IDOs 3.2 and 9.2).

CoA 2.4 Trees supporting sustainable agroecological intensification

The overarching hypothesis is that 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 farm.

Research questions: What are the optimum levels of tree density and diversity in different contexts required to increase total factor 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 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[37], fix nitrogen, control erosion and sustain soil biota[38]. By providing fuelwood and fodder on farms, they free up labor for other tasks and may substitute for other resources, such as fuelwood being burnt instead of dung, 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[39,40]. 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[41]. Advances in genomics[42] 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 silvopastoral systems? Where are there trade-offs and synergies between production goals and the provision of other ecosystem services?

FAO[43] estimate 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 refugia at landscape scales for farm-level regeneration to be possible[44]. 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[45]. Loss of production due to heat stress in farm animals has been estimated at over USD 40 billion per year and presents a major animal welfare challenge. We are researching how best to develop multistrata silvopastoral systems, live fences, windbreaks and fodder banks as key development options to sustain smallholder livelihoods based on pasture use. This research closes yield gaps through improved pasture management and animal husbandry, and contributes to reducing and reversing land degradation (Sub-IDO 8.1).

2.2.7 Partnerships

Partnership strategy: We engage with development partners, the private sector and policy makers from the outset of our research so that outputs address important issues in a form suitable for uptake, and thus generate outcomes and impact (Figure 1). Upstream partners deliver understanding and expertise that underpin the development of new options. These include: Simulistics[46] (software SME) co-developing a proprietary modeling environment; CSIRO collaborating to incorporate trees within their APSIM suite of globally calibrated crop models; Bangor University of Wales, UK researching genomics to understand functional profiles of soil biota; local knowledge and participatory GIS; and a range of other advanced research institutes (SLU, Cornell, Columbia, University of Adelaide). We have ongoing collaboration with African universities including JKUAT in Kenya (joint long-term research site with many registered postgraduate students), Makerere in Uganda, and Mekele, 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; Unilever on *Allanblackia* in Africa; Clarins on plants for the cosmetic industry in China), and with national SMEs that co-develop novel products such as nonperishable forms of *Docynia indica* in Vietnam[47]. IFAD, ESPA, WWF, Action Aid, CARE and SahelEco are 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. 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 communities of practice around sustainable intensification. The success of our research in development strategy is dependent on development partners engaging and delivering and so we have developed a six point plan to manage risk with respect to interactions with partners elaborated in section 2.2.3.

Comparative advantage: Livelihood systems are at the heart of the new SRF, as it is here that poverty reduction and food and nutrition security manifest. Trees have been undervalued components of fields, farms and agricultural landscapes, often eliminated as more intensive agriculture has developed, and then later reintroduced when sustainability challenges become acute. Hence, there is a huge gain possible from research on developing and promoting tree options to enhance smallholder livelihoods. 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 involves novel methods, tools and approaches, and because it demands profound change in the way that national and regional bodies do business. FTA has an ability to bring to bear on these issues, a unique combination of partners, from upstream research to development practitioners, covering a broad combination of disciplines, applied across a carefully selected geographical range that typifies the challenges that are faced globally. We collaborate as shown in Figure 3, with CCAFS and RTB on developing tree-crop commodity production systems (CoA3), with MAIZE, RICE, WHEAT, DCL-AFS and WLE in addressing sustainable intensification (CoA 4) and with Livestock around silvopastoral systems (CoA 5).

2.2.8 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, and we work collaboratively with CCAFS on integrating climate change predictions about areas likely to be suitable for growing coffee and cocoa in the future into our intervention options as well as the potential for using shade trees to buffer these effects. Similarly, climate changes are likely to have larger implication for smallholder forestry and agroforestry in some geographies more than 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, as in 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 regarding appropriate germplasm for climate proofing in different contexts and with FP7 on both 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 have a key focus on developing carbon finance initiatives that are positive rather than negative for smallholders in terms of equity, vulnerability and empowerment of marginalized groups such as women and ethnic groups that are constrained in their access to land.

2.2.9 Gender

Gender-focused research comprises over 20 percent 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 means of effecting 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 shaping decisions[48]. In Phase 2, 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.

2.2.10 Capacity development

The co-learning paradigm (Figure 1) embedded within our theory of change (Figure 2) and key impact pathways (Figure 3) 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 skillset 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[49]. In Phase 2, 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 both research (D.1.3) and development (D.1.4) organizations/or partners, as well as the private sector. The adopted co-learning paradigm moves away from a top-down approach to knowledge transfer in favor of the co-production – and hence ownership – of new knowledge and experience. We explicitly deliver learning materials and delivery approaches (Element 2), and through strengthening communities of practice (that include innovation platforms), contribute to Element 10. We partner with a number of universities and have built in PhD and Masters studentships as a key element of the flagship (Element 4).

2.2.11 Intellectual asset and open access management

Intellectual Assets 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;
- 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 specific narrative on FTA IA Management and Open Access Implementation is available in section 1.12 and 1.13 of the Full FTA Proposal, including a detailed strategy for IA management in Annex 3.10 and OA/OD implementation in Annex 3.9.

2.2.12 FP management

The FP is led by Fergus Sinclair at ICRAF who has navigated the flagship through the first phase, creating an effective program across participating institutions and a broad range of upstream and development partnerships to deliver high science quality with development impact. Cluster leaders have been nominated from across the partners within FTA and have two out of five (40 percent) as women. Cluster leaders will be financially supported to organize research within their cluster across partners within FTA as well as, where appropriate, with other CRPs. The flagship has strong links from CoA 3 with CCAFS and RTB, from CoA 4 to Maize, Wheat, Rice, DCL-AFS and WLE and from CoA 5 to livestock. The cluster leaders will form a management team for the flagship, while inclusivity across partners will be achieved through the use of a yammer group, which has proved successful in the proposal and pre-proposal writing phases in keeping a critical mass of scientists engaged. The nominated cluster leadership is as follows:

1. Systems analysis, synthesis and scaling. Tim Pagella, Bangor University
2. Timber, food and fuel production and marketing. Peter Cronkleton, CIFOR
3. Tree-crop commodities. Philippe Vaast, CIRAD
4. Sustainable intensification. Catherine Muhturi, ICRAF
5. Silvopastoral systems. Adriana Chacon, CATIE.

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

2.3.1 Rationale and scope

The vision. FP3 facilitates innovations in public policy, responsible finance, private investments and business models to stimulate the sustainable supply of timber from natural and planted forests, enhance sustainable production of high-value tree crops (oil palm, rubber, cocoa, coffee and coconut), and reduce the impacts of agricultural expansion (soy and beef) in forests. It does this through supporting the adoption of more intensive production systems that comply with higher environmental standards, while 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 an improved governance of global value chains to adhere to sustainable supply standards in order to reduce negative environmental impacts while supporting more intensive management and production systems and a greater participation of smallholders and SMEs in the value chains, with emphasis on women, youth and other marginalized groups. A major challenge is aligning approaches to sustainability of public, private and civil society.

Background. Commercial agriculture is driving significant deforestation, mainly associated with the expansion of oil palm, soy and beef supply for national and international markets[1]. Unsustainable logging in natural forest contributes to forest degradation, 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[2]. Commercial pressures on land have accelerated due to a growing demand from emerging economies (e.g. China and India)[3]. In recent years, several public and private policy responses have emerged. Commodity-specific voluntary standard systems (VSS) were developed to promote more sustainable production[4]. Companies are also adopting commitments to sustainability, such as pledges for 'zero deforestation'[5]. 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[6]. A major recent development is the integration of Environmental, Social and Governance (ESG) criteria by financial service providers (FSPs) into their financial products and services design[7]. The latter is, however, limited to international FSPs, and has yet to fully permeate the financial sector in producer countries[8].

Problem statement. Public policy often has contradictory impacts in either reducing or fostering deforestation as well as degradation of forests and of species-rich landscapes[9]. VSS and self-regulatory commitments are gaining increasing traction among consumer good companies, traders, industry and financial institutions, yet their adoption rates are still low and their long-term effects uncertain[10], 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 capacity and resources to comply with more stringent sustainability requirements[11]. Moreover, voluntary standards typically lack gender-sensitivity and inadequately address issues related to women workers[12]. Approaches linking VSS to regulatory frameworks and specific business models integrating smallholders and SMEs in more effective ways could help to overcome these barriers. Yet the latter are often perceived to be economically unviable and are associated with significant financing and investment risks[13]. In addition to the possible crowding out of smallholders and SMEs from value chains with more rigid standards, the expansion of zero deforestation initiatives aimed at

protecting high-carbon stock lands are likely to increase pressures on what are considered degraded lands often controlled by smallholders[14].

Scientific rationale. Enhancing the sustainability and inclusiveness of global timber, tree-crop and agricultural value chains increasingly requires more complex governance and institutional arrangements involving governments and private sector in both consumer and producer countries. An improved evidence base is needed on what are the most effective complementarities between regulatory frameworks, system standards and corporate sector self-regulatory commitments in order to reverse the political economies shaping inefficient and inequitable land use. In addition, better knowledge is needed on how to reverse adverse inclusion of smallholders and SMES in commodity value chains, and build business options and livelihood opportunities for these local actors increasingly involved in global value chains, and promoting investments that safeguard the rights of local populations, mainly marginalized groups such as women and indigenous people. Finally, better understanding is required on the potential of financial institutions and innovative mechanisms to trigger transformational change while attending in equal ways the needs of investors and of 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:

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

2.3.2 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 crop and agricultural production and value chains. This will be achieved by reducing their impact on forests, improving their alignment with long-term conservation objectives, and improving the integration of smallholders and of SMEs. FP3 will generate evidence, distill best practices, produce methods and tools, convene stakeholders and engage in business and multi-stakeholder platforms to:

1. Improve the sustainability of production by identifying complementarities between public regulations, private commitments and VSS;
2. Inform businesses and service providers about business models that are more socially inclusive and gender responsive, economically viable, and environmentally sustainable;
3. Support ESG integration in FSPs products and services design to increase the flows of finance and investments in forest and tree crop sectors, and contribute to the development of an alternative finance mechanism (The Landscape Fund, TLF)[15] to support smallholders and SMEs

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

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

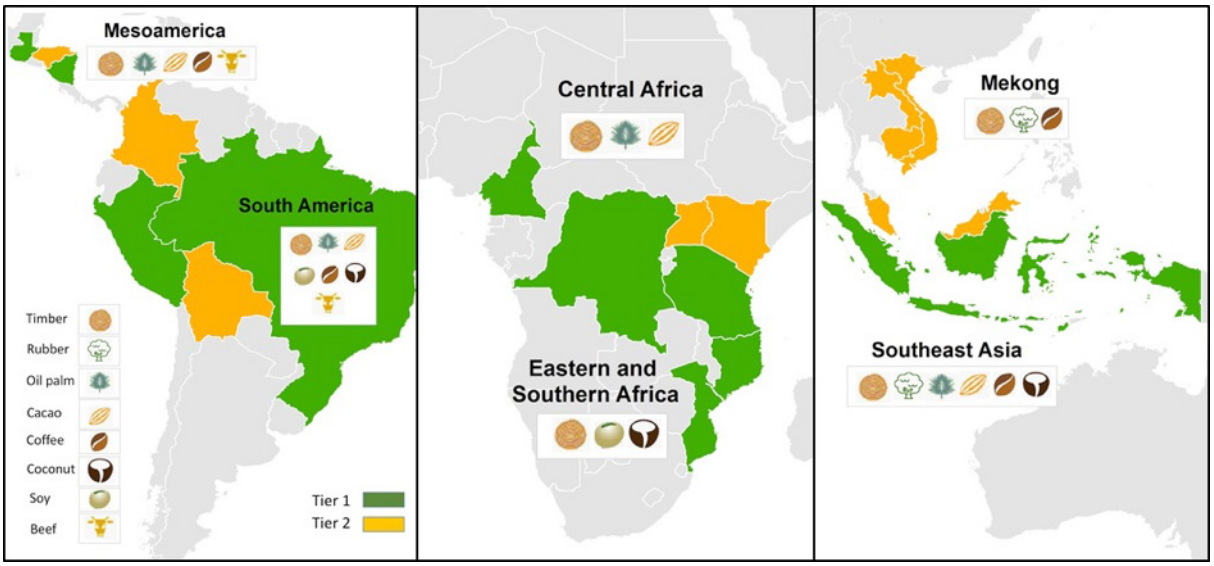


Figure 1. Selected countries and commodities by region.

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

1. Promoting the development of integrated public-private arrangements in at least three major producer countries that directly increase the uptake of sustainability standards;
2. Ensuring that at least 50 percent of tropical timber and tree-crops is produced under internationally recognized sustainability standards or commitments in Tier 1 countries;
3. 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;
4. Creating an enabling environment so that at least 30 percent of the FSPs lending to timber, tree and select agricultural crops adopt ESG criteria, and increasing by 25 percent 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 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 (USD)	W1/2 (%)	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, 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 in 25% 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 (USD)	W1/2 (%)	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

2.3.3 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 alignment between the public and private actors, and financial institutions. We, however, do not ignore the existence of strong entrenched interests and incentives supporting non-inclusive and non-sustainable business practices in the commodity chains that have to be reversed. FP3 builds on identified processes on which there is opportunity to make a difference, and that can have multiplier effects within diverse political and economic systems, at different levels. We embrace three main strategies for impact. We expect to achieve these outcomes through a multi-level approach involving the joint generation of knowledge products and through targeted engagement and capacity development actions with key select actors (Figure 2). The three mutually reinforcing pathways adopted by FP3 are as follows:

Pathway 1: Informing political decision makers and policy dialogues on improved policy options. We will engage sub-national and national governments and international intergovernmental platforms to enable more informed policy decision-making processes. At the sub-national level, we will keep supporting debates on ways to improve sustainable palm oil and soy/beef production. At the national level, we will build on current engagement 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, DRC, and Tanzania). At the global level, we will engage and inform intergovernmental commodity-specific platforms, 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), and other networks to reach official representatives to endorse recommendations on new approaches and policy instruments to be included in strategic government planning. Based on our acquired knowledge, we will aim to reach with key policy recommendations to diverse and influential stakeholders by participating in international events (e.g. Global Landscapes Forum, World Bank Land and Poverty Conference, Innovation Forum conferences).

Pathway 2: Engaging multi-stakeholder processes at different levels to improve capacities and practices. FP3 has a strong track record of effective participation in global and national multi-stakeholder processes, where our scientists and programs are seen as credible sources of information. We have actively contributed to improving timber certification standards, notably the Forest Stewardship Council (FSC), and will continue to do so. FP3 partners also participate in global roundtables, such as Roundtable of Sustainable Palm Oil (RSPO), Global Roundtable for Sustainable Beef (GRSB), the association of sustainability standards (ISEAL Alliance), the Sustainable Agriculture Network and other less formalized platforms such as The Forest Dialogue and issue-based platforms such as the Global Land Tool Network and the Business Call to Action (BCtA). At the national level, we contribute to multi-stakeholder working groups, such as the Indonesian Sustainable Palm Oil System (ISPO) and the Sustainable Cocoa Production Program in Indonesia, the Joint Implementation Committee on FLEGT in Cameroon, and the Brazilian roundtable on sustainable beef (GTPS). We will share findings with international NGOs (e.g. The Nature Conservancy [TNC], World Wide Fund for nature [WWF-International], Friends of the Earth and Rainforest Alliance) and national civil society organizations. We will also collaborate with the Netherlands Development Organization (SNV), Fair Trade International, UNDP, UNEP and the World Bank. The target beneficiaries of our engagement with multi-stakeholder processes are governments, private sector and civil society organizations involved in those platforms.

Pathway 3: Supporting private sector initiatives and commitments to sustainability to improve practices. FP3 collaborates closely with private sector sustainability initiatives, such as the World Cocoa Foundation, the Indonesian Palm Oil Pledge (IPOP), the Indonesian Palm Oil Association (GAPKI), the Brazilian Beef Exporters Association (ABIEC), and timber producers/traders organizations in the Congo Basin and Latin America. We assume that companies that have made commitments to sustainability will continue their efforts in these commodities. FP3 will contribute

to help develop business models and sustainable practices for these actors to achieve their goals. Recommendations on scaling options will be actively shared with business sustainability platforms including the Sustainable Agriculture Initiative (SAI), and the Tropical Forest Alliance (TFA2020). In addition, based on the assumption that FSPs are increasingly motivated to integrate ESG criteria, multilateral financial institutions such as the International Finance Corporation (IFC), European Investment Bank (EIB) and regional development banks (e.g. Inter-American Development Bank, Asian Development Bank, African Development Bank), will be informed about our research findings through events such as the Global Landscapes Forum: The Investment Case. Practical lessons learned through the TLF initiative will also be harnessed, and shared across other funds. Large financial institutions 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) Investment Action Group. The end-users in this pathway are private sector actors including major corporate groups and financial institutions and international financial frameworks.

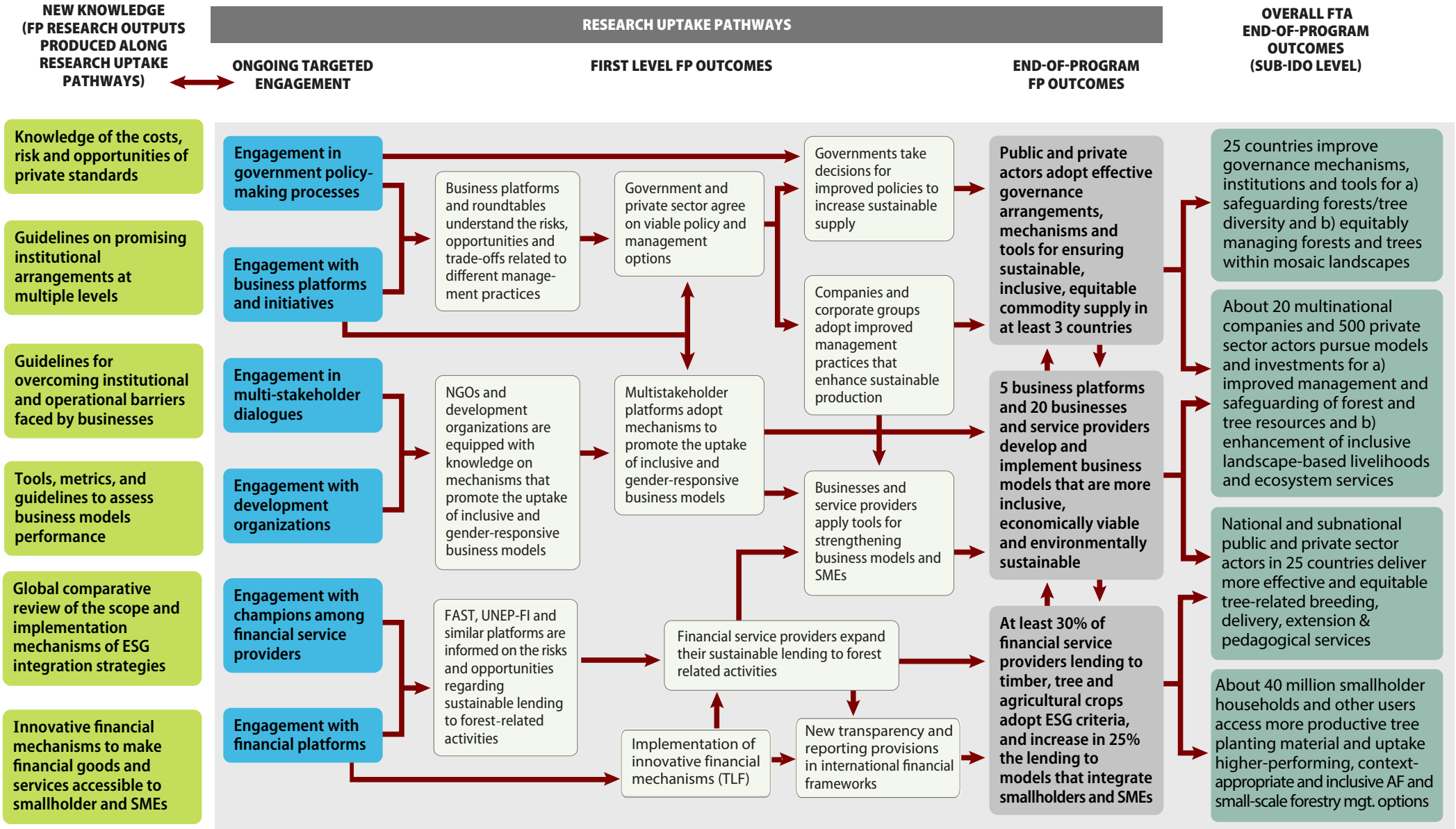


Figure 2. Theory of change and impact pathway

2.3.4 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[16]. Similarly, the influence of social, political and economic factors on agent behavior, institutional systems and governance arrangements has been aptly explored[17]. Research has also shown that VSS are increasingly filling the public policy gap[18], and has highlighted how VSS can incentivize behavioral change[19]. 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[20].

A body of literature has emerged examining 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[21]. Building viable business models that include smallholders and rural SMEs requires strong coordination across a range of stakeholders, learning and adaptation over time, and innovative interventions across scales[22]. Critical questions remain unanswered, however, about the challenges and risks associated with enhancing the participation of resource-poor smallholders in value chains linked to high potential markets[23]. 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 lack of knowledge on how best ESG integration can translate into the adoption of sustainability practices[24]. 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 needs to be explored, as well as the impacts from emerging innovative financing mechanisms[25].

Novelty of science and methods. FP3 proposes a set of methods that will enable it to fill critical knowledge gaps. This includes the development 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. We will assess the implications of adoption through surveys with value chain stakeholders and explore alternative models for agricultural intensification, as well as silvicultural intensification in natural and planted forests. We will link the analysis on public regulations and voluntary standards with more macro-oriented modeling exercises, based on partial equilibrium approaches, to understand the (potential) impacts of VSS, in their interaction with regulations, on commodity supply and income distribution, and land use change. To inform these modeling exercises, we will apply and develop global production to consumption systems (PCS) analysis tools in order to better capture the interaction between consumption and production geographies and trends.

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. To do this, we will employ 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 that aim 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 in order to more effectively translate findings into actionable policies and more targeted interventions that produce greater impacts at scale.

FP3 will, furthermore, support the adoption of responsible finance practices by analyzing factors that encourage or impede more meaningful integration of ESG into FSP product and service design, as well as those shaping investments into more sustainable and inclusive business models and practices. This will be linked to TLF action research. We will also conduct analysis of viable mechanisms through which FSPs are able to most effectively exert influence over corporate policy and practice, as well as innovative financial schemes able to reach smallholders and SMEs. Both analyses will employ 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 work on ESG integration, and the opportunities arising from investments in support of smallholder sustainable land use through TLF, and similar emerging financial schemes that are arising in support of sustainable and inclusive supply.

Research team niche and qualifications. FP3 core team comprises an interdisciplinary group of scientists with social (e.g. economy, business, finance and geography), natural (e.g. ecology and forestry) and interdisciplinary environmental science backgrounds. We have a strong team of scientists at CIFOR and CIRAD working on understanding the interactions between agricultural expansion and land-use dynamics, and assessing policy options for transitioning to more sustainable land uses, including public and private interactions at multiple levels. This work has increasingly included a business perspective, with an explicit gender approach. Several CIRAD and CATIE scientist contribute knowledge on technical options for enhancing sustainable forest management and production systems of oil palm in Southeast Asia, cacao in Central America, Central Africa and Indonesia, and soy/beef in the Amazon. In turn, Bioversity International is building work on production systems and value chains for coconut in Brazil and Indonesia, among other countries. FP3's team has built links to partner research organizations (see section 2.3.7) to complement our expertise with expertise on economic modeling (International Institute for Applied Systems Analysis, IIASA), analysis of PCS (Stockholm Environment Institute, SEI) and analysis of environmental degradation, lifecycle analysis and sustainability assessments (Copernicus Institute). FP3 is also bringing on board expert groups on finance, such as Profundo as well as new boundary partners associated with the CIFOR-led TLF initiative including the European Investment Bank, Innpact and UNEP-FI. This latter area of research will be strengthened by CIFOR hiring of one finance expert.

2.3.5 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 focused on analyzing sustainable production potential and access by different stakeholders to timber and non-timber resources. FP5 focused 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 (oil palm, soy, 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 and environmental impacts.
- 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 regards to environmental performance and the promotion of increased inclusion of smallholders and rural communities in global value chains.
- Where local communities and SMEs have greater capacity and control in global value chains, there is the possibility to overcome the failure of public regulations through the adoption of VSS, yet this may also have negative undesired effects if not accompanied by access to market rewards.
- In the cacao sector, Fairtrade certification has considerable potential to support increased benefits for smallholders from cocoa production; however, 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.
- 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, and often exclude resource-poor smallholders.
- 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.

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.

2.3.6 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, soy 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 (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.

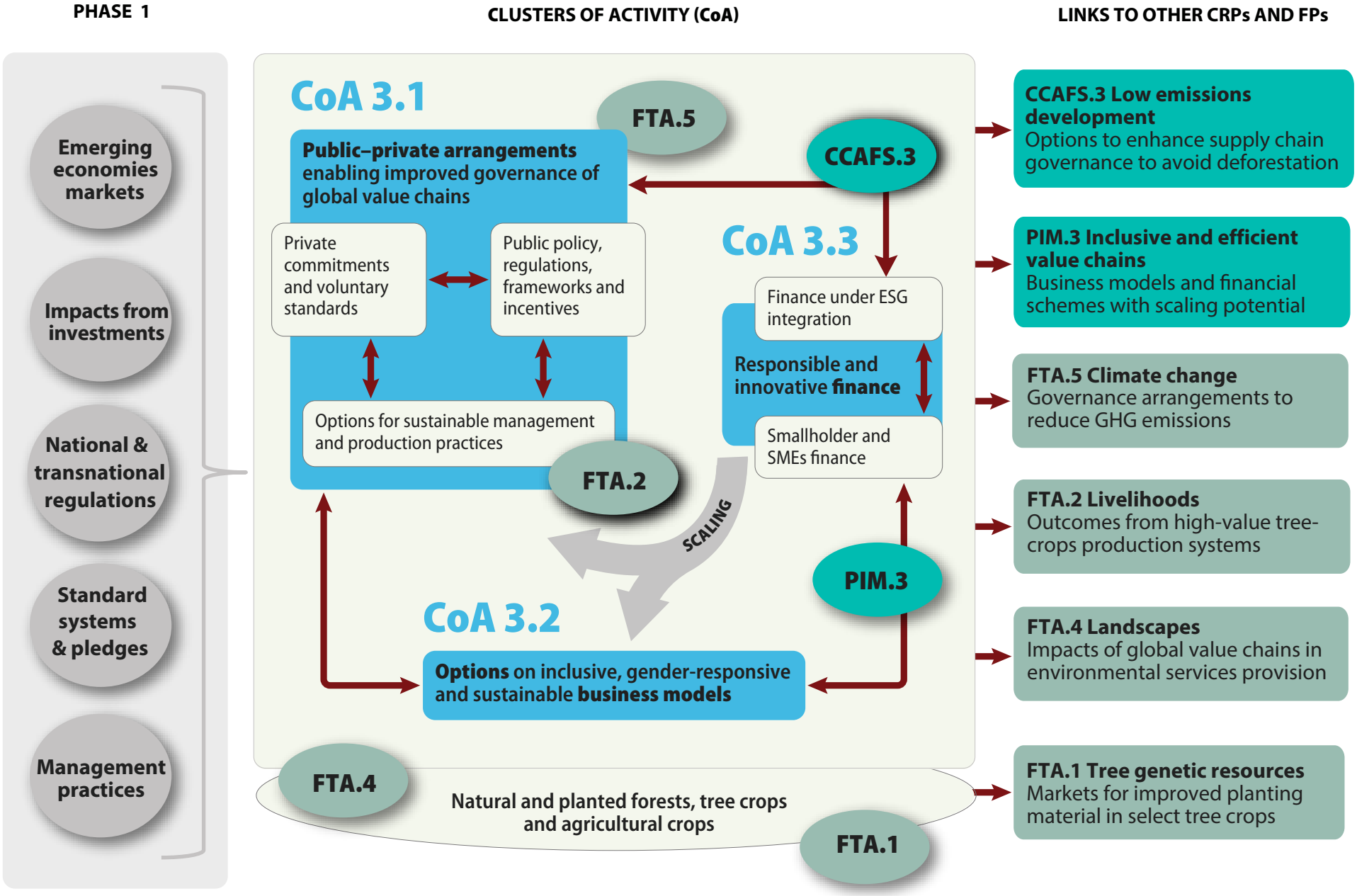


Figure 3. FP3 clusters of activity and links to other FPs in FTA, PIM and CCAF

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 (oil palm, rubber, soy and beef) with a large forest footprint. Governments tend to promote these commodities due to their significant contribution to fiscal revenues and economic benefits, yet they struggle to ameliorate the associated negative social and environmental impacts. Emerging voluntary sustainability standards (e.g. certification and commodity roundtables) as well as private self-regulatory commitments (e.g. zero deforestation) aimed at enhancing the social and environmental performance of commodity production suffer from a number of limitations. These initiatives also differ in their approaches, scope and targets, conflicting in some cases and complementing government-backed efforts in others, and adoption rates vary across sectors, with smallholders and SMEs often being excluded as they lack the capacity to comply. This calls for exploring synergies and conflicts 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 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 operations development in the value chain to support sustainable supply chains. Finally, we will assess the costs, benefits, risks and opportunities, and their 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:

- What political, institutional and social factors shape the adoption and implementation of public policies, and private sustainability standards and commitments and how do they contribute to the social and environmental performance of timber, tree crop and agricultural crop supply?
- What are the main gaps in sustainable value chain governance (e.g. information and knowledge, operational implementation, power and legitimacy) and how can these best be addressed?
- 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 analysis identifying the political, economic and social factors (including gender) enabling or preventing the adoption and implementation of private sustainability initiatives;
- A comparative assessment of the implementation gaps, challenges and opportunities in sustainable value chain governance with analysis of social and environmental impacts across disparate sustainability standards (e.g. certification schemes, 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;
- A decision support tool based on a global comparative analysis of costs, benefits and trade-offs of improved natural forest management practices vis-à-vis 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 are able to 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 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;
- 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 have the potential to 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 businesses on 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. ESG integration, however, instead of leading to improved corporate social and environmental performance may also stimulate a bifurcation of the financial sector since businesses that already exhibit good social and environmental performance are able to 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 mechanism 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 on 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:

- 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 smallholders, including women and youth, and SMEs access to financial products and services and under what conditions could access and availability to these good 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 inter-connected. The work under **CoA 3.1** focuses on the 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 emissions 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 the 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 (i.e. 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 on reduced GHG emissions.

2.3.7 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.

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 for our prioritized commodities. **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 from 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 with research on finance, and linking with the Banking-Environment initiative. **Profundo** will contribute specialist approaches and professional networks in the finance 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 Program (**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 finance 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 between 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 UN Food and Agriculture Organization (**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 to adopt socially and environmentally sound practices.

2.3.8 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 at least 10 percent to global GHG emissions[26]. Over the last two decades, export-driven commodity agriculture linked to oil palm, soy and beef production has constituted the main driver of deforestation in the tropics[27], which has been accompanied by increases in EETs[28]. The production of agricultural commodities for national and international markets is a significant source of GHG emissions from agriculture, forestry and other land use[29]. Likewise, oil palm is expanding onto peat swamp soils producing emissions from the decomposition of peat over many decades following the cutting of the forest[30]. 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[31]. Increasing demand for timber may continue stimulating additional destructive logging and increase vulnerability to forest conversion, stimulated by a perceived lack of value of the degraded ecosystem[32]. 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. First, by supporting an effective implementation of private commitments to increase sustainability in the agricultural commodity sector, and therefore to the reduction of GHG emissions. Second, by facilitating innovation in the climate-smart production of timber from natural forests and 'tailored' tree crops products to meet an increasing national and international trade. Third, by reducing Emissions Embodied in (global) Trade of agricultural commodities.

2.3.9 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 through 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. Through 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 2.3.2). 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.

2.3.10 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 M.Sc. and Ph.D. 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 select state agencies. For example, guidelines and tools will be produced for monitoring the effectiveness of select 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 in Indonesia and SMEs development in the cacao sector in Peru. Fifth, through FSP research and boundary partners engaged in CIFOR's action research on The Landscape Fund. 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.

2.3.11 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 research outputs and maximize global impact. The following CGIAR IA Principles shall be adopted as guidance on IA management of FTA: (i) research results and development activities 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 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 1.12 on FTA IA Management and section 1.13 Open Access Implementation in the CRP narrative.

2.3.12 Flagship management

FP3 will provide a platform for conducting collaborative research for scientists of the different partner organizations (CIFOR, CIRAD, ICRAF, Bioversity International, CATIE and Tropenbos). FP3 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, Trobenbos.

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 to 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 end-users' priorities and availability of financial resources. In order to ensure coordination in developing and implementing FP3, quarterly virtual meetings will be held, and one in person annual retreat will be held by taking advantage of either CIFOR, ICRAF and/or CIRAD Annual Meetings. These meetings will integrate knowledge-sharing partners and as much as possible policy and out-scaling partners as well.

2.4 Flagship 4. Landscape dynamics, productivity and resilience

2.4.1 Rationale and scope

Closing 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.

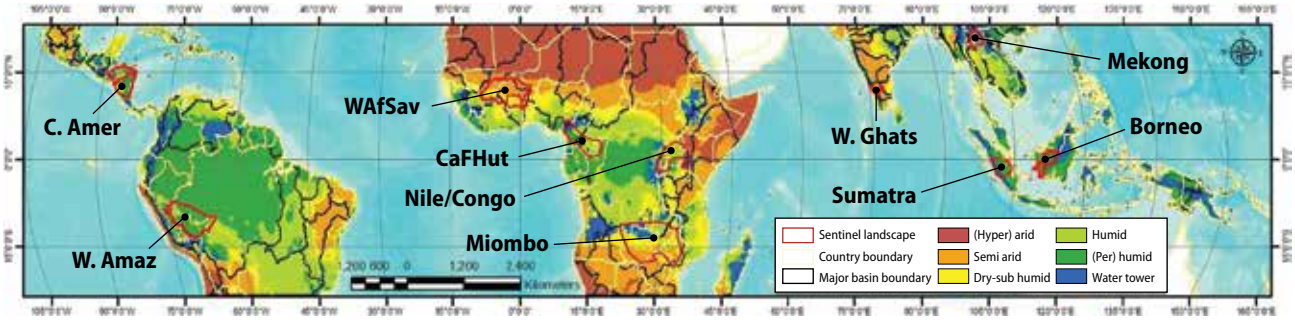
Scope and geography

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[1], 2. Landscape mosaics, biodiversity and ecosystem services, 3. Healthy diets from diverse landscapes and 4, Adaptive landscape institutions: “learning landscapes”.

[1] 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) **S. Asia Water towers** (W. Ghats in India)	(0)–172–(17,025) 14% (118)–240–(1360) 43%	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
Humid forest: 19.7.2% of tropics; 22.0% of people (61.9 km^{-2}) 19% of SL area	**Mekong** (China, Laos, Vietnam, Thailand) **C. America** (Nicaragua/ Honduras)	(7)–43–(301) 67% (0)–56 –(70) 63%	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
(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) **CAFHUT** (Came-roon/Congo/**DRC**) **Insular SE Asia** (Sumatra/**Borneo**)	(0)–3–(228) 92% (1)–33–(5622) 82% (0)–45–(8705) 58%, 73%	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

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

2.4.2 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)	W1/2 (%)	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 inter-disciplinary 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)	W1/2 (%)	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**".

2.4.3 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.

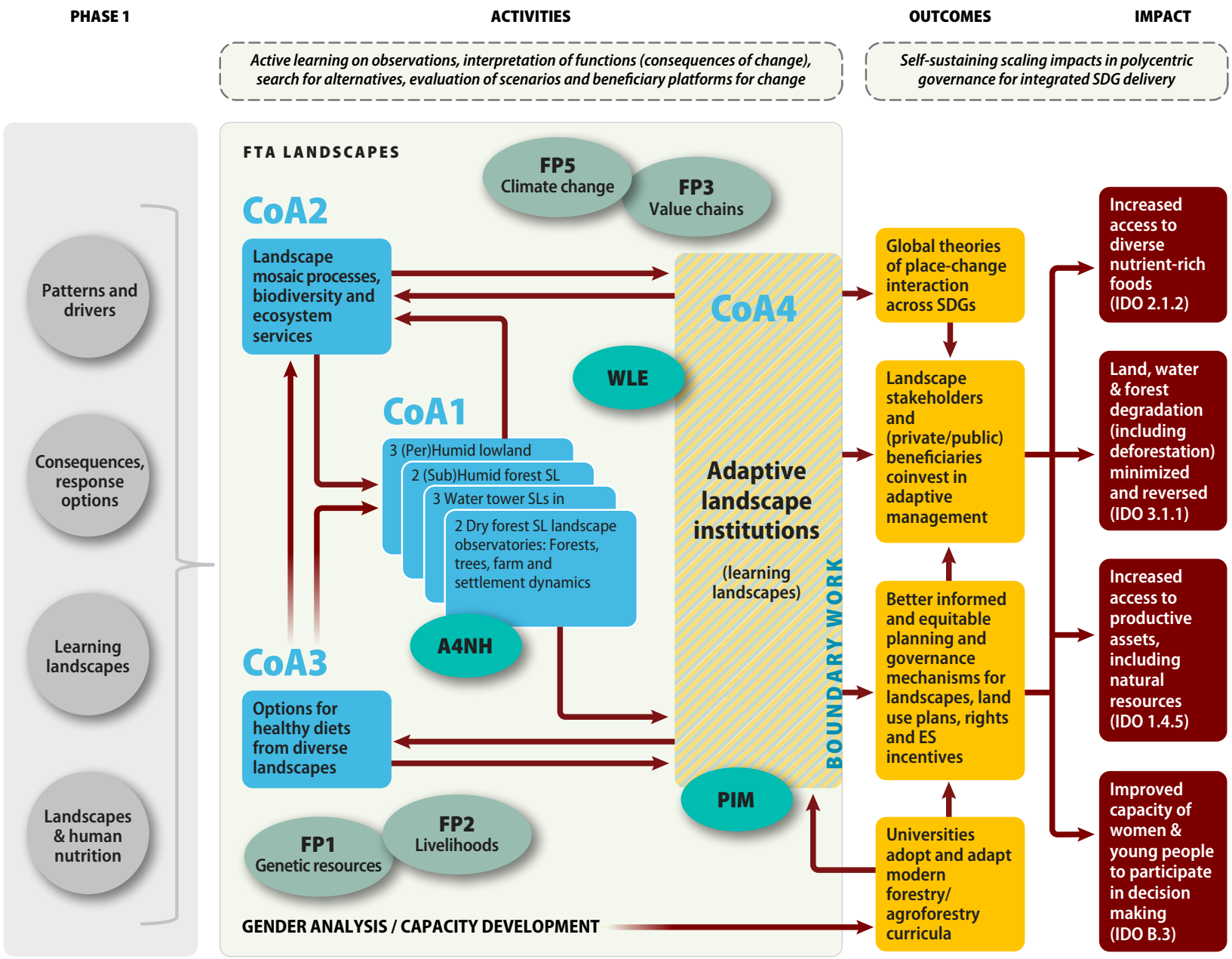


Figure 2. Schematic relationship between structure in Phase 1, CoA's in Phase 2, the generic types of outcomes targeted in boundary work, and the CGIAR Intermediate Development Outcomes (IDO). These are related to; interactions with other FPs in FTA and three integrative CRPs (PIM, WLE and A4NH) are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

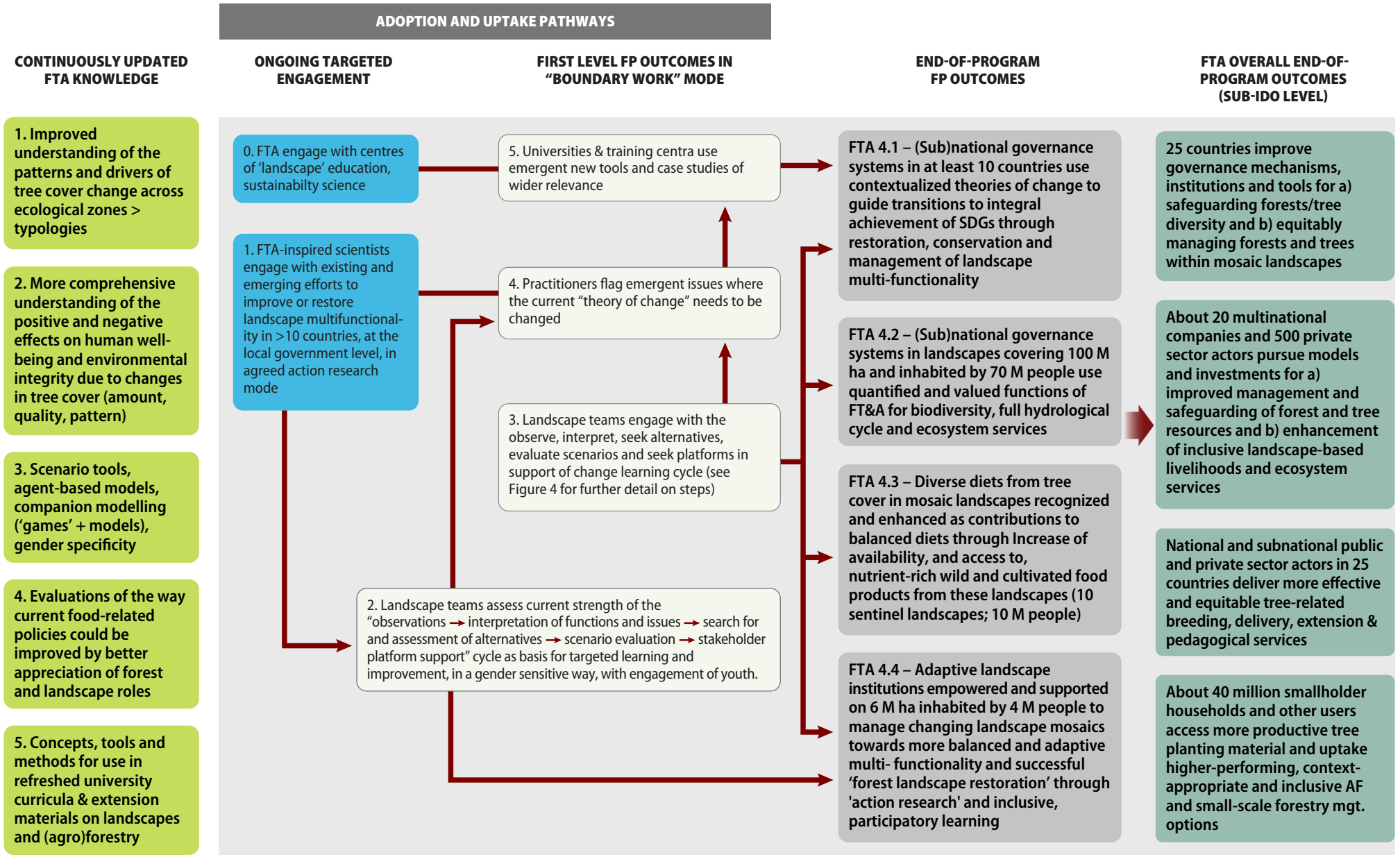


Figure 3A. Theory of change for the landscapes flagship project.

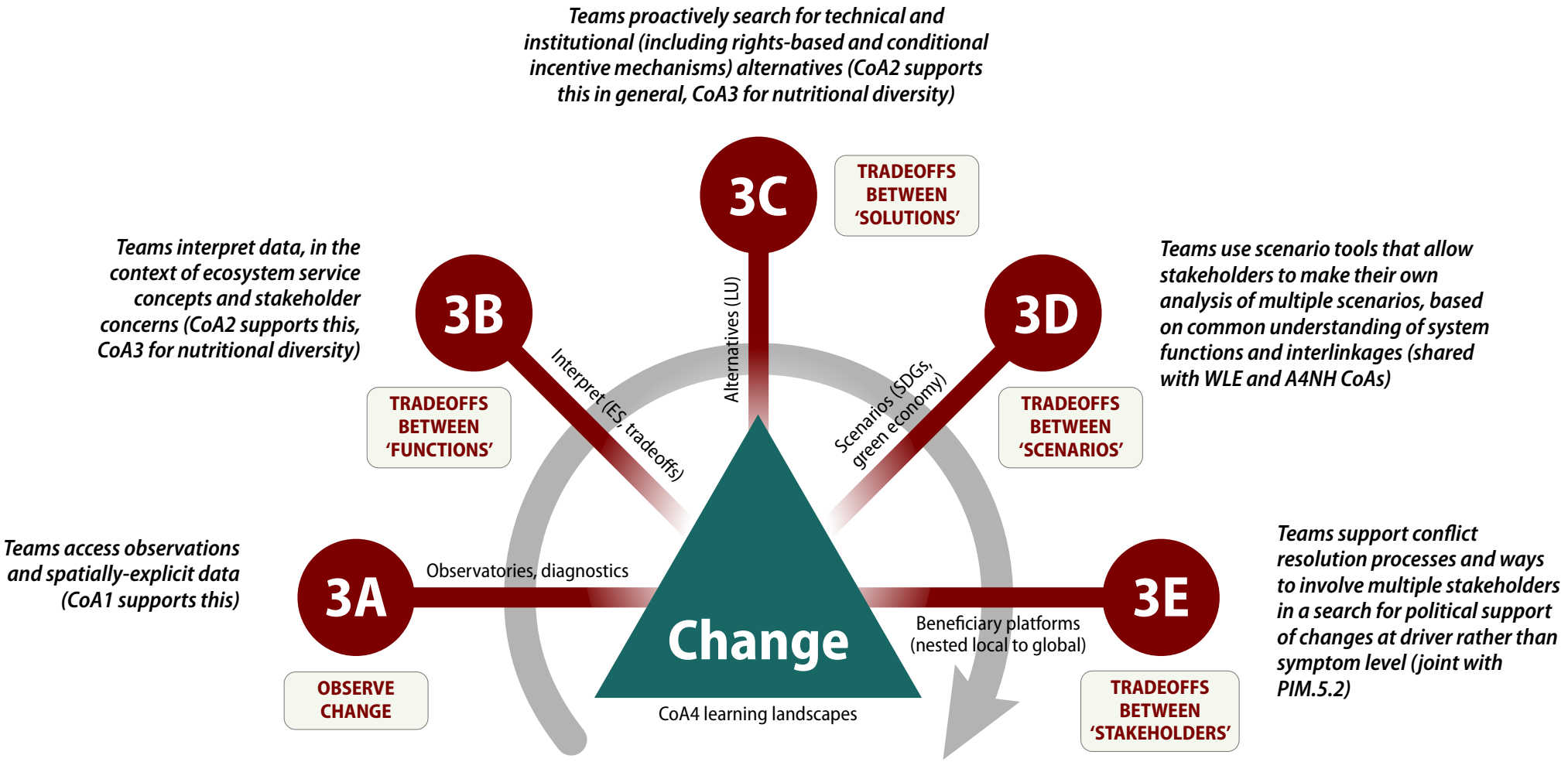


Figure 3B. The learning loop in 'learning landscapes' as part of overall theory of change.

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].

2.4.4 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:

A) 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,
B) 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
C) 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	Quantified buffer functions used in climate downscaling	Tenure reform as basis for increased landscape multi-functionality

C. New ideas, seeking 'proof of principle', extending theory	B. Closing in on paradigm shifts	A. Utilizing current paradigms in practical applications
service management		
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).

A forest (*F*) and agriculture (*A*) continuum under single (community) control

An institutionally segregated *F* (forest institutions) and *A* (agrarian institutions): zero-sum-game sparing

A gradient from *F* to *A* with intermediate 'agroforestry' *af* land uses: sharing for multifunctionality

A configuration with *F* (supporting and *af-A* gradient): combining sparing and sharing aspects

A low tree cover version of any of the other four, where grassland (*G*) interacts with *A*

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	TotCit	Rank in CGIAR	FP4 role/liaison	FTE
Meine van Noordwijk, ICRAF[#1]	Ecologist, modeler	62	17111	3	FP4 leader, WLE	0.8
Terry Sunderland, CIFOR[#2]	Ecologist	26	3028	61	FP4.1 leader, A4NH	0.8
Peter Minang, ICRAF[#3]	Social ecologist	17	964	176	FP4.2 leader	0.7
Eduardo Somarriba, CATIE[#4]	Agroforester	26	3326	58*	FP4.3 leader	0.8
Beria Leimona, ICRAF[#5]	Env. economist	15	845	191	FP4.4 leader	0.8
Delia Catacutan, ICRAF[#6]	Social scientist	13	669	234	FP4.4, PIM liaison	0.6
Bryan Finegan, CATIE[#7]	Forest ecologist	30	4050	45*	FP4.2 focal	0.8
Laura Snook, Bioversity[#8]	Forest ecologist	16	1106	155	FP4.3 focal	0.2
Rene Boot, TBI	Ecologist	22	2056	102*	FP4.4 focal	0.8
Sonya Dewi, ICRAF[#9]	Spatial ecologist	17	1144	151	FP4.2 focal	0.8
Douglas Sheil, CIFOR assoc	Ecologist	49	8681	18*	FP4.2 scientist	0.15
Christine Padoch, CIFOR	Anthropologist	43	5160	35	FP4.1 scientist	0.3
Sven Wunder, CIFOR[#10]	Economist	43	12429	9	FP4.2 scientist	0.7
Manuel Guariguata, CIFOR	Forester	35	5589	30	FP4.1 scientist	0.8
Jianchu Xu, ICRAF	Ethno-ecologist	33	8290	19	FP4.2 scientist	0.6
Robert Nasi, CIFOR	Forester	33	4180	44	FP4.3 scientist	0.2
Edmundo Barrios, ICRAF	Soil Biologist	25	2549	88	FP4.2 scientist	0.2
Ravi Prabhu, ICRAF	Forester	23	2696	73	FP4.4 scientist	0.15
Rhett Harrison, ICRAF	Ecologist	22	2014	103	FP4.1 scientist	0.6
Barbara Vinceti, Bioversity	Forest ecologist	20	1637	122	FP4.3 scientist	0.2
Cheikh Mbow, ICRAF	Geographer	20	1889	112	FP4.2 scientist	0.5

2.4.5 Lessons learnt 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.

2.4.6 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 port-folio 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.

2.4.7 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.

2.4.8 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.

2.4.9 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).

2.4.10 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.

2.4.11 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 1.12 and 1.13 of the Full FTA Proposal, including a detailed strategy for IA management in Annex 3.10 and OA/OD implementation in Annex 3.9.

2.4.12 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.

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

2.5.1 Rationale and scope

The importance of forests in climate change mitigation and adaptation has strongly been recognized in the Paris Climate Agreement. It endorses Reduced Emissions from Deforestation and Forest Degradation (REDD+), allows for alternative (non-market) 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 INDCs (later NDCs[a]) towards reaching the 2.0/1.5°C goal. Likewise, the UN Sustainable Development Goals (SDGs) emphasize climate, forests and bioenergy (see section 2.5.2). 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 to reduce emissions, or that of agriculture as a major deforestation driver, areas that 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 Facilitative Dialogue in 2018 and the five-yearly Global Stocktakes 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 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[1]. But forests also absorb 4–6 Gt of carbon annually[2], part of it from fossil fuel emissions; the Paris Agreement's *mitigation goal* (see section 2.5.4) includes 'sinks' and needs 'negative emissions' (removals), where afforestation/reforestation will be crucial[3]. 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 emissions development.

FT&A ecosystem services are vital for the Paris *adaptation goal* (see section 2.5.4). They support livelihoods of ca. 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[b]. Measures will be more durable if they also reduce harmful inequalities based on gender, ethnicity and economy.

[a] Intended Nationally Determined Contributions (INDCs) were submitted by 188 countries up to October 2015. Countries have to submit updated Nationally Determined Contributions (NDCs) before 2018, and then again every 5 years.
[b] For example, forests provide climate regulation and water provision through climate teleconnections to remote regions.

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

Effective, cost-efficient and equitable (3E+ criteria[c]) 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.

[c] The 3E+ criteria refer to effectiven ess, efficiency and equity of mitigation options and their outcomes, including non-carbon benefits. Cf. Angelsen et al. (2009) Realising REDD+ national strategy and policy options. p.5. http://www.cifor.org/online-library/browse/view-publication/publication/2871.html

2.5.2 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 (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 emissions 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. 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 2.5.6). 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 SDG goals and CGIAR research outcomes (sub-IDOs[d]). The supported SDGs are:

- Urgent action to combat climate change and its impacts (SDG Goal 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 Goal 7);
- Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss (SDG Goal 15); and
- Sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all (SDG Goal 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, Democratic Republic of the Congo (DRC), Indonesia, Cameroon, Peru, and Vietnam). This would be achieved through better policy formulation and more efficient climate action on the side of the users of the knowledge generated in the program. 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 (those depending on

[d] The CGIAR Strategy and Results Framework 2016–2030 defines Intermediate Development Outcomes (IDOs) and research outcomes (sub-IDOs).

remote forest products and services). We expect our *adaptation* research to support about 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[4].

FP5 supports gender outcomes by considering important gender aspects as these relate to decision-making power and asset and resource control (cf. section 2.5.9). Capacity development (section 2.5.10) in developing countries is central to our theory of change (section 2.5.3) – 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 Paris, 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 W3/bilateral. Window 1 and 2 funding will cover 21% of the overall FP budget and be used for three purposes: (i) to partially cover staff time of CoA coordinators (see section 2.5.13) working on flagship integration, coordination, fundraising and reporting; (ii) cover expenses of FP5 integration and partner engagement (e.g. in-country meetings and workshops); and (iii) 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 right 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, and in this 6-year program we are likely 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)	W1/2 (%)	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)	W1/2 (%)	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

2.5.3 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 also enabled or hindered by institutions at multiple levels of governance – they often show structural biases disfavoring marginalized groups or preserving inequalities (see section 2.5.9). 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 2.5.7).

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 theory of change requires leveraging political economy and governance dynamics at national and sub-national 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 2.5.7) 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 sub-national 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 not an uncritical application but 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 on the national arena, but we will also works directly and early on with policy makers in the various levels of administration. As an endpoint we expect the generated knowledge to become (more) reflected in policy and practice at sub-national, 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 1.14). 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 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'[7], 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.

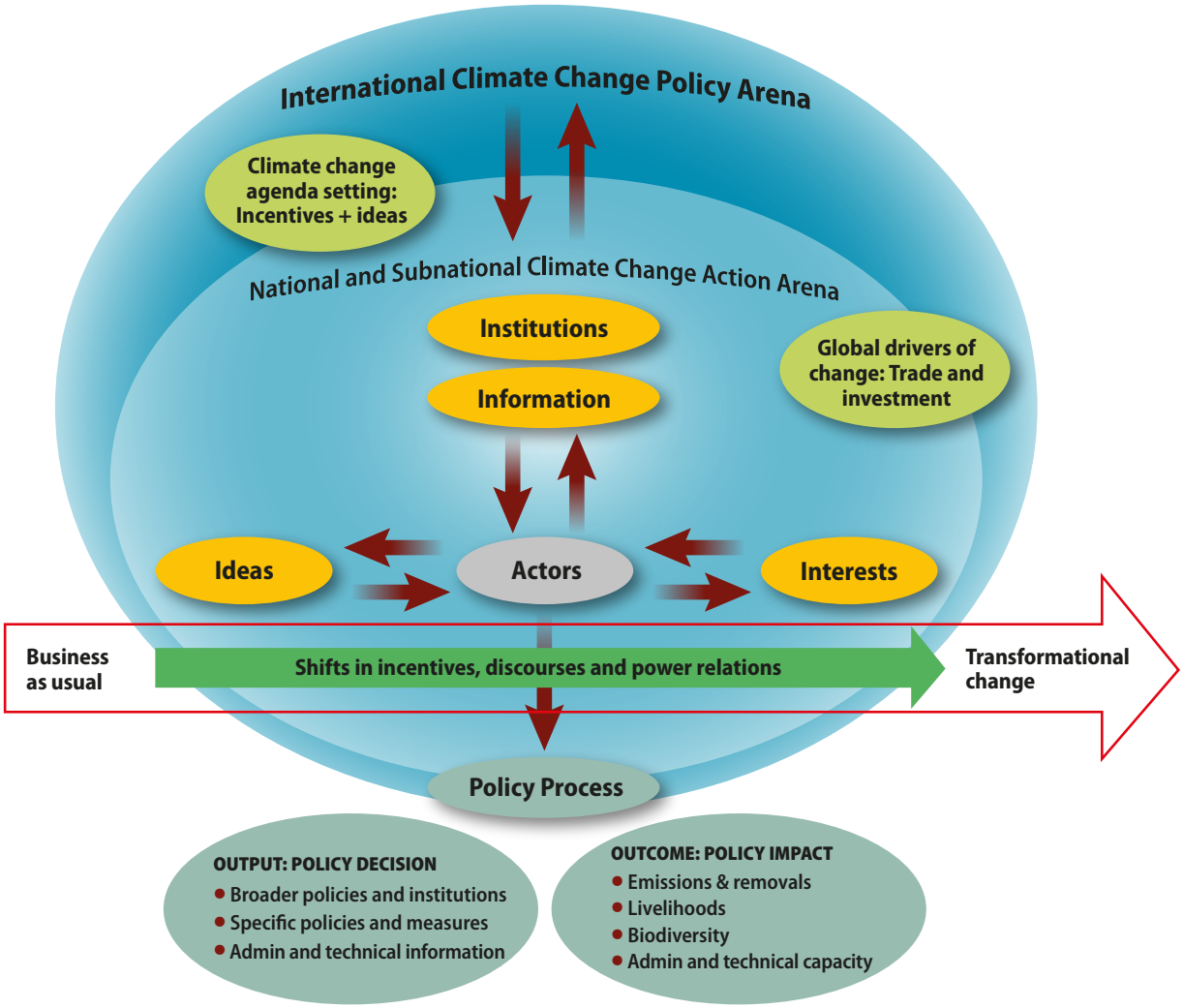


Figure 1. FP5's theory of climate change policy transformation

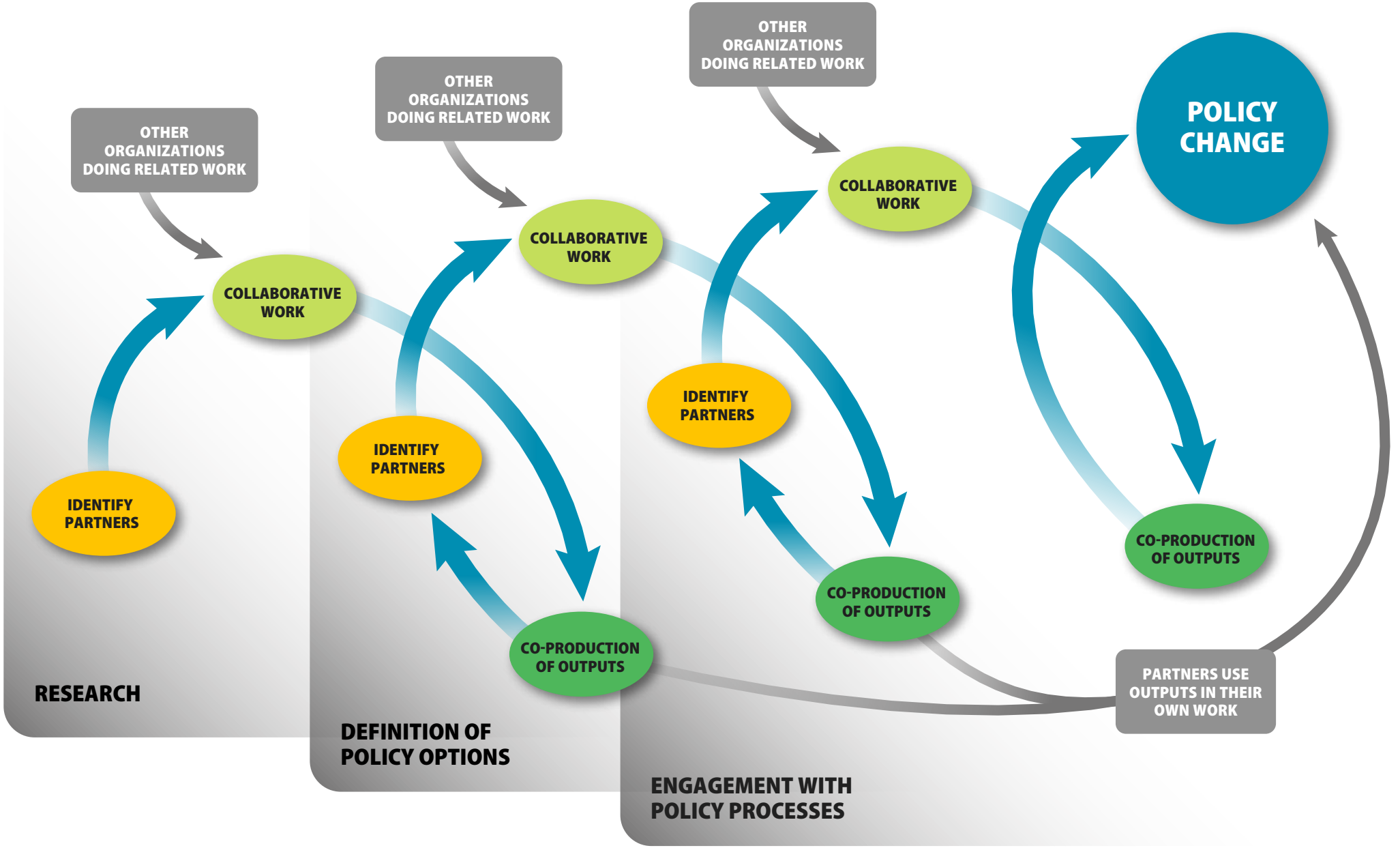


Figure 2. Linking research activities to end-of-program outcomes, policy change and sub-IDOs in FP5 through multiple partner engagement in our co-production of science model (for details on CoAs see section 2.5.6; for details on which sub-IDOs are addressed see Figure 4).

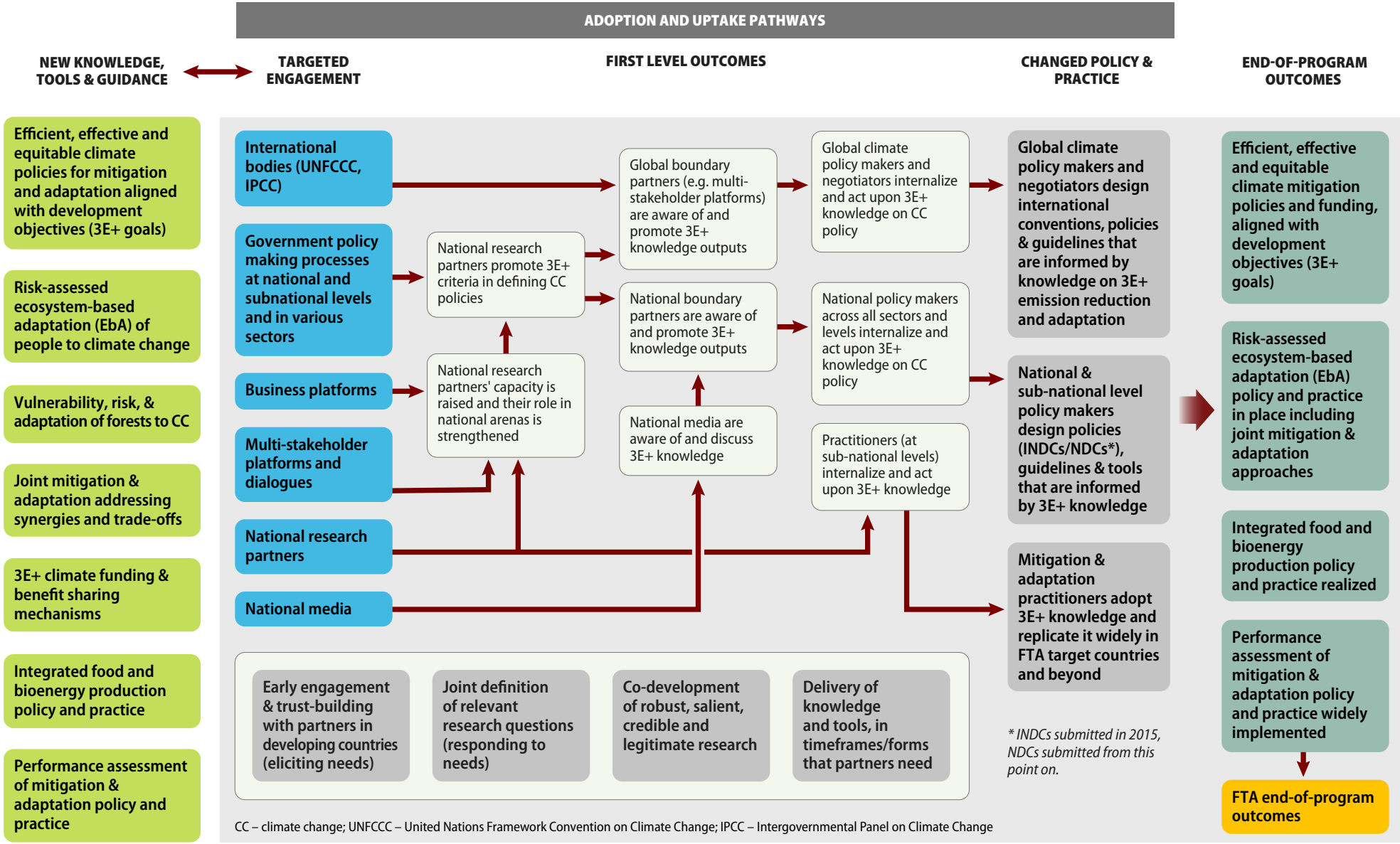


Figure 3. FP5 theory of change

2.5.4 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 3 and 5). We relate this discussion to the topics addressed in the four CoAs (see section 2.5.6).

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[5]. It has created a substantial body of work on the elements of REDD+ (national strategies, baselines and emission factors, MRV and safeguard information, multi-level and multi-sectoral governance challenges, equity, benefit-sharing and livelihood effects) – 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 quickly changing policy environments, together with our effective partner engagement approach based on our 4i approach (Figure 1) explained in section 2.5.3. Paris 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 deforestation driver, on synergies between mitigation and adaptation, and on climate finance/benefit sharing, 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 2.5.3) 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 places 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 woodfuel and charcoal production in Africa, and is now ramping up is 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 be enhanced with a more interactive approach to policy making that acts flexibly upon feedback on policy measures and decision-makers act upon this feedback. 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 on measuring, reporting and verification 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, 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 2.5.7), and through our close partnerships with research partners and policy-makers in developing countries (see section 2.5.3). 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 Ph.D. and M.Sc. 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 *c*. 900 scientific and policy publications to date (February 2016). Our achievements were positively assessed in the CGIAR-required FTA assessment[8] as well as the assessment of our global comparative REDD+ study[9]. Science quality in development is also defined by the accessibility and comprehensibility of science. We make great efforts to translate 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; and
- 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 poor people and forest users.

2.5.5 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[10]: 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 intensify work with CCAFS (see section 2.5.8). Finally, our REDD+ experience enables much accelerated policy learning also 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 (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 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 also, on non-carbon benefits that got greater focus in Paris (see section 2.5.4).
- 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 2.5.3). 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+[12], the interaction between the long-term mitigation and adaptation goals[13] and the recognition that adaptation can contribute to mitigation outcomes[14]. We have long 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 2.5.8).

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 unadaptive premises for climate change policies and practices.

2.5.6 Clusters of activity (CoA)

Following on the research questions from section 2.5.1, 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 done 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 2.5.8), 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) in landscapes (Figure 4).

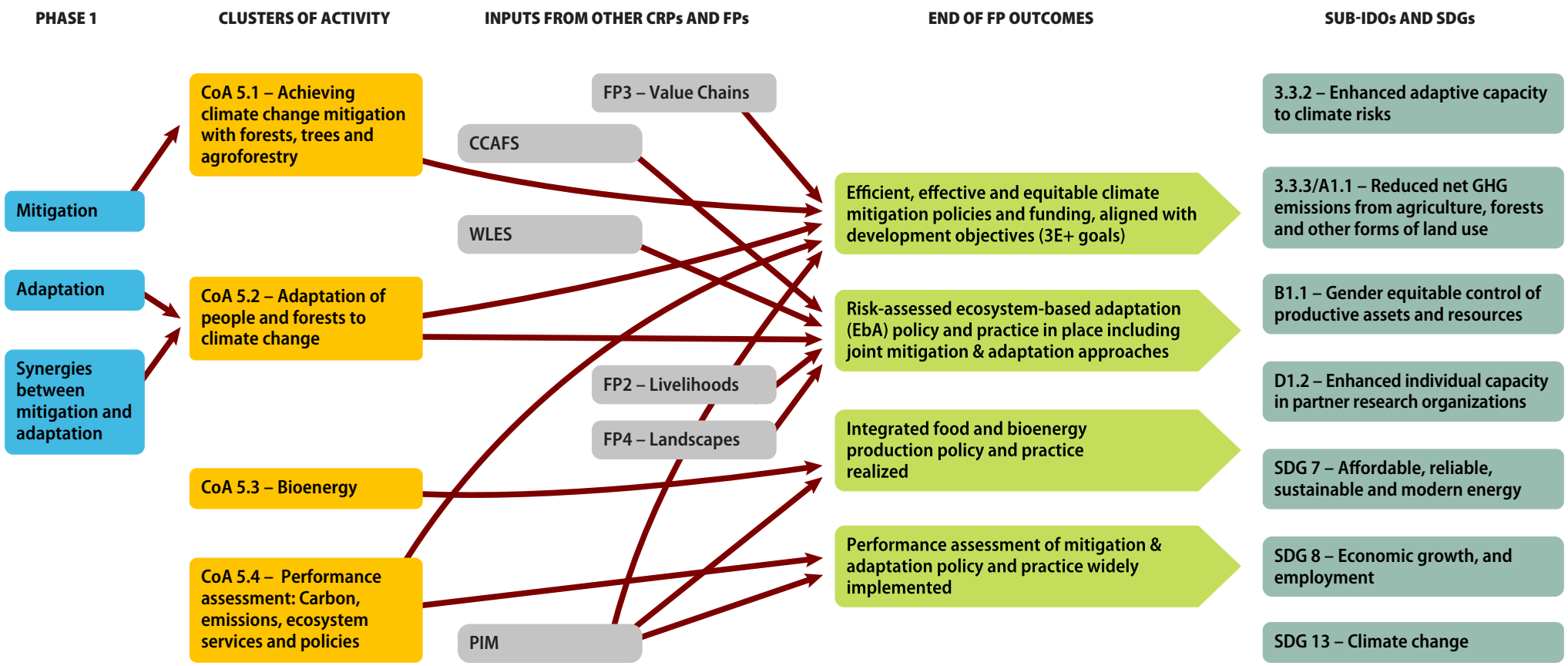


Figure 4. Clusters of activity in FP5 and links to other FPs and CRPs

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); (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 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[e]. These approaches share many elements: they account for GHG emissions and removals; some form of 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, emissions reduction, and sustainable bioproduction in comprehensive national, long-term LED strategies. We anticipate growing demand for capacity development and analysis in support of LED implementation, realistic targets and means of reaching them. CoA 5.1 builds on 8 years of comparative research on mitigation policy and practice (see section 2.5.4) 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). Besides guidance on policy design and architecture, the political economy of enabling policies will be an important focus. Foresight studies on FT&A-based mitigation and adaptation with respect to SDGs and Paris targets will be undertaken.

[e] NAMAS = National Adaptation and Mitigation Actions; SFM = Sustainable Forest Management; JMA = Joint Mitigation and Adaptation

CoA 5.1 addresses sub-IDOs 10.3/A.1, reduced net GHG emissions from agriculture, forests and other forms of land use; and also 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+[f], NAMAs, SFM, 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 multilevel and multisector 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 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. 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 CoA 5.2 we seek to advance knowledge on 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 agro-ecosystems and communities especially those including smallholders; and also 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 **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 contribute analysis to the 'loss and damage' debate.

[f] The complete UNFCCC methodological framework for REDD+ consists of the Warsaw REDD+ Framework adopted in 2013 together with draft decisions at the UNFCCC's 42nd SBSTA meeting in Bonn, June 2015.

- 5.2.3. Identifying options to reduce climate-related risks, analyzing trade-offs, exploring adaptation economics, using and demonstrating ***EbA***, developing adaptive capacity of social groups and exploring the interface to climate-smart agriculture (CSA).
- 5.2.4. Comparison of 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 toolset integrating vulnerability assessments of the socioeconomic and ecological systems to increase resilience outcomes.
- 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; case studies at household/landscape level; 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[15] and achieve the Paris goals[16]. Many governments have renewable energy targets and the Paris goal of balancing sources and sinks requires thorough understanding of the role bioenergy can play. However, globally, the level of government subsidies to fossil fuels remains high[g]. Also, in many regions, biofuels are unsustainable, contribute to climate change and human health problems (e.g. open cooking fires; charcoal production), and face a dilemma for being considered 'backwater technologies' by national actors.

In CoA 5.3 we analyze climate 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 Livelihood (smallholder production), FP34 Value Chains, and FP4 Landscapes (agroforestry production).

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 relative benefits, disadvantages and the extent of their utilization 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 to 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 in national and sub-national level Indonesia.
- 5.3.4. Analysis of the **impact of bioenergy on social and environmental outcomes** (e.g. health, poverty,

[g] In 2013, the International Energy Agency (IEA) estimated that consumer subsidies for fossil fuels amounted to USD548 billion, while subsidies for renewable energy amounted to USD121 billion. https://www.iisd.org/gsi/fossil-fuel-subsidies.

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 world 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, and assessment of how future energy developments may affect the role of biofuels, retaining flexibility to include new developments (e.g. lignocellulosic fuels) and how they may benefit stakeholders.

CoA 5.3 will use bioeconomic 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 we call it 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 safeguard 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[17]. Private-sector pledges also require performance assessments (link to FP3). Data-driven approaches will improve confidence and enable effective and transparent policy implementation. Building on our expertise in performance assessment (see section 2.5.4), this CoA can be expanded into broader performance assessment, e.g. for the SDGs, also supporting 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 Paris Agreement.
- 5.4.3. Measuring **non-carbon benefits** (biodiversity, governance and livelihood outcomes, social equality, and informing the implementation of safeguard 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 datasets.
- 5.4.5. **Develop approaches to cost-efficient, transparent, reliable MMRV:** Linking MMRV for forest- and agriculture-related mitigation should create important synergies for mitigation planning and implementation.
- 5.4.6. Coupled **bioeconomic 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.

2.5.7 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; and 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 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 (ii) they play a key role or have the potential for such a role, and (iii) 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 a potential, to reach key national decision-makers and practitioners effectively. We work with local, national and international partners to support all implementation levels. In the coming years, national implementation (e.g. INDCs) and sub-national action will be key; we will temporarily increase the focus on these levels. But, national and sub-national 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 theory of change, as they ensure local ownership of research and results. We have evidence[18] 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 3). Regarding **outputs**, developing country research partners are central for capacity development and research in our co-production of 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, and they link us to international processes (i.e. IPCC, GFOI, GOFC-GOLD). Networks such as SWAMP[19] (with over 200 partners in 20 countries working on tropical wetlands) or Global Forest Watch[20] (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 sub-national 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 currently expand our partnerships with multi-stakeholder roundtables 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 3. 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 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 outscaling 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 sorganizations → national/subn. research, dissemination, & implementation	Earth Observation Institute; Rights and Resources Initiative; Instituto de Mudanças Climáticas (IMC); Instituto de Pesquisa Ambiental da Amazônia (IPAM) [Amazonian Environmental Res. Inst.]; Society of Indonesian Environmental Journalists (SIEJ); The Nature Conservation (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
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

2.5.8 Climate change

FP5 provides knowledge on how to use FT&A resources for the mitigation of, and the 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 ~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; 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.

2.5.9 Gender

Equality 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 what the gendered impacts are of adaptation policies, projects and interventions. FP5 aims to identify mechanisms to enhance 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, 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, our REDD+ research team has a F:M relation of 2:1 (both by 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.

Heeding the CG focus on youth, 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.

2.5.10 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 with universities into academic training of future developing country leaders; and (iii) producing training materials (e.g. online tools). The long-term impact of our research program on 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 4). We expect direct involvement in 3–40 new Ph.D. studies and 20–30 M.Sc. and B.Sc. studies in the course of this phase.

2.5.11 Intellectual asset and open access management

Intellectual Assets 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;
- 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 specific section on FTA IA Management and Open Access Implementation is available in sections 1.12 and 1.13 of the Full FTA Proposal, including a detailed strategy for IA management in Annex 3.10 and OA/OD implementation in Annex 3.9.

2.5.12 FP management

FP5 will rely on a collaborative management model in which the three lead partners distribute responsibilities and manage the flagship in close collaboration, building on 6 years of a successful partnership (Table 4). The overall coordination of FP5 is 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 currently named people in the table. Teams will meet annually and consult frequently over e-mail and VoIP. The coordinating team (column 2) will meet bi-annually if possible and consult frequently over e-mail and VoIP. This arrangement will be revised every 2 years – or earlier in specific cases, e.g. should one of the leaders leave.

Table 4. 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): will be determined later	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