Working Paper

Agro-biodiversity and CGIAR Tree and Forest Science: Approaches and Examples from Sumatra

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Southeast Asia

World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

Agro-biodiversity and CGIAR tree and forest science: approaches and examples from Sumatra

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The Future Harvest agricultural research centres of the consultative group on international agricultural research (CGIAR) interact with (agro)biodiversity in many, if not all of their priorities and sub priorities. We here focus on the research and development activities targeting forests and trees, and use examples from the Sumatra (Indonesia) benchmark to highlight five current initiatives in partnership with research and development agencies:

- the global DIVERSITAS Agrobiodiversity workplan and our links with the three main domains in the biodiversity/productivity tradeoff that it recognizes,
- the CIFOR-ICRAF Biodiversity Platform that is focused on the conservation + use opportunities in dynamic landscape mosaics,
- the Sustainable Management of Below Ground Biodiversity (BGBD) project.
- the RUPES (Rewarding Upland Poor for the Environmental Services they provide) program in Southeast Asia,
- the CI – ICRAF partnership 'hot spot alliance' to enhance conservation landscapes through agroforestry science and technology,

Agroforests with rubber or coffee as main exotic tree crop, but abundant presence of the indigenous flora and fauna can provide a biodiversity-friendly alternative to the dominant development paradigm that is still based on monocultural plantations.

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1. Introduction – the CGIAR and Millenium Development Goals

The Future Harvest centres supported by the Consultative Group on International Agricultural Research are committed to ending global poverty, contributing to the 2015 targets of the Millenium Development Goals. They also anticipate that further progress will be needed beyond that date, which requires that fundamental questions are addressed now. The Millenium Development Goals can only be reached by reducing both ***rural*** and ***urban*** poverty. Key dimensions of poverty are lack of food (quantity, quality), lack of income to buy food, lack of access to clean water, lack of access to energy, lack of voice in the public and political arena, lack of access to relevant education and lack of respect as a human being. Integrated natural resource management is essential to address all these dimensions of poverty, both for rural and urban poor. Forest use and protection, and forms of agroforestry (using trees on farm and in the landscape) will be an important component of integrated natural resource management reducing various forms of poverty.

Economic growth as provider of employment in urban and non-agricultural sectors has to be the main way out for the next generation of rural people across the tropics. This requires both the provision of affordable high quality food and the provision of clean water and other environmental services. The real and perceived contrasts and tradeoffs between these two aspects of agroecosystems thus need to be resolved. Agricultural intensification has traditionally supported the 'affordable food' part of this relationship, but also caused concern on the environmental service side[1]. 'Domesticated forests' and agroforestry as pathway for a more gradual intensification has the potential to balance the food and water aspects of urban Millenium Development Goals, while also improving rural livelihoods. The CGIAR centres are jointly approaching these targets by partnering with national and international partners across the research-development continuum, with separate centres responsible for annual food crops, livestock, fish, trees and forest, as well as attention for integration at the ago-ecological zone level. We will focus here on the 'tree and forest' part of this agenda.

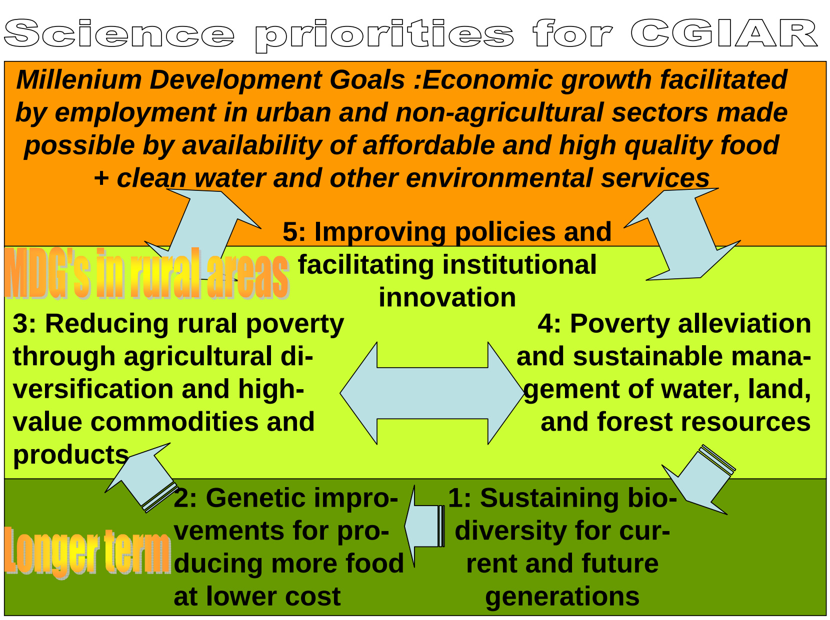


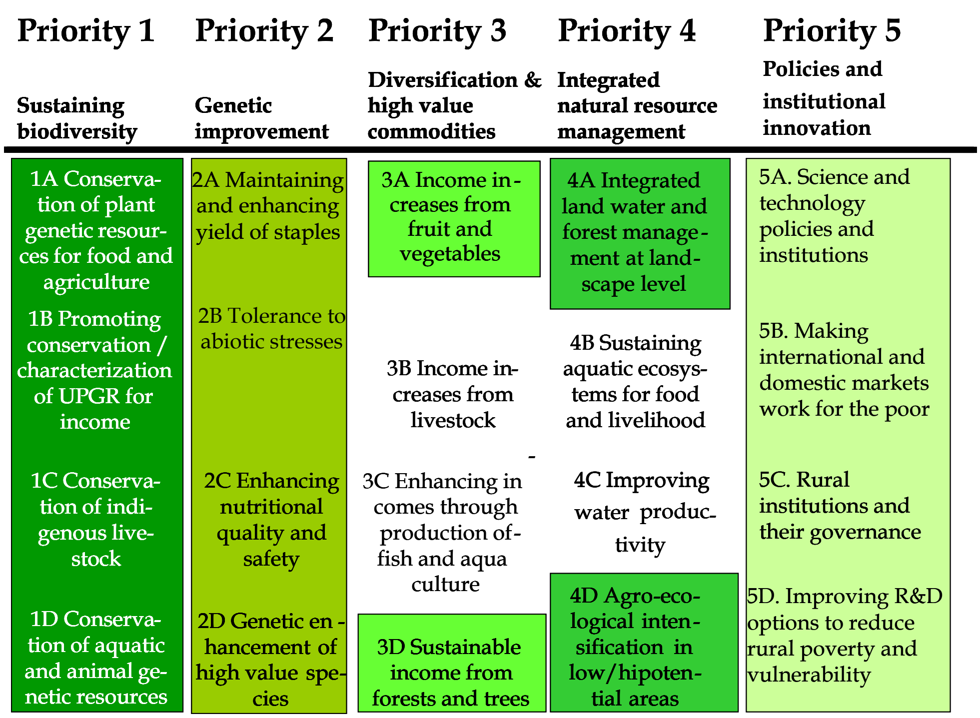
Figure 1. Relationships between the CGIAR priorities and Millenium Development Goals

[1] The alternative development pathway based on imported food while conserving the local environment is only feasible for well-endowed countries with large oil or mineral reserves (or possibly on the basis of a tourism industry) – so for most countries' development the agricultural and forestry sector has to be the basis.

In brief, the 'Future Harvest' research priorities to support Millenium Development Goals are thus to support rural development processes that:

A. (=3) Reduce rural poverty through profitable farms based on agricultural diverse and high value commodities, including products derived from forests and trees,
B. (= 4) Manage the water, land and forest resources in a sustainable way to maintain the provision of environmental services,
C. (= 5) Improve policies and facilitate institutional innovation that balances the short and long term needs of both rural and urban parts of the population.

To support these processes in the long term, a continued investment in plant (and animal) genetic resources is needed to D. (=1) sustain biodiversity and E. (=2) provide crop and tree germplasm and livestock of high quality. Aspects A…E, in a different order are the 5 priority areas adopted by the CGIAR in December 2005.



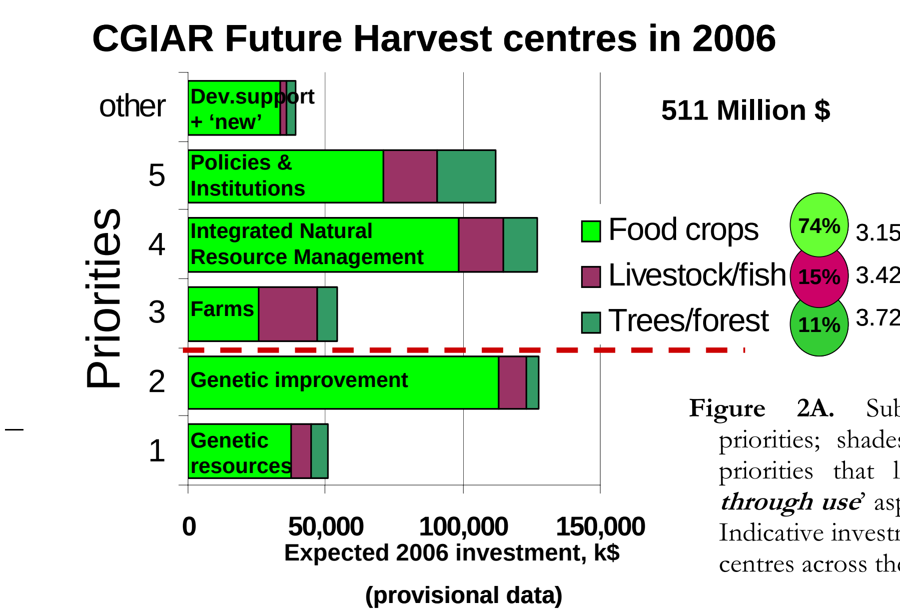


Figure 2A. Sub-priorities within CGIAR priorities; shades of green indicate the sub priorities that link with the '***conservation through use***' aspects of (agro) biodiversity; **B.** Indicative investment of the combined CGIAR centres across the 5 priorities in 2006

Table 1. Indicative investment of the 15 ‘Future Harvest’ CGIAR centres across the 5 priorities in 2006

	Food crops	Livestock/ fish	Trees/ forest
Share of total cgiar investment	*0.74*	*0.15*	*0.11*
1. Sustaining biodiversity for current and future generations	0.10	0.10	0.11
2. Producing more and better food at lower cost through genetic improvements	**0.30**	0.13	0.08
3. Reducing rural poverty though agricultural diversification and emerging opportunities for high value commodities and products	0.07	**0.27**	0.13
4. Promoting poverty alleviation and sustainable management of water, land and forest resources	0.26	0.21	0.23
5. Improving policies and facilitating institutional innovation to support sustainable reduction of poverty and hunger	0.19	0.26	**0.38**
Other -- incl. development support	0.09	0.03	0.06
Total	*1.00*	*1.00*	*1.00*

With 74% of the CGIAR resources attributable to annual food crops, 15% to livestock and fish and 11% to forest and trees, the original signature of the CGIAR is still largely intact. In terms of research topics, however, a substantial shift has occurred over the years from a focus on genetic improvement to a more balanced approach to agricultural systems in their policy and institutional context. The relative allocation of effort across the food crops/ livestock + fish / and forest + tree categories shows some interesting patterns: genetic improvement is 30% of the food crop portfolio, but only 8-13% for the other categories; enhancing farm income is 27% of the livestock + fish portfolio and 0nly 7-13% of the two others, while improving policies and facilitating institutional innovation is the particular focus (38%) in the tree + forest area, but still 19-26% of the two others.

In line with the overall emphasis on annual food crops, the interface between CGIAR science and ‘biodiversity’ is largely focussed on ‘***agrobiodiversity’***. rather than ‘wild biodiversity’ . During the 8th Conference of the Parties (COP 8) of the UN Convention on Biological Diversity in Curitiba, Brazil (March – 30 March 2006), IPGRI announced on behalf of the Future Harvest Centres that a Platform for Agricultural Biodiversity Research has been formed (in line with COP7 in Resolution VII/3.) The Platform is being established in association FAO, Civil Society Organizations and other stakeholders. With the support of the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) of France, a small secretariat has been constituted in Nairobi to oversee the full establishment and operationalization of the platform. In response to a request from COP7, IPGRI and FAO have been working together with the CBD Secretariat to develop a proposal for a cross-cutting initiative on biodiversity for food and nutrition. This global initiative will examine and promote the use of biodiversity to address a major symptom—and cause—of poverty, namely malnutrition. The initiative will complement existing efforts to combat malnutrition by marshalling local agricultural biodiversity to counter the twin burdens of micronutrient deficiency in poor countries and the epidemic of the so-called diseases of affluence—obesity, heart disease, diabetes and cancer—associate with the oversimplification of diets. This proposed initiative to use a broader range of biodiversity for better nutrition also directly contributes to biodiversity conservation.

Within the CGIAR approaches on Integrated Natural Resource Management (iNRM) have developed from a ‘top down management’ approach with ‘decision support’ for the line managers, to a multi-agent, multi-scale learning cycles approach (Sayer and Campbell, 2004; Swift et al. 2004; van Noordwijk et al., 2001; van Noordwijk, 2005), where ‘negotiation support’ for the various actors is the main role for well-willing external agents such as researchers or development supporters.

Of specific relevance in the Environment * Poverty nexus is the ‘***policy-induced poverty***’ that derives from restricted access to lands in the expectation that upland land use is necessarily in conflict with the interests of downstream society. In terms of quantifiable watershed functions compatible land uses for uplands can be found that, if adopted will be profitable and poverty reducing. However, these land uses will not be a full substitute for forest protection from a biodiversity perspective, making the differential thresholds of soil quality necessary for watershed functions and of aboveground

vegetation for biodiversity conservation a target of studies supporting policy reform. However, large tracts of 'forest' land are excluded from use without either compelling biodiversity conservation or watershed protection reasons, maintaining rural poverty. Sorting out 'myth' from 'reality' is a potentially important contribution iNRM science can make – as long as it can be communicated in non-threatening ways.

The two primary concepts in iNRM for the relationship between 'agriculture' and 'wild biodiversity' are one that is based on ***spatial segregation*** (and with a direct tradeoff between the land area used for 'agriculture' and that for 'conservation'), and that based on ***functional integration*** (with the tradeoff between objectives at the more immediate farm management scale). In principle, the choice between these two pathways that meets the various objectives best depends on the shape of the trade-off curve between the 'productivity' and 'biodiversity' function. For convex curves segregation is the best approach, for concave ones integration is a realistic option (van Noordwijk et al., 1995; Van Noordwijk et al. 2004a; Green et al., 2005; Swift et al., 2004).

In the rest of this overview of how CGIAR science interacts with agrobiodiversity, we will focus on a part of the forest + tree agenda that may more directly relate to the USAID Biodiversity Code, with its focus on 'wild' biodiversity, and highlight five current initiatives in which the World Agroforestry Centre and its various partners are involved:

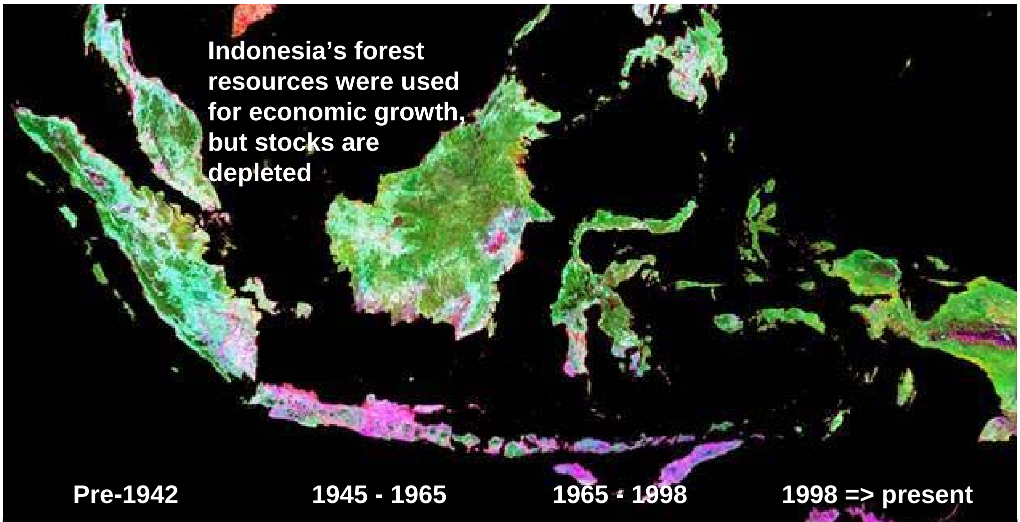
- the global DIVERSITAS Agrobiodiversity workplan and our links with the three main domains that it recognizes,
- the CIFOR-ICRAF Biodiversity Platform that is focused on dynamic landscape mosaics, efforts to get 'Belowground Biodiversity' recognized, managed, used and conserved
- the RUPES (Rewarding Upland Poor for the Environmental Services they provide) program in Southeast Asia,
- the CI – ICRAF 'Hot Spot' alliance.

These 5 initiatives will be illustrated by examples from ongoing work in Sumatra (Indonesia).

2. Sumatra as microcosm of the biodiversity – productivity tradeoff

Sumatra is a recognized hot-spot of global biodiversity, as part of the Sundaland domain, with high bird, plant and mammal diversity. The combination of forest exploitation, conversion of lands for commercial plantations, government-sponsored and spontaneous migration of rural and urban poor from Java, conflicts over land and the use of fire as both tool and weapon has led to a dramatic loss of forest cover. The current land cover has only a weak relationship with the 'forest zone' maps, as is evident from http://www.dephut.go.id/informasi/buku2/rekalkulasi05

The relationship, or presumed relationship, between 'agricultural intensification' and 'forest protection' has been the focus of the 'Alternatives to Slash and Burn' (ASB) systemwide program of the CGIAR, with Sumatra as one of the global benchmarks (Tomich *et al*., 2004). The agroforests of Sumatra represent a stage in the domestication of forests (Michon, 2005) and intensification of land use where the tradeoff is imminent between increased returns to labour and land of more intensively managed systems and the loss of environmental values due to such intensification (Joshi *et al*., 2003; Schoth *et al*., 2004; Tomich *et al*., 1998).



Pre-1942	1945 - 1965	1965 - 1998	1998 => present
Colonial Forest Ser-vice tries to get control over all forest lands but fails to get a ***legal basis*** for this.	**'Merdeka'**, natural re-sources are for the Indonesian people… Chaotic period. 1960 Agrarian Law gives ***legal basis*** for land ownership.	'**New Order**' regime claims all forests for the state, controlled and used by ***natio-nal elite***; local pro-tests are interpreted as 'communist'	'**Reformation**' period implements decentra-lization; initial exces-ses of local elite cap-ture; illegal logging issue prominent; legal basis of state's forest claim still weak…

Figure 3. Overview of Indonesia's land cover and 4 periods in recent history

Agricultural intensification has been found to indicate ***necessary*** but ***not sufficient*** conditions for forest protection (Angelsen and Kaimowitz 2000, 2001; Tomich *et al.*, 2001, 2005). The associated 'Pandora's Box' problem (Tomich *et al.*, 2005) refers to the likelihood that profitable intensive land use practices at the forest margin as alternative to less intensive and less profitable ones will attract migration flows in an open market for labour and land. Sumatra, adjacent to the smaller but densely populated Java, has become a study ground for the relationships at multiple spatial and temporal scales of the productivity – (forest) biodiversity relationship, as the general gradient of

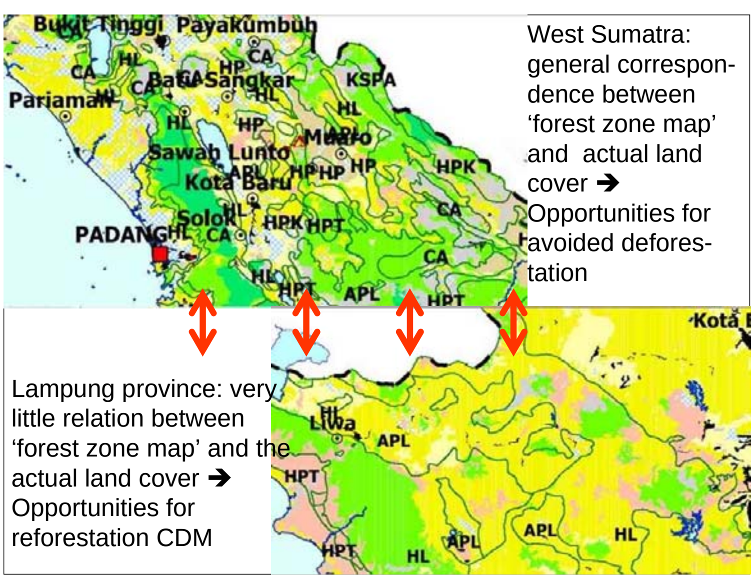


Figure 4. Contrasts in the way the governments forest classification matches land cover in West Sumatra and is unrelated in Lampung

population density from Lampung in the south towards the centre in Jambi reflects the stepwise migration strategies of families displaced or voluntarily moving away from Java, into a land of mixed opportunities: fertile soils and opportunities for coffee cultivation in the mountains that are considered to be 'protection forests', and poorer soils in the lowland peneplain or swamp zone where resettlement has been officially promoted.

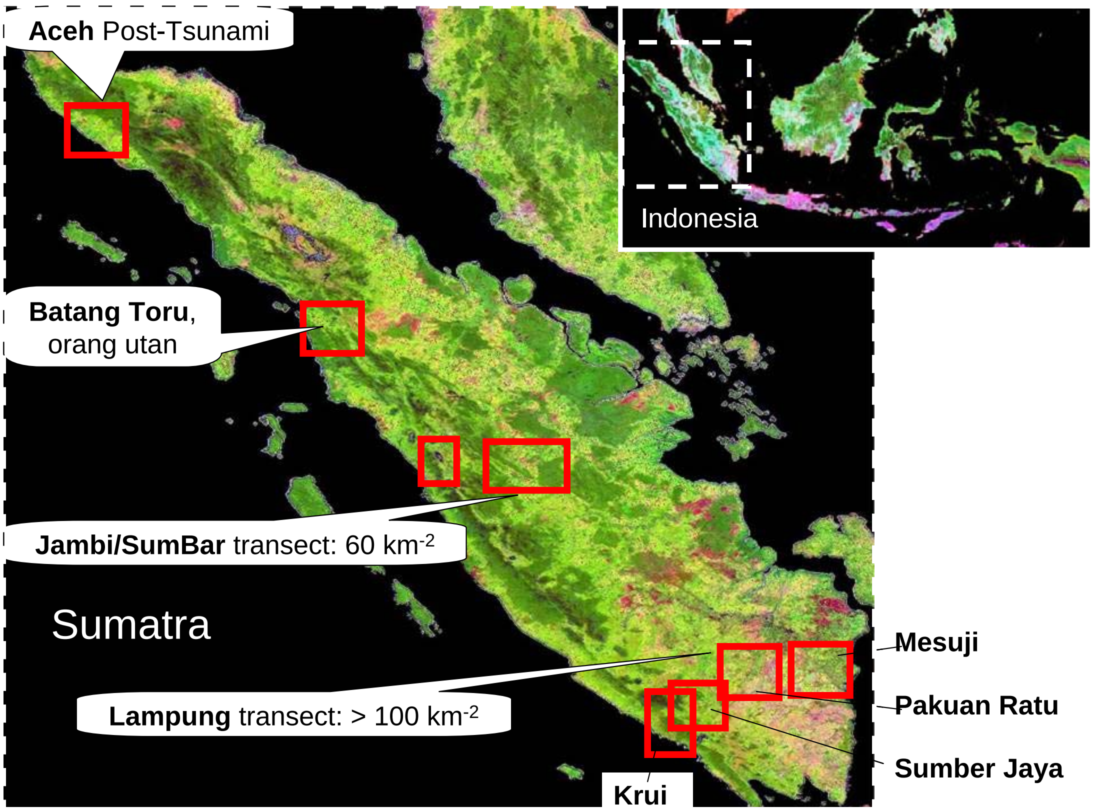


Figure 5. Sumatra land cover and benchmark sites of ASB and ICRAF

landscape in Batang Toru, and in the coastal zone of Aceh, where the Tsunami recovery represents a very dynamic phase in land use dynamics in a rubber-dominated livelihood system.

3. DIVERSITAS Agrobiodiversity

DIVERSITAS, the International Programme of Biodiversity Science, is one of the four international research organizations in the Global Earth Partnership, along with the International Geosphere-Biosphere Programme (IGBP), the World Climate Research Program (WCRP) and the International Human Dimensions Programme (IHDP). These organizations provide global connectivity on aspects of 'Earth Science' and are closely associated with the Millenium Ecosystem Assessment.

Within Diversitas, the cross-cutting program on Agrobiodiversity (Jackson *et al.*, 2005) relates to the three primary foci:

- Determining the factors that increase biodiversity in agricultural landscapes and anticipating the impacts of social and environmental change (bioDISCOVERY)
- Using biodiversity in agricultural landscapes to enhance ecosystem goods and services (ecoSERVICES)

- Ensuring that society supports the use of biodiversity for sustainable agriculture and equitable sharing of the benefits of conservation of agrobiodiversity (bioSUSTAINABILITY

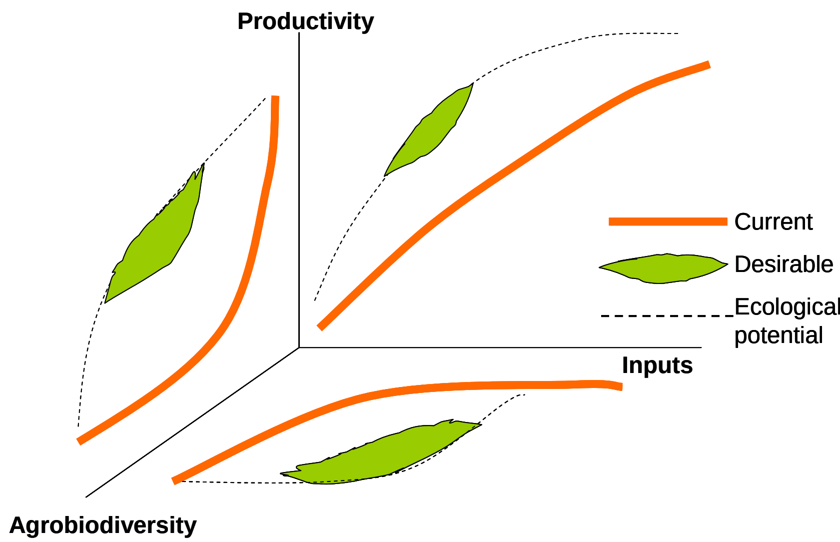


Figure 6. Three-dimensional representation of the relationships between inputs, productivity and agrobiodiversity, with current 'baselines' in red, the ecological potential in a dotted line and the socially desirable domain in green

While much of the conventional attention to increases in agricultural productivity has been focused on the dosage-response curve and the (lack of) financial profitability of input use for smallholder farmers, the position of the response curve can be substantially varied by the overall condition of the soil, the health of the agro-ecosystem, and the services provided by agrobiodiversity (Figure 6). For agroecosystems experiencing transitions toward agricultural intensification, the red line demonstrates the current status or baseline situation. That is, productivity is highly dependent on synthetic or off-farm inputs (quadrant I), agrobiodiversity is either too low or not efficiently marshaled to increase productivity (quadrant II), and agrobiodiversity is reduced by the inputs that ensure high productivity (quadrant III). Shifts from these low-efficiency (red) baselines towards the ecological potential should target the green domain in each quadrant.

For quadrant I (Figure 6), increasing the efficiency of inputs by reducing losses and optimizing applications to fit spatial and temporal demands will produce a concave relationship between productivity and inputs. The negative effect of chemical inputs on agrobiodiversity (above and belowground) is widely acknowledged, and the equivalent red and black lines in quadrant III indicate the targets for the use of inputs with low eco-toxicological effects, to support the green target. Finally, these relations are reflected in quadrant II in the relationship between agrobiodiversity and productivity. The current baseline here is a strongly convex curve where most biodiversity is lost in early efforts to enhance productivity, with relatively small further losses in intensification (but potentially a substantial 'substitution' effect where biological functions such as Biological Nitrogen Fixation have to be replaced by industrially fixed nitrogen). To achieve the 'dotted line' of ecological potential of biodiversity-friendly agriculture, with the target domain in green, as in the other two quadrants, agrobiodiversity must increase ecosystem functioning. This is most likely to be achieved when a unique or complementary effect is added to an ecosystem, e.g., by planting genotypes with specific genes for higher yield or pest resistance, mixing specific genotypes of crops, using cover crops or intercropping, supporting more parasitoids or insect enemies with specific roles in controlling pests, or including a plant functional group, such as a legume, that increases nitrogen inputs and

cycling. Simply adding more species is less likely to enhance ecosystem functions and services (Swift et al., 2004). Please note that these quadrants represent 'co-variation', not unidirectional 'causation'.

If we have a closer look at this quadrant that represents the relationship between biodiversity and agricultural productivity (Fig. 7), we can identify four relative positions of agricultural systems

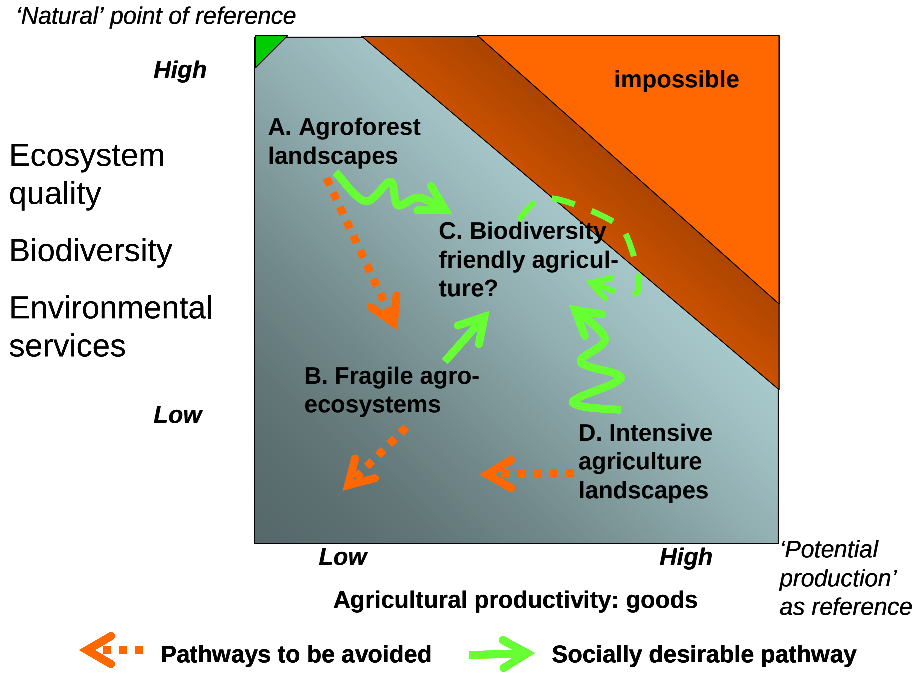


Figure 7. Relationship between agricultural productivity ('goods') and ecosystem quality as a basis for continued supply of 'services', with four broad domains for current agro-ecosystems (A…D), the red trajectories to be avoided and the socially desirable pathways in green

(please note that the endpoint of each axis is the potential maximum productivity or biodiversity in each landscape):

A. High biodiversity, low productivity, as in the 'agroforest landscapes' of the humid tropics

B. Low biodiversity, low productivity, as in many fragile agroecosystems under the impact of 'land degradation'

C. High biodiversity, high productivity – an impossible dream scenario, but approachable in biodiversity-friendly agriculture

D. Low biodiversity, high productivity, as found in intensively managed agricultural landscapes that (so far) have avoided thresholds of critical environmental degradation where the relatively low levels of agrobiodiversity may be highly appreciated by society….

Instead of 'productivity' we may want to look at 'profitability', as the primary goal for farmers' land management. Where 'quality' or 'price per unit product' declines with the approximation of the productivity maximum, it may be easier to approximate the upper right corner for 'profitability' than it is on a 'productivity' axis. Measures of profitability should include the value that is added by ecolabels, payments for environmental services, and other rewards that may foster biodiversity-friendly farming.

A series of hypotheses has been formulated by the DIVERSITAS agroBIODIVERSITY network as research foci that will require integrative approaches between biophysical and socioeconomic sciences:

I. Currently dominant pathways of agricultural intensification have negative effects on ecosystem conditions and environmental services

II. Alternative, biodiversity-friendly options can be derived from traditional management practices and 'unpacked' modern technology to provide environmental services, including increased agricultural productivity

III. Adoption of such biodiversity-friendly pathways has benefits at local community as well as external scales

IV. Recognition, rewards and payments are appropriate mechanisms for providing positive incentives for the adoption of biodiversity-friendly pathways

The ASB-Jambi benchmark area in Sumatra with its highly diverse rubber agroforests (Murdiyarso *et al.*, 2002; Tomich *et al.*, 2005; Joshi *et al.* 2003, 2005) provides one of the primary examples of the 'green' target in reality. It represents domain A. Opportunities for enhancement of productivity (or at least profitability) while maintaining (close to) current levels of biodiversity can be generally indicated as 'clonal rubber polyculture' (Fig. 8).

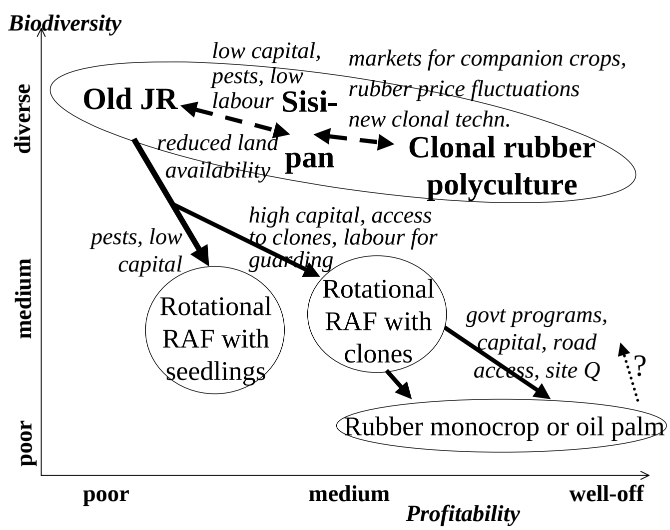


Figure 8. Possible intensification pathways for jungle rubber agroforests, dependent upon various criteria and conditions (italics) which dictate farmers' management decisions. Resulting land use systems are classified in terms of their biodiversity and profitability. JR=Jungle rubber; sisipan=gap rejuvenation; RAF=Rubber agroforest; Q=quality.

The relative position of the various land use options in Jambi requires assessment of both a productivity/profitability and a biodiversity axis. The first can be suitably expressed on a per ha basis, the latter is implicitly dependent on the broader landscape context. In that regard the tradeoff between carbon stocks and profitability is much easier to assess (Tomich et al., 2002). Earlier appraisals of biodiversity at plot scale (Gillison and Liswanti, 2004; Murdiyarso et al., 2002) have now been confirmed at landscape scale ((Beukema and Van Noordwijk, 2004; Rasnovi, PhD thesis forthcoming), with the rubber agroforests requiring about twice the area of natural forest to achieve the same fern or tree sapling richness. As the profitability (on an area basis) is substantially more than twice as high, the basic criterion for 'concave' relationship is met. However, intensification of agroforest management with ensuing reduction of biodiversity may still be attractive for the farmers with limited access to land.

Our research has highlighted that there are essentially two management styles: one based on the rotations that are common in the plantation world, where clear-felling and replanting maintain productivity, and one based on 'interplanting' ('sisipan' in Bahasa Indonesia) where a tree or gap level replacement maintains productivity in mixed-age and mixed-species stands.

The slash-and-burn pathway is the only choice if farmers want to grow a first season's rice crop (Ketterings et al., 1999). Until recently the general perspective was that such clear-felling was also the only way to benefit from the genetic advance in clonal rubber selection - with a 2 – 3 fold increase in production-per-tree possible under limited management intensity (Williams et al., 2001). The opportunities for introducing high yielding clonally propagated rubber and selected fruit and timber trees in the gap-regeneration system, however, may have been underestimated (Wibawa et al., 2005). The opportunities for introducing high yielding clonally propagated rubber and selected fruit and timber trees into existing agroforests probably offer the best opportunity to achieve biodiversity-friendly, productive mixed garden systems.

Because Jambi (and other parts of Sumatra) had river-based economies and transport systems in the early part of the 20'th century when rubber (*Hevea brasiliensis*) became the mainstay of local livelihood strategies, the oldest rubber gardens are close to the river. With the shift to a road-based economy in the 1970's, the landscape has been substantially re-organized with much of the current development focus in the interfluve positions that previously supported the remaining natural forests. As a consequence, the riparian rubber agroforests now offer a major opportunity to conserve biodiversity at landscape scale, as they are extensively used, provide connectivity and as little untouched natural forest remains. While there are a number of protected areas in Jambi (including three national parks: Kerinci Seblat, Bukit Tigapuluh, Bukit Duabelas) and innovative 'conservation concessions (operated by Birdlife International), the 'matrix' in between provided by rubber agroforests is probably of substantial conservation value.

4. Belowground biodiversity

The belowground aspects of biodiversity have recently received recognition in the Convention on Biological Diversity (CBD). A global project on 'sustainable management of belowground biodiversity' coordinated by the Tropical Soil Biology and Fertility program of CIAT, links teams in 7 tropical countries.

The relationship between soil biota and the maintenance of rainfall infiltration capacity is probably the most obvious link to an 'environmental service' that tends to get in short supply under intensification. Slash and burn land clearing as such does not have dramatically negative effects on soil biota or hydrological functions (van Noordwijk et al. 1998; Ketterings et al., 2002; Malmer et al., 2005), but repeated burns and an absence of organic inputs does. The abundance of top-level predators in the belowground + litter layer food webs across a forest – grassland continuum in Sumatra seem to be directly linked to the annual input of litter (Susilo et al., 2004).

Evidence so far indicates that belowground biodiversity is more resilient than aboveground manifestations of biodiversity, but that there are thresholds that have to get serious attention, as soil degradation is poorly reversible once the domain of resilience is trespassed. Where land use affects the replacement of an indigenous flora and fauna by exotic invasives, such thresholds may well be crossed in de facto irreversible ways. Current research in the coffee agroforestry landscape of Sumber Jaya (Lampung, Sumatra) provides insights into reversible litter-based effects, and probably irreversible biotic effects, as the native earthworm fauna (endogeic) of the forests (larger size *Methaphire spp*) becomes replaced by invasive exotics (smaller *Pontoscolex spp*) in the coffee monocultures, with multistrata coffee gardens as a transition zone.(Hairiah *et al*., 2006 and work in progress).

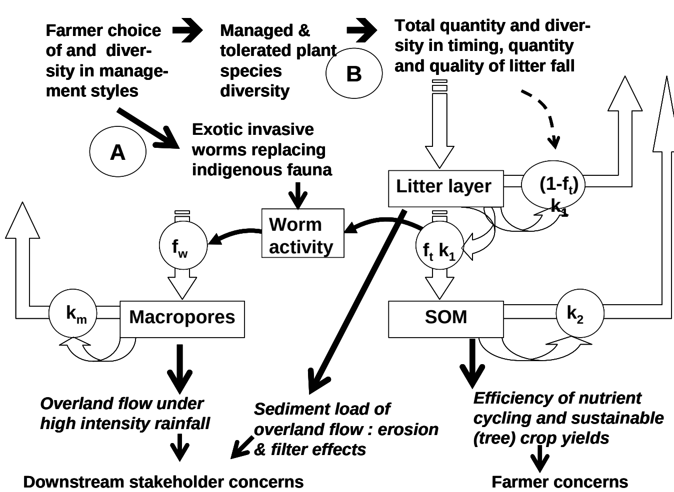


Figure 9. Conceptual scheme of the relationships in coffee gardens of various levels of structure ('multistrata' or 'simple') and plant diversity and the watershed functions that are a concern of downstream stakeholders; ongoing research in Sumber Jaya tries to distinguish between the 'biotic' and 'resource-based' pathways between farmer land management and environmental effects

5. CIFOR-ICRAF Biodiversity platform: 'Matrix Matters'

Following up on recommendations made by an external review panel, CIFOR and ICRAF have initiated a joint 'biodiversity platform' where landscape scale research across the forest – agriculture spectrum will be coordinated. The approach is a truly interdisciplinary one, as we recognize that communication gaps between three domains of knowledge (local ecological knowledge, the public/policy ecological knowledge of the public domain and the various disciplinary takes on scientific knowledge of ecological processes and patterns) need to be recognized before they can be addressed and overcome (Fig. 10).

A key hypothesis for the platform is that the 'appreciation' of the environmental services provided by 'intermediate intensity' land uses such as agroforests depends on the overall character of the landscape and will increase with decreasing forest cover (Fig. 11). We hypothesize that the 'external' value for globally important biodiversity may well exceed the local appreciation when there is still some 'natural' forest in the landscape. With a further decrease in forest cover, the local appreciation of the intermediate intensity landscape elements is likely to increase, while the external value is bound to decrease (a matrix without gemstones to connect…). There thus appears to be justification for external involvement in a mixed landscape to provide conservation incentives, anticipating the increase in local appreciation of these elements of the landscape.

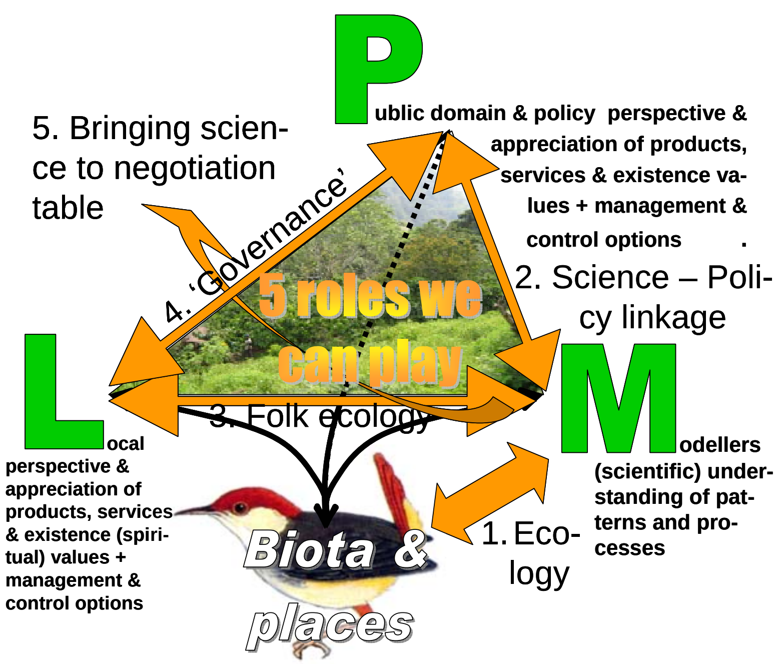


Figure 10. Three domains of knowledge and five possible roles for 'scientists' in enhancing the emergence of biodiversity-friendly productive landscapes in the interaction between local and policy-level stakeholders

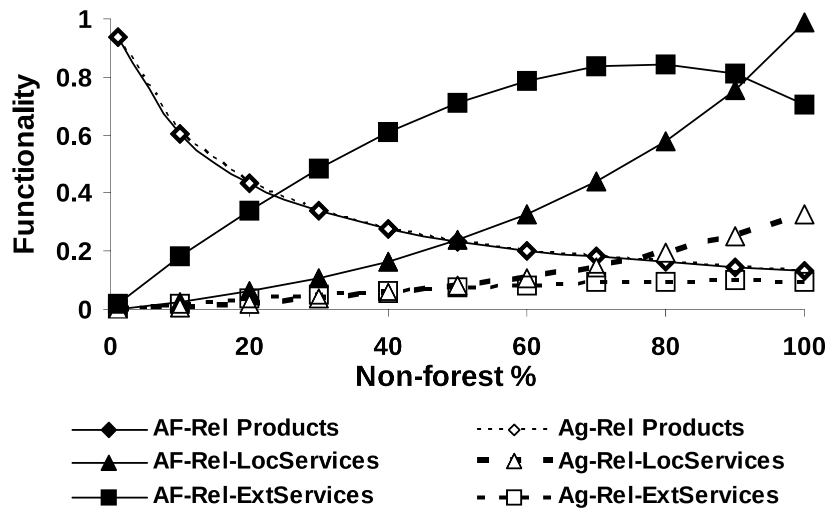


Figure 11. Hypothesis of the way the productivity, local service contribution and external service (biodiversity) contribution of agroforestry (AF) and agriculture (Ag) may depend on the degree of non-forest cover; assumptions: product flows 10, 50 an 100 units per ha for forest, AF and Ag, respectively; local service value 100, 60 and 20, respectively with a 'scarcity' factor of 1.25; biodiversity intercept 0.05 and power 1.5, with relative area contributions of 1, 0.5 and 0.05, respectively.

6. RUPES

The RUPES (Rewarding Upland Poor for the Environmental Services they provide) program in Southeast Asia (Van Noordwijk et al., 2004, 2005), explores the various emerging mechanisms across the spectrum of 'rewards' and 'payments' for environmental services (Fig. 12). The approach expands beyond the 'payments for environmental services' approach tried elsewhere (Ferraro and Simpson, 2005; Landell-Mills and Porras, 2002; Wunder, 2005) by including a broader array of 'reward' mechanisms,

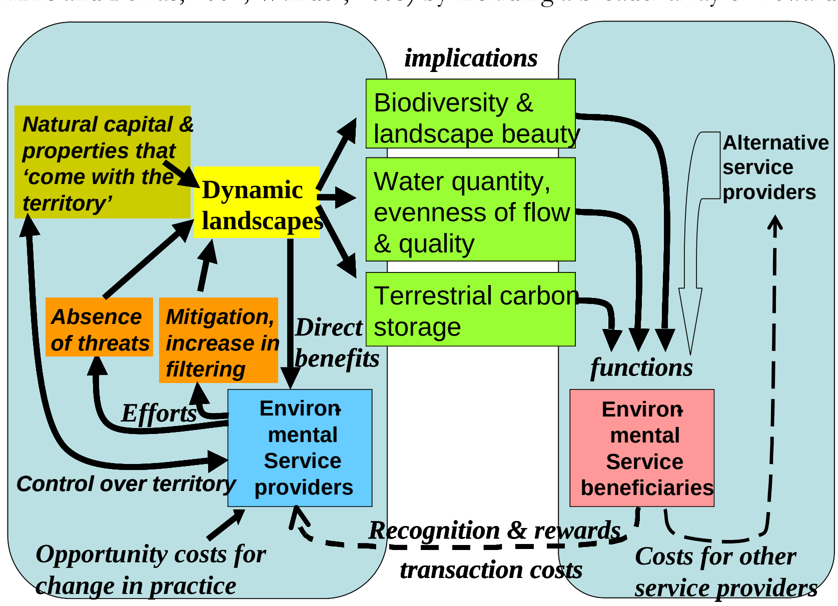


Figure 12. Linkage of two 'subsystems' with their respective drivers in mechanisms that provide recognition and rewards for biodiversity (and other environmental service)-friendly land use practices in the uplands

Four stages in developing ES reward mechanisms

	Stage	Providers, sellers of ES	Interme-diaries	Beneficies, buyers of ES
I	Scoping	↔	Rapid As-sessment of Marketable ES	↔
II	Identifying partners		↔	
III	Negotia-tions		↔	
IV	Monitoring agreement			

Figure 13. Four steps in the development of sustainable reward mechanisms for environmental services that are based on ‘real ES value’, ‘conditional and transparent rewards’, ‘manageable threat levels and opportunity costs’ and ‘guarded trust’ between upstream and downstream stakeholders; rapid assessment approaches are available for ‘scoping’

including the provisioning of conditional security of tenure for ‘stewardship’. One of the main lessons of the RUPES program is that among the four ‘environmental service’ categories of interest (biodiversity conservation, watershed functions, carbon storage and landscape beauty), the more local value of watershed function has so far translated into more direct concerns and potential for tangible benefits for upland poor than the global functions of carbon storage and biodiversity conservation. Avoiding losses in still environmentally benign landscapes (domain A of figure 7) is institutionally more complex than efforts to rehabilitate landscapes that have suffered from a degradation phase – as ‘win-win’ situations are more feasible after a substantive ‘lose-lose’ trajectory (domain C of figure 7). Avoiding losses is only credible if it involves large areas, as the risk of ‘leakage’ by lateral transfer of ecological pressures is real. Ironically, the largest financial transfers for environmental services ion agriculturally used landscapes currently occur in the domain D of figure 7, where these services may be the lowest in absolute terms (but where industrialized societies can afford to pay and seek politically acceptable ways to maintain an agricultural sector).

In both ‘human welfare’ and ‘ecosystem’ discussions we can recognize a ‘stock’ and a ‘flow’ approach: the dominant poverty criterion of the Millenium Development Goals is income (and thus flow) based, rather than emphasizing access to assets (stock); the focus on ‘environ-mental services’ (‘flows’) provides a utilitarian justification for maintaining ecosystem integrity that ultimately depends on conserving natural capital (‘stock’).

Among the RUPES test sites the Bungo site in the rubber agroforest landscape of Jambi tries to get recognition for the landscape connectivity of riparian + park-adjacent rubber agroforest. One of its challenges for the ‘pro-poor’ target is to address the concerns and interests of the ‘share-tappers’ whose interests differ from those of owner-tappers.

The Sumber Jaya test site is pioneering with forms of ‘community based forest management’[in a formal ‘protection forest zone’, that allow coffee farms to gradually evolve into multistrata systems. Ongoing impact study under the BASIS-CRSP project provides rich quantitative details on effectiveness and distributional effects.

7. Hotspot alliance

Through the Biodiversity Hotspots Alliance, Conservation International (CI) and ICRAF have recently joined forces to enhance the integration of livelihoods and biodiversity conservation through the science and practice of agroforestry. The alliance will foster innovations in balancing livelihood needs with biodiversity conservation. CI and ICRAF are currently engaged in a project on conservation of orang-utan and development/strengthening of sustainable agroforestry land use alternatives in Batang Toru in Northern Sumatra. The Hotspot Alliance initiative will help deliver agroforestry innovations to enhance conservation of orang-utan habitats while generating livelihood benefits for smallholder farmers. Research will foster critical learning for landscape conservation strategies more generally and help to draw attention on environmental (biodiversity) services from agroforestry systems that enhance connectivity and stabilize populations in forest remnants).

Figure 14. Landscape context of the Batang Toru area where CI and ICRAF are engaged with local stakeholders in seeking effective conservation + use of the area that harbours the southernmost population of the critically endangered Sumatran Orangutan

8. Discussion - synergies between networks and international public goods

Within the CGIAR there is current debate on the optimum positioning along the research-development continuum (Table 2), so as to meet the expectations on the generation of 'international public goods' as well as the more immediate 'development impact' that the national governments and international donor community wants to achieve as part of the 'Millenium Development Goals'. The only way for CGIAR centres to avoid being pulled apart between these two forces, is to be strategic in its partnerships. The examples provided here for Sumatra may show the value of a long-term commitment to 'benchmark' areas that have a recognizable 'domain of similarity' for wider application, while they harbour significant contrast that facilitate hypothesis testing at both pattern and process level.

The ASB benchmark areas in Sumatra have become part of the DIVERSITAS Agro-biodiversity network, the CIFOR-ICRAF biodiversity platform, the RUPES program, the CI-ICRAF hotspot alliance and the Below Ground Biodiversity (BGBD) project., as well as more direct development-oriented programs on smallholder rubber agroforestry, post-Tsunami recovery of Aceh with 'trees farmers want' and negotiation support systems to resolve conflicts over land between (migrant) farmers and the local government. So far this bundling of activities has been mutually beneficial.

Table 2. Stages in the research-development continuum, partners, examples and quality criteria

Stage	*Component knowledge & patterns*	*Underlying principles* (processes)	*Proof of concept* (systems)	*Proof of application* (systems)	*Wide-spread adoption*	*Wide-spread impact*
Partners	Universities	Universities (disciplinary) NARS	Universities (interdisciplinary), NARS	NARS, NGO's Private sector	Government extension; NGO's; Private sector	
	<== C	G	I	A	R ==>		
Examples	Heuristic surveys; databases of component characteristics	Hypothesis testing under (semi)-controlled conditions; policy brief	On farm experiments; simulation models using realistic assumptions; negotiation support systems	Farmer-lead experiments fine tuning technology; (local) policy & bylaw reform; market links	National policy reform	
Criteria	Coverage of full range of conditions; rigor of statistical analysis; spatial context of results; databases & typology	Rigor of statistical tests of hypotheses; development of new concepts, methods & models	Quality of results in pilot benchmarks; potential profitability (ex ante impact studies); opportunity to influence policies	Ease of adaptation to new setting; reduced level of involvement of researchers; actual profitability; 'scaling out'	Cost effectiveness of 'service providers' (transaction costs); 'scaling up'; # of farmers adopting	Ex post impact: economic & environmental impro-vement
	Credibility		*Salience*	*Legitimacy*		*Salience*

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The World Agroforestry Centre is the international leader in the science and practice of integrating 'working trees' on small farms and in rural landscapes. We have invigorated the ancient practice of growing trees on farms, using innovative science for development to transform lives and landscapes.

Our vision

Our Vision is an 'Agroforestry Transformation' in the developing world resulting in a massive increase in the use of working trees on working landscapes by smallholder rural households that helps ensure security in food, nutrition, income, health, shelter and energy and a regenerated environment.

Our mission

Our mission is to advance the science and practice of agroforestry to help realize an 'Agroforestry Transformation' throughout the developing world.

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