World Agroforestry Centre

Annual Report 2001–2002

TRANSFORMING LIVES AND LANDSCAPES

World Agroforestry Centre

ANNUAL REPORT 2001–2002

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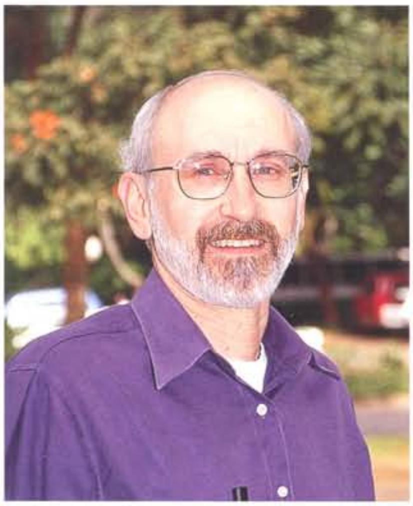
MESSAGE FROM THE DIRECTOR GENERAL



Dr Dennis Garrity
Director General of the
World Agroforestry Centre

A HEIGHTENED SENSE OF RESPONSIBILITY is changing the way we view the world. There is a growing realization among the more fortunate that hunger and poverty can – and must – be eradicated. Governments in the South and the North increasingly recognize, both in word and deed, that the future well-being of everyone on the planet depends on overcoming these challenges.

Progress has been made on many fronts, but much more remains to be done. Post-September 11 realities have created a new urgency and momentum to tackle these challenges. World leaders recently convened in South Africa in an effort to chart a course towards more sustainable forms of development, and at that Summit, the fundamental importance of agriculture to sustainable development was clearly recognized. Moreover, the important contributions of agricultural research to alleviating poverty and hunger are achieving a level of attention not seen before.

I assumed the helm of the Centre three weeks after September 11. The dramatic changes precipitated by the tragic events of that day quickly provided a radically altered backdrop to our role in the world. We began immediately to rethink that role, from the local to the global level.

Agroforestry is about "working trees for working people." Trees that farmers – especially small-scale, resource-poor farmers – plant and nurture to improve their own economic welfare. As they do so, these farmers help improve the quality of the local and global environment. Our mission is to push forward the science of using trees for these ends and, through science, enable accelerated development impact.

Land and People

Regenerating the land to achieve food security.
Poor farming communities in many parts of the tropics face a continuing battle against the decline in the fertility of their farmland. They often have little access to fertilizers, or cannot afford them. Instead, they must rely on natural methods to replace the nutrients taken

by their crops from the soil. Our scientists have been working with such quietly desperate farmers for over 15 years to understand how tree-based fallow systems can effectively replenish soil fertility. Together they have evolved methods that can double, sometimes even triple, crop production, while also providing fuel wood and fodder. These systems have now been adopted by tens of thousands of farm families in southern and eastern Africa, and their use is growing exponentially every year. Leaders in the countries where these systems have been piloted are asking for assistance to extend their use more widely.

We know that such systems could be extended to benefit millions of farm families. We have therefore rededicated ourselves to dramatically scaling up the use of these practices by smallholder farmers in those agroecological zones to which they are well suited. And to build more comprehensive solutions, we seek to join forces with other institutions whose strengths complement our own. During the past year, we formalized our alliance with the Tropical Soil Biology and Fertility Institute of our sister centre CIAT – Centro Internacional de Agricultura Tropical – to pursue just such a joint approach to new solutions.

Trees and Markets

Tree cultivation systems that generate income and build assets.

Farmers must have marketable products to sell in order to move beyond subsistence livelihoods. An enormous range of tree-based products exist that can provide cash income to smallholders. Our tree domestication programme has been a leader in raising awareness of the many possibilities for expanding the income-earning potential of indigenous fruit, medicinal, fodder and timber species. And it has been developing effective models and methods for domesticating indigenous tree species. These approaches can be adapted and widely applied by national programmes to strengthen the performance of their unique indigenous tree resources.

The development of markets is critical to improving farmer welfare through tree domestication. This is why we are strengthening our competence in market analysis. Our goal is to help our national partners increase the local, regional, and international demand for traditional and novel agroforestry products. Our team in Cameroon, for example, has been demonstrating a systems approach to domestication involving nine clonally propagated indigenous fruit and medicinal species. This approach – which is closely linked to the marketing potential of the resulting products – has generated great interest throughout the humid tropics of Africa.

The primary tropical tree crops of smallholder farmers, which include rubber, cocoa, coffee, and coconuts, have been a driver of economic development for many countries. But prices for these commodities have declined seriously in recent years. Farmers are seeking to diversify such tree crop systems by intercropping other income-earning trees in these systems. Building on our work with smallholder rubber and coffee agroforestry systems in Indonesia, we are forging an expanded effort to provide diversification methods and options for smallholder tree crop growers in Africa and other parts of the tropics.

Environmental Services

Enhancing ecosystem functions for sustainable livelihoods.

Sustainable development depends on maintaining the health of the natural resource base upon which rural livelihoods depend. Agroforestry is well recognized as a promising means of combining production systems with resource conservation – but the devil is in the details of how you balance a complex set of social, economic, and biophysical tradeoffs. Our research is leading to a clearer understanding of those tradeoffs, and how to cut through them to more integrated solutions. We have strong research and development teams in six watersheds in Southeast Asia, and in the Lake Victoria basin in eastern Africa. They have evolved and applied science-based negotiation support systems that are generating robust principles and practices for wide application in integrated watershed management in the tropics. We are now applying these principles to develop innovative approaches to the conservation of biodiversity in agricultural landscapes and in protected natural areas.

Climate change is increasingly seen as the greatest single threat to developing world agriculture. Agroforestry systems, through their very diversity, can provide farming communities crucial resilience to climate change. We are therefore accelerating our work on adaptive agroforestry options that can address these stresses. Carbon markets are also emerging as a means of mitigating the threat of global warming, and we are committed to developing and demonstrating practical means through which the rural poor – by integrating working trees in agricultural landscapes – can benefit from these growing markets.

In watershed protection, biodiversity conservation, and carbon sequestration, the question is: "How can the rural poor be rewarded for the ecosystem services that they provide to society and the greater global community?" To answer this question, we have initiated a consortium of research, conservation, and development organizations across tropical Asia. The consortium has launched work to investigate the practical possibilities for assisting smallholder communities to gain concrete benefits by improving their delivery of these environmental services.

Capacity Building

Strengthening the ability of national systems to engage in innovative and pragmatic problem solving, as well as technical knowledge sharing, remains a fundamental aspect of our mission. We have approached capacity building in non-conventional ways in the past, for example by investing in the building and strengthening of agroforestry education networks in Africa and Asia. These networks reach educators and provide them with more advanced teaching materials and curricula for the young and rapidly advancing field of agroforestry. We are also continuing to upgrade national technical training in agroforestry through a new global project. Beyond that, we are now launching a strategy to reach the rural youth in elementary and high schools through a "Farmers of the Future" Initiative. It will instill natural resources training through a collaborative effort with a range of national and international institutions.

On Becoming the World Agroforestry Centre

As part of our effort to more clearly connect with broader constituencies of the global community, and to increase awareness and understanding of the role of agroforestry in addressing a range of great challenges in development and in environmental conservation, we have this year changed the name of our Centre. Henceforth we will be known as the World Agroforestry Centre. We believe that this change will assist us to better reach and serve our various stakeholders, and ultimately better achieve our goal of transforming lives and landscapes.

As we rededicate ourselves to addressing the huge challenges of hunger, poverty, and environmental conservation, we have been delighted and heartened by an historic recognition of the role of agroforestry research and development in addressing them. Dr. Pedro Sanchez, my predecessor as Director General of the Centre, has been honored as the 2002 recipient of the World Food Prize. The prize commemorates his outstanding career accomplishments toward reducing hunger and poverty in the developing world. All of us at the World Agroforestry Centre take great pride and inspiration from this recognition.

Dennis Garrity

THE WORLD FOOD PRIZE FOUNDATION

Pedro Sanchez is Awarded 2002 World Food Prize

DR PEDRO SANCHEZ, previous Director General of the World Agroforestry Centre (1991 to 2001), is the 2002 recipient of the World Food Prize. Dr Sanchez was selected for his groundbreaking contributions to reducing hunger and malnutrition throughout the developing world by transforming depleted tropical soils into productive agricultural lands. Dr Sanchez's election was announced on August 11, 2002 by Ambassador Kenneth M Quinn, President of the World Food Prize Foundation.

Excerpts from Ambassador Quinn's announcement:

Dr Sanchez's leadership over the past 25 years has been vital to the great strides made toward improving food security in Latin America, Africa, and Southeast Asia. With his help in the 1970s, Peru dramatically improved its national food security, achieving self-sufficiency in rice production within three years, and achieving among the highest rice yields in the world.

Dr Sanchez's efforts to develop a comprehensive approach to soil management enabled 30 million hectares of Brazilian land, known as the Cerrado, to be brought into production – the single largest increase in arable agricultural land in the last half-century.

In addition, Dr Sanchez has lead the charge toward providing smallholder farmers in Africa and Southeast Asia with the means to replenish crucial nutrients in exhausted soils, through the development and promotion of agroforestry. The practice of planting trees on farms has provided over 100,000 farmers in Africa with a way to fertilize their soils inexpensively and naturally, without relying on costly chemical fertilizers.

Dr Sanchez is also being honoured for having played a critical role in establishing real alternatives to slash-and-burn farming, which has destroyed millions of acres of rainforest throughout Latin America, Asia, and Africa, as well as his work in driving the international effort to establish agroforestry as a means of both mitigating global warming – by removing millions of tonnes of CO_2 *from the air – and as a means of adapting to the effects of global warming, by making smallholder farming systems more resilient to extreme weather events, such as droughts and floods. While many have dedicated their lives to ending hunger and many others to saving the environment, few can claim to be a world leader in both fields. An innovative pioneer, he successfully merged the often-conflicting goals of increasing agricultural productivity and protecting the land.*

The World Food Prize is the world's foremost award recognizing breakthrough contributions to improving human development by increasing the quality, quantity, and availability of food in the world. In acknowledgement of Dr Sanchez's contributions toward ending world hunger, Kofi Annan, Secretary General of the United Nations, has honoured Dr Sanchez by appointing him to Chair the UN Taskforce on World Hunger, as part of the UN Global Millennium Development Project.


World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

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 combine excellence in scientific research with innovative development partnerships to address poverty, hunger and environmental problems throughout the tropics.

ABOUT THE WORLD AGROFORESTRY CENTRE

The World Agroforestry Centre is part of a global network of 16 Future Harvest centres, funded by the Consultative Group on International Agricultural Research (CGIAR). We are an autonomous, not-for-profit research and development institution supported by over 50 different governments, private foundations, regional development banks, and the World Bank. The Centre was founded in 1978, initially as the International Council for Research in Agroforestry (ICRAF), to promote the exchange of information about agroforestry research in the tropics. The Council was created in response to a visionary study led by Canada's International Development Research Centre (IDRC), which actually coined the term "agroforestry."

In 1992, ICRAF joined the CGIAR, and in the years since then has transformed itself into a world-class international agricultural research centre. During the past few years, we transformed ourselves once again by adding an explicit development agenda to the Centre's offerings. Our reason for doing so was to help ensure a broader adoption of agroforestry systems and practices, to be proactive in the creation of innovative development partnerships that leverage and extend the impact of our research.

In order to more fully reflect our global reach, as well as our more balanced research and development agenda, we have adopted a new brand name: "World Agroforestry Centre." Our legal name – International Centre for Research in Agroforestry – remains unchanged, and so our acronym as a Future Harvest Centre – ICRAF – likewise remains the same.

OUR VISION

Through agroforestry, tens of millions of poor people in developing countries will be able to improve their livelihoods and, in so doing, enhance in sustainable ways both their own local ecosystems and the global environment.

OUR MISSION

The Centre aims to improve human welfare by reducing poverty, improving food and nutritional security, and enhancing environmental resilience in the tropics. To achieve this mission, we conduct innovative agroforestry research and development, strengthen the capacity of our partners, enhance worldwide recognition of the human and environmental benefits of agroforestry, and provide scientific leadership in the field of integrated natural resource management. We strive to combine the best of science with farmer knowledge in a wide range of strategic alliances.

OUR BUSINESS

The Centre is sharply focused on agroforestry research and development – the integration of "working trees" on small-scale farms and in agricultural landscapes throughout the tropics. We engage in strategic and applied research and development activities leading to more sustainable and productive land use. We do this in close partnership with national agricultural research systems, universities, NGOs, and private organizations, both in the South and in the North. And we engage in a range of capacity building activities that cut across our three primary research and development themes:

- **Land and People:** The development of agroforestry systems that help to regenerate degraded lands and restore soil fertility in order to improve food security and reduce poverty in developing countries.

- **Trees and Markets:** The development of tree cultivation systems that are closely linked to – indeed, driven by – local and international markets. Farmers can use these systems to generate income and build assets, moving them beyond subsistence livelihoods, and helping to improve their health and nutrition.

- **Environmental Services:** The development of agroforestry systems that enhance key ecosystem functions, such as watershed protection, and carbon sequestration, and in doing so contribute to the sustainability of livelihoods while maintaining the natural resource base.

AGROFORESTRY SCIENCE: A DISCIPLINE OF TRADEOFFS

AGROFORESTRY SYSTEMS PRODUCE BENEFITS appreciated by farmers, consumers and policy makers alike, including wood for construction and fuel, fruits and medicinal products of many kinds, shade, better soil fertility, erosion and flood control, biodiversity conservation, and carbon sequestration. But implementing agroforestry systems also entails costs – direct costs for labour, management, and planting material, as well as indirect costs in the form of foregone opportunities to use the land in ways that could generate higher economic returns or greater levels of ecosystem resilience. Even the most avid fans of agroforestry recognize that such systems are not necessarily the ideal land use for all circumstances or for all functions. There are times and places where pure stands of trees or uniform cropping systems better meet private and social needs.

Agroforestry science thus rests on recognizing, measuring, and valuing the tradeoffs inherent in agroforestry systems. Understanding the multiple benefits and costs of agroforestry systems, and fully appreciating the tradeoffs incurred at differed social, temporal, and spatial scales requires an integrated approach to managing natural resources. This framework – summarized in the following article "Of Sustenance and Sustainability" – serves to organize and inform much of the World Agroforestry Centre's work.

Agroforestry development is also an arena of tradeoffs, and the development analogue to the Centre's research framework is the negotiation support approach discussed in the subsequent article "Levelling the Playing Field: Negotiation Support for Integrated Natural Resource Management." Negotiation support embraces the fact that there are many people who make decisions affecting the management of landscapes and watersheds, all of whom have different objectives, levels of power and influence, and perceptions of the same realities.

The Centre's research and development work will continue to apply the science and art of analyzing tradeoffs, but in the future, more attention will be given to those occurring beyond the level of the experimental plot or individual farm. Particular emphasis will be given to tradeoffs among the multiple users of upper watersheds and to tradeoffs or complementarities between carbon sequestration, biodiversity conservation, agricultural sustainability, and farmer incomes.

OF SUSTENANCE AND SUSTAINABILITY

The last 50 years have witnessed unprecedented gains in developing country agricultural productivity. Dubbed the "Green Revolution," agricultural science boosted crop yields and helped feed hundreds of millions of people who would otherwise have suffered the harsh consequences of hunger and malnutrition. But there are signs that the Green Revolution may be running out of steam. The natural resource base upon which the Green Revolution ultimately rested is threatened.

THE GREEN REVOLUTION WAS A HUGE EXPERIMENT in agricultural intensification, and it did what it promised. But agricultural researchers must now develop and embrace a more integrated approach to increasing agricultural productivity in tropical countries, one that rests on a clear understanding of many physical, biological, and ecological relationships that determine productivity in the long run.

Such an integrated natural resource management (INRM) approach is the foundation of the World Agroforestry Centre's research and development efforts. The Centre's work builds on the results of the Green Revolution, but differs in several important ways. First, we focus on the needs of the poorest farmers, integrating the interests of community-level land users and managers, as well as national and international policy makers. Second, we focus on diverse environments in which Green Revolution solutions are not readily applicable. And third, our approach focuses on the functions of natural capital in agriculture in order to further increase productivity while ensuring the sustainability and stability of these increases.

Using natural capital

Sustainable natural resources management is about achieving balance. It involves using natural capital in agriculture to meet the production goals of farmers, while still meeting the goals of the rest of society, such as poverty reduction and protecting the environment.

This idea of using natural capital in balanced ways to achieve multiple goals goes to the heart of agroforestry. At the farm level, agroforestry trees planted or maintained by farmers provide a number of benefits. The most obvious and

Transforming Lives: World Agroforestry Centre research and development efforts increase agricultural productivity while ensuring the sustainability and stability of these increases. C Ong

important ones to farmers are the food, raw materials, and income provided by such tree products as fruits, medicines, and timber. But these same trees also provide a variety of essential biological functions, such as nutrient and water cycling, which help maintain healthy ecosystems.

It is very difficult to accurately measure the economic value of such "ecosystem services," but we know they are extremely significant for humankind, dwarfing the economic value of the food and income generated by using natural capital in agriculture. The critical point, though, is that natural capital generates a range of high-value ecosystem services at different spatial and temporal scales, from the plot level to the global level, over weeks, decades, and centuries. This means that how natural capital is managed has impacts on a wide range of stakeholders, from farmers to international policy-making bodies.

Boosting food and income

Increasing the ability of natural capital to foster food production, provide raw materials, and raise incomes is a key objective in agroforestry research and development. In our tree domestication research, for example, we work with farmers to determine which tree species are the best ones for farmers to domesticate in order to meet their needs. Researchers ask how these trees should be situated throughout the farm, landscape and region to optimize their value. What are the most effective ways of improving these trees and the systems within which they are grown? And what are the prerequisites for successful adoption by farmers?

Improving ecosystem functions

At least as important, if not more so, is our goal of improving the ecosystem functions of natural capital, such as water cycling, carbon sequestration, erosion control, and biodiversity. Researchers want to know which kinds of agroforestry systems will most improve the ecological control mechanisms of existing land use systems? Which ones will help regulate the off-site impacts of these systems? And again, what are the prerequisites for successful adoption?

For example, researchers recently measured the carbon sequestration functions of different land uses across a number of sites (in Cameroon, Indonesia and Brazil). Not surprisingly, they found that tree-based systems in the humid tropics sequester much more carbon in their above ground biomass than do crops, pastures, and grasslands. But they also determined that soil carbon sequestration is notably higher in agroforestry systems than in cropping or grazing systems (Figure 1). This kind of research helps identify land use practices and management options that rehabilitate and strengthen the ecosystem functions of agroecosystems, boosting their sustainability.

Assessing tradeoffs

Whenever a new land management system is implemented, there are inevitable tradeoffs between increasing food and income, and strengthening ecosystem functions. True win-win situations are hard to come by. However, the right combinations of options can optimize these tradeoffs, not only for farmers, but also for local communities, and for national and global policy makers. The Centre promotes the kind of policy work that can help facilitate the resolution of conflicts between individual farmers and national society (see "Levelling the Playing Field: Negotiation Support for Integrated Natural Resource Management," p 19).

Factoring everyone in

Natural resources must be managed in a balanced way to provide the wide range of benefits that people want and need today, as well as ensure their continued availability over time. This is difficult to do, especially when there are competing demands for a particular resource that lead to conflicts between different groups. To succeed, all stakeholders must be involved in the management process – from farmers' organizations, extension services,and NGOs to development organizations and research institutions. The complexity of effective integrated natural resource management necessitates such partnerships, especially in countries with poorly funded research and extension systems.

The momentum fuelling the success of integrated natural resource management in agroforestry is generated by the collaborative spirit among the scientists engaged in INRM research. These researchers work in interdisciplinary teams and know that no single science by itself can identify solutions to complex agroecosystem and natural resource management problems. These teams focus on developing flexible and adaptive options for different environments. They deal in complexities but their challenge is basic and compelling: improving the environment and quality of life for millions of poor and hungry people.

Based on: "Toward a natural resource management paradigm for international agriculture: the example of agroforestry." A-MN Izac, PA Sanchez (2001) *Agricultural Systems* 69(1–2):5–25

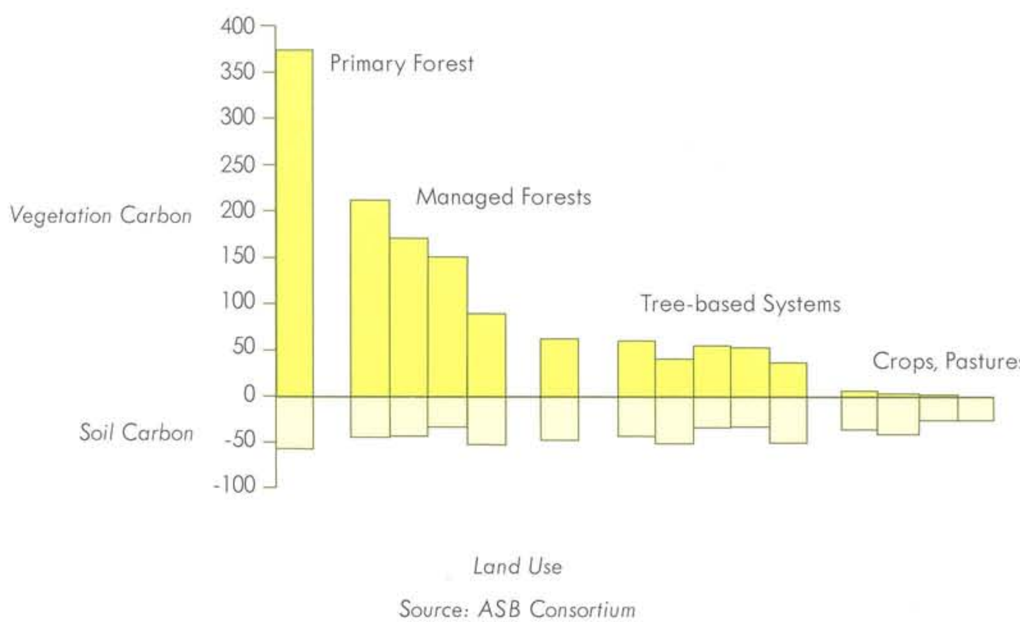


Figure 1: Time-averaged carbon stocks by land uses across benchmark sites

LEVELLING THE PLAYING FIELD: NEGOTIATION SUPPORT FOR INTEGRATED NATURAL RESOURCE MANAGEMENT

A major barrier to successful natural resource management is the conflict that often surfaces when farmers and other stakeholders manage resources according to their own priorities. Research that can objectively assess tradeoffs between different land uses helps dispel misunderstandings among individual stakeholders, and fosters compromise, providing an effective means for conflict negotiation and resolution.

NATURAL RESOURCE MANAGEMENT RESEARCH MUST EVOLVE from focusing on plans, maps, and prescriptions to embracing the complex, sometimes chaotic reality in the field. Large numbers of people, operating at different socio-political levels and motivated in different ways, make individual decisions that affect how well, or how poorly, natural resources are managed. Effective management usually depends on effective negotiation among the many people, organizations and institutions involved in decision making. Effective negotiation in turn requires understanding the perspectives of all stakeholders, building on complementarities in views, and identifying where science, social action, and compromise – often in some combination – can help resolve differences.

Integrated natural resource management (INRM) identifies land use practices that increase productivity while maintaining natural capital. The effective delivery of knowledge about new practices, when combined with changes in policies, can speed farmer adoption. A prime example is found in the forest margins of Indonesia. These complex agroforest systems provide both local and global ecosystem services, yet inappropriate policies limit the ability of farmers to effectively manage them. Creating more positive management incentives through better policies is now a major objective of INRM research in the region.

Still, even in this example it is not clear whether farmers can afford to care about externally imposed (national and global) objectives, including biodiversity conservation and increasing terrestrial carbon stocks (see "Carbon Offset Opportunities in Indonesia: Are They A Good Deal?" p 39). In the case of Indonesia's complex agroforest systems, the objectives of farmers and external stakeholders do converge, at least partially. But if this convergence is only accidental, there is no secure basis for future success. Convergence needs to rest on

Transforming Landscapes: The remote Sumber Jaya watershed. Sumatra, Indonesia. *B Verbist* shared values, consistent incentives, and common perceptions of the likely impacts of change.

Stakeholders other than farmers work to modify farmers' decisions. While careful planning and regulation of land use practices can be effective in countries with strong institutions and good governance, the reality in many tropical countries is otherwise. Centralized planning philosophies that often influence development projects are naïve about their ability to modify decisions by millions of rural households. These decisions are crucial to farmer livelihoods. They determine how farmers will manage their rural landscapes, and introducing INRM terminology in and of itself will make no difference.

The M of INRM: recognizing and supporting the manager

The overall objective of INRM research and development is to help managers at various levels do a better job of managing natural resources. This involves making and implementing decisions that will change the way in which agroecosystems function and how they respond to external forces. Such decisions usually reflect managers' objectives and a sense of how their decisions will affect agroecosystem performance. Helping these managers make better decisions therefore requires understanding how they see the ecological relationships that affect their objectives and underpin their decisions.

The goal of INRM research and development is to help managers balance their interests with those of the broader public. Success and failure should be measured accordingly. Integrated natural resource management efforts should lead to tangible impacts on the ground. If impact is measured solely in terms of the adoption of specific technologies, then the work of researchers and development specialists is likely to

NEGOTIATION SUPPORT FOR COFFEE FARMS IN SUMBER JAYA, LAMPUNG, INDONESIA

In Sumatra, Indonesia, research and development activities in the mountain zones of Lampung illustrate the way knowledge derived from scientific inquiry is being used to challenge the conceptual basis of existing conflicts.

Local forestry officials claim that removing coffee farms and reforestation would be in the best interests of the pubic. But political changes in Indonesia have given district level governments a larger say in such issues, and a number of farmer groups have successfully negotiated for community forest management contracts that will allow them to manage their coffee farms in ways that maintain essential environmental functions.

The agreements were facilitated by the World Agroforestry Centre and partner organizations. Centre research results demonstrated that increasing diversification with coffee agroforestry systems and allowing the accumulation of more organic matter in the understory would largely achieve the government's watershed management objectives. Farmers involved in the negotiation process used this new knowledge to make their case. Research is now focusing on the development of transparent criteria and indicators that reflect real watershed functionality.

Recent conversion of forest to coffee monoculture. Sumber Jaya, Sumatra, Indonesia. *B Verbist* be misdirected. Effectively supporting farmers as managers may in fact mean that "informed non-adoption," or "adaptation-beyond-recognition," are better signs of success.

Traditional agricultural research is based on designing technologies that lead to predictable increases in yields in well-defined situations. This approach can certainly lay claim to success, most notably by avoiding predictions of mass starvation in the developing countries of South Asia in the 1960s and 70s. However, its focus on yields has led to negative impacts on sustainability and other performance indicators. It also did little to help farmers become better resource managers, and it worked against the inherent variability and diversity of real-world agroecosystems.

The INRM approach involves "adaptive learning" by farmers, supported by outsiders who are themselves learning in the process. Adaptive learning is closely linked to issues of sustainability. Sustainability at any level of complexity – from cropping systems to the level of the planet – depends either on the sustainability of system components, or on adapting the system by introducing new components. Current system sustainability indicators focus primarily on the "persistence" of the system or its component parts, mainly because assessing adaptive capacity is much more difficult. Research on adaptive capacity differs from that on the sustainability of existing systems. The latter targets specific land use practices and involves experiments and modelling of longer-term behaviours. Adaptive capacity research, on the other hand, considers the full range of options available to managers, and the way in which these options themselves are adopted over time.

Taking natural resource managers seriously, then, implies trying to understand the "mental models" of ecological relationships that underpin their resource use and conservation decisions. In this context, farmers' ecological knowledge often complements ecological science, and can significantly contribute to the discovery of new approaches to natural resource management.

Conflicts and the need for negotiation

Conflict management entails clarifying options from all perspectives. It requires searching for mutually acceptable options and negotiating compromises. This in turn requires monitoring outcomes and enforcing compliance. Three types of natural resource management problems are evident at the margins of tropical forests.

Local problems regarding watershed and landscape ecological services – Conflicts between local and downstream stakeholders following forest conversion are evident throughout Southeast Asia. Such conflicts may be based, at least in part, on misperceptions of forest hydrological functions. These misperceptions often lead to the enforcement of rules aimed at maintaining "watershed protection forest" in areas that either produce no such services, or where they are irrelevant at best or even counterproductive. Yet some forms of spatial integration of forest and agricultural functions may in fact meet the needs of downstream land use. One key hypothesis is that complex integrated tree-based systems provide opportunities to minimize conflicts between private and public interests. In the appropriate settings, such systems may enable increased production and profitability, and improvement in local environmental services (including hydrology, ecology, and air quality).

Global-local conflicts of interest in biodiversity conservation – Another key hypothesis is that to conserve biodiversity (including animals), spatial segregation is imperative, and that this requires socially acceptable ways to protect conservation areas. For local biodiversity conservation, a partial integration option, such as agroforests, may be superior in terms of resilience and risk management. But because there is no substitute for spatially segregating many endangered species, mechanisms are needed for stabilizing the boundaries of conservation areas. These mechanisms can include tools for conflict management and actual compensation based on agreed performance criteria. In order to stabilize physical boundaries of protected and reserved areas, farmers and other stakeholders need to be able to earn livelihoods at least as good as they expect in their current situation. Alternatively, sufficient incentives can be put in place to shift stakeholders toward sustainable use. At the moment, little is known about either approach.

Conflicts between global interest in carbon stocks, and local interest in converting forest to more profitable land uses – Evidence from research done by the global Alternatives to Slash-and-Burn Programme suggests that, for the combined objectives of increasing carbon stocks and annual food-crop production, segregation works better if it allows for maintaining high carbon stock areas intact (including peat swamp forests) and intensifying production elsewhere. For the combined objectives of farm profitability and carbon stocks, however, production systems based on tree crops provide a sensible integration option.

In this instance, the key hypothesis is that carbon stocks can be increased by expanding tree-based production systems on grasslands and in degraded watersheds if a coherent approach is taken to the land tenure, market, policy, and institutional bottlenecks impeding the application of existing rehabilitation technologies. This type of INRM issue requires institutional and policy reform to eliminate disincentives for planting trees. Compensation mechanisms to increase incentives for planting trees are also justified.

How decision support evolves into negotiation support

In the real world, human impact on natural resources hinges on a large number of individual decisions. These decisions are made on the basis of different knowledge and information, the availability of dif-

THAI VILLAGERS MONITOR STREAM FLOWS AND WATER QUALITY TO MANAGE LAND USE CONFLICTS

In Northern Thailand, frequent and often heated public debate centers on the way agricultural activities in mountain mosaic agroforestry landscapes influence the amount, timing, and quality of stream and river flows. Exciting progress is being made by supporting local multi-village watershed management networks that use simple tools to monitor climate and seasonal stream flows at strategic points in local sub-catchments. This monitoring work includes assessments of water quality that use aquatic insects and other organisms as biological indicators of stream health. When apparent changes in water quality are noticed at downstream locations, they now have a basis for verifying and locating likely causes of problems in an early stage. The Centre's efforts in calibrating and adding credibility to this tool, and integrating it into village-operated stream monitoring and early warning systems, strengthens the use of locally collected science-based data and indigenous knowledge in negotiating solutions at local sub-catchment levels.

This process is further reinforced through collaboration to develop basic spatial information support tools for use by watershed management networks and sub-district governments. Under mandates given to them by a new national constitution and local governance legislation, these stakeholders are working to improve local natural resource management. Efforts are now underway to explore how this approach can be scaled up to cover the entire 4,000 square kilometre benchmark sub-basin watershed.

Villager in Kong Kan, Thailand collects aquatic animals to measure stream water quality. *P Saipothong* ferent technologies, and in the context of a range of often dissimilar objectives, constraints, priorities, and strategies. The best that can be hoped for is a process of negotiation among stakeholders that leads to collective action leading to better outcomes from the broader social perspective.

The term "decision support system" suggests that a single management entity will seek solutions that optimize the ways in which multiple objectives can be achieved, and then will make decisions to be imposed on the various stakeholders. A better term for INRM challenges is "negotiation support system." This term reflects and helps facilitate a common understanding of cause and effect relationships for a range of possible future landscapes. To function effectively, the negotiation support model itself will have to be the subject of negotiation and shared development efforts among stakeholders. While the main role of research and development organizations is to help develop predictive systems, they can also help develop and facilitate stakeholder consultation and negotiation processes.

Integrated models

The need for forests to protect watersheds and the pressure to convert forests to more profitable land uses is a major source of conflict in Southeast Asia. Because several layers of stakeholders are involved, a complex negotiation process is likely to be necessary. Models that show how the real-world landscape actually functions can be helpful tools in these negotiations.

Integrated system models can serve as a common framework of analysis that clarifies the kind of information needed from the various participants in the negotiation. Perhaps more importantly for the implementation phase is how the models function to facilitate discussion. Different scenarios developed by different stakeholders can be analyzed and probable future outcomes can be evaluated and discussed. This approach can generate the basis for overcoming conflicting interests in the present for the sake of a better collective future.

Different "what if" scenarios, based on stakeholder inputs and feedback, allow an exploration of various possible management options. The main objective of such model building is to put stakeholders on a more equal footing – to help level the playing field – and thus help them negotiate mutually beneficial natural resource management agreements.

Based on: "Negotiation support models for integrated natural resource management in tropical forest margins." M van Noordwijk, T Tomich, B Verbist (2001) *Conservation Ecology* Vol. 5/Issue 2/Article 21 *www.consecol.org/vol5/iss2/art21*

Bucking a Downward Trend: Sumatran farmers plant coffee on steep slopes. The roots of this cash crop will help prevent the severe soil erosion that previously led to a landslide on this same hilltop. *M Chapman*

WATERSHED MANAGEMENT: MYTH VS. REALITY

Over the years, a number of myths have taken root in the minds of policy makers dealing with watershed management issues. Here are a few common ones that continue to distort policy decisions today.

MYTH: *Water shortages are due to the removal of forests and trees in upland areas.*

REALITY: Because trees use more water than other types of vegetation, deforestation usually leads to *increases* in total water yield from a catchment. However, deforestation often changes the timing of water supplies coming from upland areas. Forests and trees can act as natural sponges – soaking up excess water during storms, then slowly releasing it to downstream areas. The usual result of deforestation, therefore, is to increase total water yield, and to increase the likelihood of floods during peak flow periods.

MYTH: *Agriculture is the main source of soil erosion in managed landscapes.*

REALITY: Non-agricultural land uses, such as footpaths and roads, are actually the main sources of erosion and sediment. In parts of Kenya, for example, the level of erosion has been measured at 16 tonnes per hectare per year for grazed land, 13 tonnes per hectare per year from terraced land, and 250 tonnes per hectare per year from roads.

MYTH: *The dominant concern about soil erosion is the amount of soil lost from the landscape.*

REALITY: Farm-level studies of erosion are often "scaled up" to the landscape level by simply multiplying plot measurement by the area in such plots. At the landscape level, however, soil that moves from one place is often deposited at another place in the same landscape. The key issue therefore is not how much soil moves, but where it moves to. Soil that moves from a hillside to a eutrophying lake changes from an asset to a liability. Soil that moves from a hillside to a rice paddy may actually increase in value.

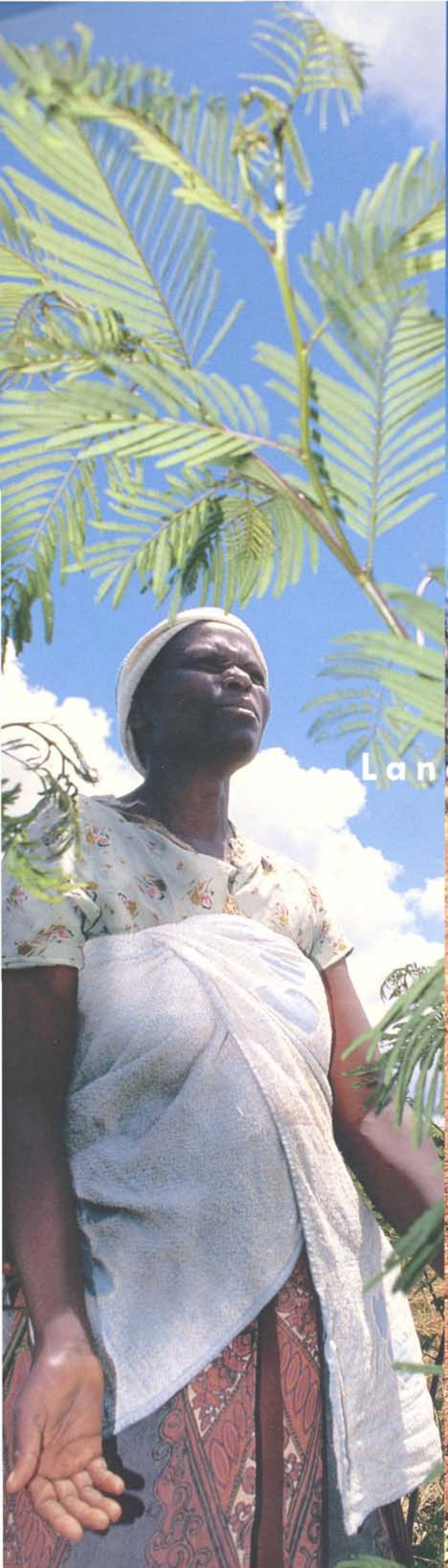
MYTH: *Eroded soil is quickly deposited in major rivers or lakes.*

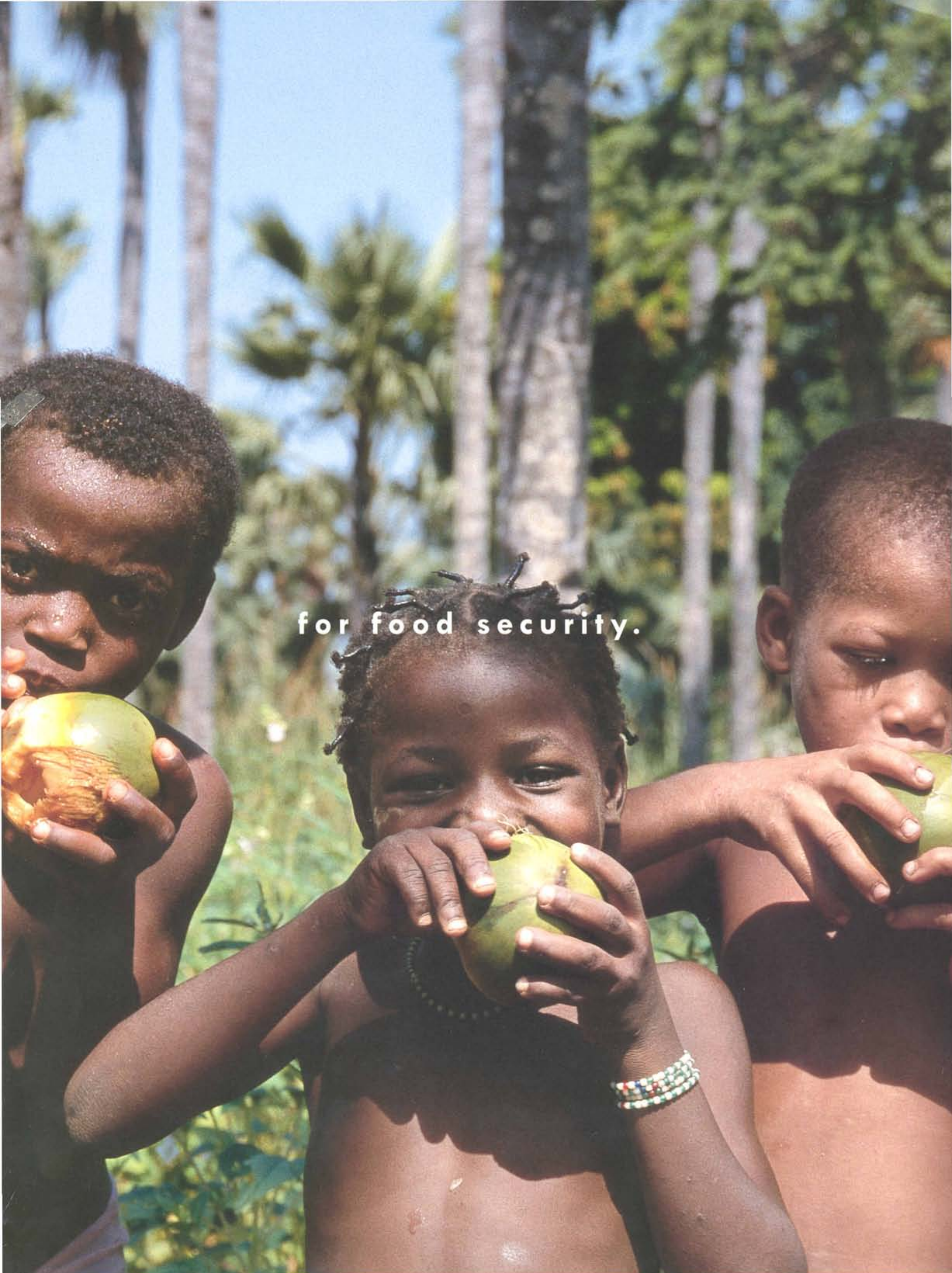
REALITY: Eroded soil tends to move slowly through water catchments or systems, often taking decades to complete its journey. Agricultural landscapes contain sediment sources, sediment filters, and stores of past sediment. Under-appreciation of these dynamics can lead to the inappropriate use of engineering and reforestation solutions for watershed management.

Based on: "The effects of scales, flows, and filters on property rights and collective action in watershed management." B Swallow, D Garrity, M van Noordwijk (2001) *Water Policy* 3:457–474

Awash: Deforestation of watersheds leads to periodic floods, such as this one in a Zambian village, sweeping away precious crops and possessions. *A Njenga*

Land regeneration




for food security.

CLIMATE CHANGE RESEARCH AT THE WORLD AGROFORESTRY CENTRE

DEVELOPING COUNTRIES AND THE RURAL POOR are going to bear the brunt of climate change. Global conventions are not going to halt the increase of atmospheric greenhouse gases, and governments need many years to address the underlying drivers of climate change. Local climates and terrestrial ecosystems will inevitably change. Yet, even as climate changes, food and fibre production, environmental services and rural livelihoods must improve, not just be maintained.

The World Agroforestry Centre is working with many partners on the climate change issue. Two primary goals shape the Centre's efforts: the first is to help provide options for farmers that increase the sustainability of their operations and buffer them against increasing climatic variability. The second goal is centred on mitigation of the problem itself, as called for in the Kyoto Protocol.

In the short term, the major threat for small farmers is increased variability in local climates, rather than long-term changes in average rainfall or temperatures. Research indicates that certain agroforestry systems, such as the improved fallow systems being implemented in parts of Zambia and Malawi, buffer against drought and help farmers to successfully produce maize, even in low rainfall years. Research aimed at validating these findings at other sites is underway, and other such adaptation options are being developed and assessed.

In the longer term, however, much needs to be done to reach the greenhouse gas reduction targets agreed in the Kyoto Protocol. One key question is how much carbon can actually be sequestered in agricultural landscapes? Agroforestry has been singled out by the Intergovernmental Panel on Climate Change report as having high carbon sequestration potential, second only to natural forests. By quantifying the real carbon sequestration potential of different systems, we can help guide decision makers to the types of agricultural practices that are most likely to improve the sustainability of tropical farming, and provide global environmental benefits (see "Testing the Clean Development Mechanism in Western Kenya," p 44).

Centre scientists are also contributing to regional and global analyses of the mitigation potential of agroforestry in the humid tropics and the feasibility of carbon-offset schemes through participation in the Alternatives to Slash-and-Burn Programme (see "After the Burning: Greenhouse Gas Emissions and Slash-and-Burn Agriculture," p 32; and "Carbon Offset Opportunities in Indonesia: Are they a Good Deal?," p 39).

The climate change issue is extraordinarily complex. There are a considerable number of inherent biophysical uncertainties. There is real potential for irreversible damage to ecosystems. Planning horizons must extend far into the future, in part because of long time lags between greenhouse gas emissions and their effects; and despite the global scope of the problem, there are wide regional variations in causes and effects, further complicating the political dimensions of the challenge. What is sorely needed is better information about climate change processes, the impacts of those changes on agriculture and forestry, and appropriate ways to facilitate adaptation.

AFTER THE BURNING: GREENHOUSE GAS EMISSIONS AND SLASH-AND-BURN AGRICULTURE

Deforestation in the tropics produces about 25% of the world's net annual CO_2 emissions, and about 10% of global N_2O emissions. Traditional slash-and-burn agriculture is one source of these releases, but their ultimate effect on the atmosphere – and hence on global warming – depends a lot on how the deforested land is used once the trees are removed.

FIRE IS A CHEAP WAY TO CLEAR LAND for agriculture, which is one reason why slash-and-burn agriculture persists in the tropics. Once cleared, deforested land often remains as pastures and degraded grasslands, or is used for producing annual crops. Unfortunately, these replacement systems do not store much carbon. The good news, however, is that there are other land use systems in the humid tropics that can sequester much of the carbon lost through deforestation. These systems begin with short-term cropping, followed by the establishment of tree-based systems, including forest fallows, tree crops and plantations, and agroforestry systems.

The not-so-good news is that the widespread adoption of these high carbon systems is often limited by the costs of land and labour, as well as such inputs as fertilizers and seedlings. While some of these systems appear profitable in the longer term, the initial cost of establishing them and the length of time needed to make them profitable can be major bottlenecks to their adoption. Poor market access, insecure tenure, and misguided policies also impede their acceptance by farmers.

Carbon offset projects could provide a way of eliminating some of these bottlenecks, but the value of the carbon sequestered will depend on many things, including where it is being sequestered and in what kind of land use system.

Alternatives to Slash-and-Burn

The Alternatives to Slash-and-Burn (ASB) Programme, hosted by the World Agroforestry Centre, was launched in 1994. The overall goal of the programme was to measure the impact of current land use systems in the tropics and to identify better alternatives – environmentally, agronomically, and economically.

Before the Burning: Rapidly disappearing virgin forest. *J Baxter*

Developing and promoting policies to facilitate the adoption of these alternatives was also part of the ASB mission.

Teams of national and international scientists were established in key locations around the world (benchmark areas) representing the range of biophysical and socio-economic environments in which slash-and-burn agriculture is practiced. Standardized sets of parameters and measurements were established for assessing carbon stocks, trace gas emissions, biodiversity, sustainability, profitability, and institutional constraints for the different land use systems found in the benchmark sites. The resulting "tradeoff matrix" allows assessment of the environmental, production, and social costs and benefits of the different land uses.

Net global warming potential of ASB land uses

The effects of slash-and-burn and subsequent land use on net global warming potential were determined from changes in carbon stocks and fluxes of nitrous oxide (N_2O) and methane (CH_4).

Carbon stocks and time-averaged carbon – Carbon stocks were measured in the soils (0–20 cm) and aboveground vegetation in 94 different locations in three countries – Brazil, Cameroon, Indonesia – using standardized protocols. Data from those studies were used to describe the time course of carbon stocks over the rotation of the different land use systems and to calculate the aboveground, time-averaged carbon of each system. To compare the carbon loss or sequestration potential among the different land use systems, it is necessary to know how much carbon is stored, on average, in each system over the rotation time of the system. It is not the maximum carbon stock of each system that is important for considering net carbon fluxes, but rather the average carbon stock of each system through time.

The main findings from these carbon stock measurements indicate that primary forests, which average about 300 tonnes of stored carbon per hectare, have by far the greatest potential for locking up carbon. The aboveground, time-averaged carbon of other land uses compared to that of undisturbed forests are shown in Table 1 (p 36). Managed forests can store about 50% of the carbon found in the aboveground vegetation of undisturbed forests, while the carbon sequestration potential of logged forests ranges from 30–70%. Permanent complex agroforestry systems can store about 30% of the carbon stored in natural forests, and those on a 25-year rotation can store about 15%. These figures compare with less than 5% for annual crops, pastures, and grasslands.

Nitrous oxide and methane fluxes from slash-and-burn systems – Nitrous oxide (N_2O) and methane (CH_4) fluxes were also measured. Fluxes of N_2O from all the tree-based systems monitored were, as expected, quite low compared to other systems, especially high-input cropping systems (Figure 1). Tree-based systems absorbed significant amounts of CH_4, while high-input cropping systems released CH_4 to the atmosphere in notable amounts. For the high-input cropping systems, the release of CH_4 from these systems suggests that anaerobic soil processes are increasing. This is due to soil compaction resulting from deterioration of the soil structure with long-term tillage, which reduces oxygen availability in these soils.

In order to make an overall comparison of the net global warming potential of the CO_2 emissions from the slashing and burning of vegetation, as well as subsequent emissions of CO_2, N_2O, and CH_4 from different land uses, researchers combined the information on time-averaged carbon stocks and N_2O and CH_4 fluxes. The most notable result from this analysis indicates that the effects of CO_2 released from the vegetation as a result of the slash-and-burn process far outweigh the subsequent emissions of CO_2, N_2O, and CH_4 from the different land use systems (Figure 1). The CO_2 emission from the topsoil from the decomposition of soil organic matter in the different land use systems is also as high or higher than that of N_2O and CH_4 despite the much higher warming potential of the latter two gases. The implication of this finding is that efforts to reduce the effects of the CO_2 released by the slash-and-burn process itself should focus on reducing deforestation in the first place or, if deforestation is unavoidable, on establishing tree-based land use systems afterwards that sequester more carbon.

Economic and social aspects of slash-and-burn systems

It is one thing to determine which land use systems have the greatest net effect on global climate change and recommend how to reduce these effects by managing the systems differently. It is quite another to expect those who live on the land to adopt different systems or practices because they have beneficial environmental effects for the rest of the world. Many of the ways to mitigate the greenhouse gas effects of land uses in the tropics, such as reducing deforestation, establishing and maintaining tree-based systems, and increasing soil organic matter, all require additional inputs of labour and capital. Whether future profits from these different land use systems will eventually offset their additional cost will help determine which, if any, of the more environmentally friendly systems will be adopted.

ASB scientists have identified land use systems that may provide both reduced greenhouse gas emissions, through increased carbon stocks, and higher potential profitability. Most promising are oil palm and cocoa plantations, particularly when interplanted with fruit trees (in Cameroon), rubber agroforests using improved clonal planting material (in Sumatra), and coffee and rubber or timber agroforestry systems (in Brazil).

Many of the land use systems having low carbon sequestration potential, such as short-term fallows, annual cropping systems, and degraded grasslands, show either net losses or low potential to be profitable, so converting them to profitable tree-based systems makes both environmental and economic sense. Studies show that agroforestation of the degraded Imperata grasslands in Indonesia to *Acacia mangium* plantations or rubber agroforests is indeed profitable. These tree-based systems have time-averaged carbon stocks of 60 tonnes per hectare, compared to less than 5 tonnes per hectare for the grasslands (Table 1).

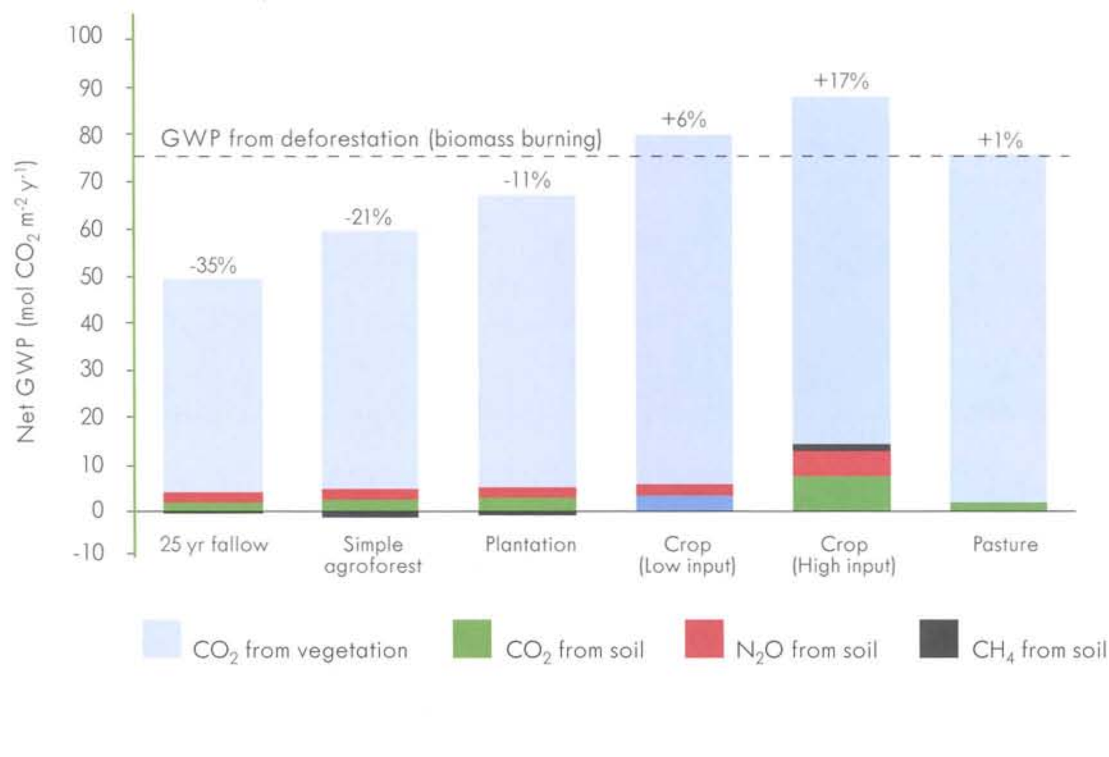
Carbon offset projects to mitigate greenhouse gas emissions

Despite the profitability and positive environmental aspects of many tree-based systems, the cost of labour and capital, as well as tenure issues, can prevent their widespread adoption. How then to encourage the adoption of land use systems that reduce the emission of greenhouse gases? The process of deforestation, in general, is profitable, so people need to be

Figure 1.

N_2O, CH_4 and CO_2 components of the net global warming potential (GWP) of land use systems in the Peruvian Amazon.

Percentages are the GWP relative to slashing-and-burning a forest. Thus a negative value indicates lower GWP for the land use. A positive value indicates additional contributions of the land use to GWP.



compensated for not cutting trees. And the adoption of tree-based systems may require government support in terms of land or tree tenure, access to markets, or other institutional support.

Although there is still considerable debate, opportunities for carbon trading that provide the necessary incentives may flow from the Clean Development Mechanism (CDM) of the Kyoto Protocol. Kyoto raises the possibility of offsetting carbon emissions with carbon sinks, and a special report of the Intergovernmental Panel on Climate Change has identified land use change from cropland and grassland to tree-based systems as the largest among potential carbon sinks globally.

But while the CDM offers the promise of financial incentives, there is still little solid information about the value of foregone resource use and development opportunities. Additional research into such tradeoffs is needed, as is real-world testing of CDM projects to determine whether they are in fact a viable means of achieving sustainable development and improvements in the global environment.

Based on: "Opportunities and constraints of mitigating greenhouse gas emissions in slash-and-burn systems of the humid tropics." C Palm, T Tomich, M van Noordwijk, S Vosti, J Gockowski, J Alegre, L Verchot (In Press) *Environment, Development and Sustainability*

Table 1. Summary of the aboveground, time-averaged C stock of the land use systems sampled at ASB sites. The range is given in parentheses (Palm et al., 1999).

Meta Land Use Systems	Country and Specific Land Use		Time-averaged C of Land Use System $t\ C\ ha^{-1}$	
Undisturbed Forest	Indonesia		306	(207–405)
Managed/Logged Forests	Brazil		148	(129–149)
	Cameroon		228	(221–255)
	Indonesia		93.2	(51.9 –134)
Shifting Cultivation and Crop-fallows	Cameroon	Shifting cultivation, 23 yr fallow	77.0	(60.2–107)
		Bush fallow, 9.5 yrs	28.1	(22.1 – 38.1)
		Chromolaena fallow, 4 yrs	4.52	(2.68 – 6.38)
	Brazil	Short fallow, 5 yrs	6.86	(4.27–9.61)
		Improved fallow, 5 yrs	11.5	(9.50–13.4)
Extensive Agroforests	Cameroon	Cacao	88.7	(57.2–120)
Permanent	Indonesia	Rubber	89.2	(49.4–129)
Rotational	Cameroon	Cacao	61	(40–83)
	Indonesia	Rubber	46.2	(28.9–75.2)
Intensive Treecrop	Brazil	Coffee monoculture	11.0	(8.73–12.5)
		Multistrata system	61.2	(47.5–74.7)
	Cameroon	Oil palm	36.4	
	Indonesia	Pulp trees	37.2	(23.6–50.7)
Grasslands/Crops	Brazil	Extensive pastures	2.85	
		Intensive pastures	3.06	
	Indonesia	Cassava/imperata	<2	

In Malawi, women often carry fresh cut wood many kilometres to market. *A Njenga*


18

CARBON OFFSET OPPORTUNITIES IN INDONESIA: ARE THEY A GOOD DEAL?

The logic of investing in "carbon offset" projects in developing countries – such as conserving forests or planting trees to capture and store atmospheric carbon – rests on the belief that the potential economic benefits for developing countries from carbon trading outweigh the resource exploitation and development opportunities they forego when implementing such projects. But are we sure about that?

IT IS ESTIMATED THAT THE MARGINAL COST of meeting the Kyoto Protocol carbon emission targets for the United States – which is currently responsible for about 25% of global carbon emissions – would fall from about $200 per metric tonne of carbon to about $25 per metric tonne if carbon trading with all other countries were allowed under the Protocol. At that price, the question becomes whether paying the people of tropical developing countries for creating and maintaining carbon sinks makes sense.

To answer this question, the real value of what developing countries must give up in order to host carbon sink projects must be compared with the financial benefits they gain from carbon trading. The administrative costs of designing, implementing, and managing such projects must also be considered, and right now virtually nothing is known about these.

The CGIAR system-wide Alternatives to Slash-and-Burn (ASB) Programme, hosted by the World Agroforestry Centre, has been working with partners in Indonesia to examine these issues. ASB scientists looked at two types of land use change in Indonesia – deforestation and agroforestation.

Protecting natural forests with carbon offsets

Little natural forest remains in the Sumatran peneplains of Indonesia. This process of deforestation, which is almost complete in lowland Sumatra, seems likely to be repeated elsewhere in the country. The peneplains are home to millions of small-scale farmers – including indigenous groups, spontaneous migrants, and government-sponsored transmigrants – and all of them depend mainly on land converted from natural forest to agricultural uses in order to make a living.

Sumatran farmer transports "slab" rubber from his agroforest to market. These slabs are about 20% carbon. *T Tomich*

Significant numbers also gather products from the forest. Public and private estates (operating forest concessions and plantations of 10,000–300,000 ha or more) compete with smallholders for the limited area of land, which further adds to the pressure to convert natural forests to agricultural uses.

Compared to natural forests, forest extraction activities and all the forest-derived land uses studied significantly reduce carbon stocks in the vegetation (Figure 1). These losses range from about 30–40% for extractive activities (community-based forest management and commercial logging) to an 85% reduction for continuous food crops degrading to *Imperata cylindrica* grasslands. Intensified tree-based systems – rubber agroforests planted with improved clones or hybrid oil palm monoculture – combine attractive returns to land with 35–40% of the time-averaged carbon stocks of natural forests. Although the profits for conversion of natural forests to these land use systems are high (especially if timber sales from land clearing are added to the returns to the land use), the possible values of carbon sequestration services are even higher.

Putting aside timber values, the range of values of carbon payments necessary to shift incentives from conversion to conservation varies from $0.10 per metric tonne for community-based forest management, to under $4 per metric tonne for large-scale oil palm plantations, to $10 per metric tonne for rubber agroforests. Indonesia's lowland forests are a very valuable and readily marketable timber resource. However, a world price of $25 per metric tonne of carbon could shift incentives from converting natural forests to conserving them – assuming that these payments reach the people doing the converting, and that agreements can be enforced.

It is not clear how such transactions would work and little is known about how high these "costs of doing business" (transaction costs) would be. Still, while the opportunity costs of not converting forests are high, the very large carbon increments from saving them lower the necessary payment per metric tonne of carbon and leave a margin of 37% or more from which transaction costs could be paid.

So far, then, carbon offset projects designed to conserve natural forests at $25 per metric tonne of carbon look like they could be a good deal for many Indonesian people. But are things really that simple?

Knowledge gaps

Carbon offsets are based on the concept of "additional carbon" stored through land use changes. The difference between the quantities of carbon stored by changing to a more productive land use is the "additional" carbon for which payments through an offset project would be made.

Most pilot forest protection projects have been carried out in remote areas with low population densities, where the rate of deforestation in the absence of the project is moderate or low. This

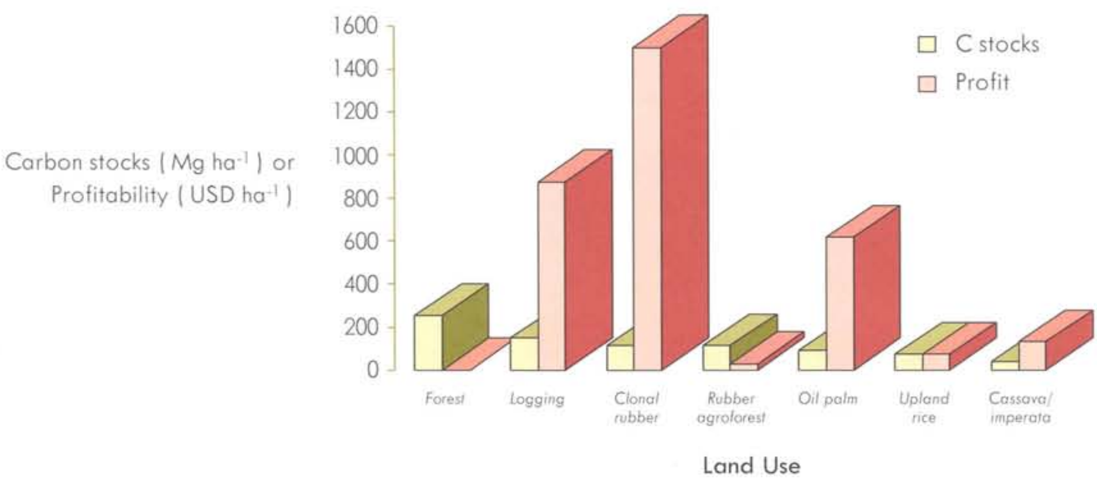


Figure 1: Carbon stocks and profitability of land use systems in Sumatra, Indonesia

raises questions about the actual "additionality" of the carbon stocks saved – perhaps they were not really at great risk to begin with.

In cases (largely outside Sumatra) where natural forest remains, how much is the timber worth? An equally important, but more difficult, question concerns option values for future development. How, for example, to factor in the option value of technological innovations – such as rubber clones – that are available, but not yet widely adopted?

Although community-based extraction of non-timber forest products may offer attractive returns to labour far exceeding rural wages, the relatively low returns to land, well below rubber agroforests, suggest that this is not a feasible alternative for large numbers of people. There is simply not enough land for everyone to practice this extensive livelihood strategy. So, in addition to the question of technological change, what compensation would be needed for the loss of livelihoods and depression of wages that would be transmitted directly through restrictions on access to resources, as well as indirectly through labour markets?

If carbon offsets are designed to include the full opportunity costs to these groups, there are additional thorny issues: which group (or groups) to compensate and how to apportion shares among competing claims? Paying two or more parties with competing claims over land or timber full compensation for timber and non-timber values, plus foregone opportunities for conversion to other uses, would undermine the cost-effectiveness of forest conservation projects in Indonesia as a means for carbon storage. Yet failing to address these conflicting interests could severely undermine the prospects for "permanence" of the stored carbon.

A key policy question

The commercial value of timber far exceeds the value of non-timber forest products in Indonesia's natural forests, and this is a decisive factor in evaluating the cost-effectiveness of carbon offsets aimed at forest conservation. The question of timber values also has a deep political dimension. Who owns the timber: the central government, provincial governments, local communities, or individuals? Since colonial times, the policy has been that timber (and other natural resources) is the property of the state. It is of course up to Indonesians how (and when) this policy question will be answered. But if local communities are not compensated for timber values, will incentives be sufficient to secure forest conservation? Moreover, in many situations in Indonesia, there are competing claims over these forestlands – between and among large-scale commercial enterprises (loggers and plantation companies) and local communities.

Carbon offsets and agroforestation

A special report of the Intergovernmental Panel on Climate Change identified land use change from cropland and grassland to agroforestry as the largest among potential sinks for carbon globally. But there are at least two major barriers to smallholder agroforestation for production of timber and other forest products in Indonesia. First is tenure insecurity for millions of smallholders because of conflicting claims on land that is no longer natural forest. A long-term process will be needed to develop workable and enforceable agreements between government and local communities regarding land use and production sharing rights and responsibilities on these lands.

Still, carbon offsets through agroforestation seem more politically feasible than offsets through forest conservation. Why? The property rights over timber from planted trees are easier to establish and resolve than property rights over timber in natural forests. Second, for the first commitment period under the Kyoto Protocol (2008–2012), forest conservation is not an eligible activity.

Under the present circumstances of insecure tenure, local people lack incentives to control fires or to plant trees. A policy to establish secure property rights over all products – including the timber – for smallholders who convert plots of grassland by planting and managing trees could be an important first step in addressing the lack of tenure security and in creating incentives for community-based fire control. Property rights over all products, including timber, would create incentives necessary for local people to do the hard work to re-establish trees on grasslands. If tree planting is profitable, local people will do it once they are convinced they will reap the rewards of their work. If it is not profitable, the land will stay as it is.

More knowledge gaps

Real community-level participation and adequate incentives for local people are necessary for permanent, secure carbon storage in Indonesian landscapes. But much remains to be learned about how to establish and replicate local participation and accountability across a huge archipelago characterized by extreme variation in ecology, culture, and socio-economic conditions.

Beyond the uncertainties about how to ensure community-level participation, it is not clear that the 25–30 year cycle of carbon accumulation and release that characterizes agroforestation would meet the permanence requirements of the Kyoto Protocol. One approach to accommodating the Protocol's permanence requirements to the realities of smallholder land uses is to take a 10-year approach to measurement. This would entail paying for a flow of carbon storage services rather than purchasing carbon stocks in perpetuity, to adjust carbon credits to duration and also to reward longer deferral of emissions. Thus, if approved within the Kyoto Protocol and if practical feasibility can be established, this approach could be a way to address a number of areas of social, economic, and technological uncertainty – in effect, land use options could be reviewed and adjusted annually.

Current regulations covering trade and marketing of timber and other "forest" products are designed for natural forest products, but are inappropriately applied to agroforestry products, which are produced from farmers' own labour, land, and capital.

Overcoming the second barrier to smallholder afforestation involves removing current regulations on the harvesting and trade of timber for agroforestry species. This would significantly improve incentives for development of Indonesia's smallholder farm forestry subsector. This would be an important step toward realizing the potential of smallholders to make a bigger contribution to meeting growing commercial demand for timber. Deregulation of agroforestry species would raise the economic benefits of growing trees on degraded lands and provide a new stimulus for farmers to improve productivity of lands that have been marginal for agricultural production. Therefore, in addition to reducing timber waste (and resulting carbon emissions), deregulating harvesting and trade in agroforestry species would help promote agroforestation and thereby produce environmental benefits on a local, regional, national, and global scale.

So are carbon offsets a good deal for Indonesians?

The short answer to this question is: "We don't know yet." ASB researchers are, however, making progress. The ability to measure carbon stocks in different land uses at scales relevant to policy makers is being refined, which should help verify real changes in carbon stocks that can be achieved by an offset project. Researchers have also developed estimates of the "forest-gate" direct payments for carbon sequestration that would be needed to shift smallholders' incentives from privately profitable, but less carbon-rich systems, to land use systems that store more carbon. But these estimates should be treated only as indicative of relative magnitudes, rather than definitive results that could be used as a basis for designing projects.

Beyond that, even less is known about the actual transaction costs of involving smallholder communities in carbon trading. These costs are important: if they are too high compared to the global price of carbon, incentives to smallholders will fall short of inducing changes in behaviour.

For both forest conservation and agroforestation in Indonesia, then, more research is needed across a wider range of circumstances before a definitive answer to our question can be provided.

Based on: "Carbon offsets for conservation and development in Indonesia?" T Tomich, H de Foresta, R Dennis, Q Ketterings, D Murdiyarso, C Palm, F Stolle, Suyanto, M van Noordwijk (2002) *American Journal of Alternative Agriculture* 17(3)

Conversion or Conservation: Can carbon offset incentives convert farmers of cash crops, such as this oil palm, to conservators of their forests instead? *J Beniest*

TESTING THE CLEAN DEVELOPMENT MECHANISM IN WESTERN KENYA

THE 1997 KYOTO PROTOCOL calls for most of its signatories to reduce greenhouse gas emissions by five to eight percent below their 1990 levels by the "first compliance period" (between 2008 and 2012). Some industrialized countries cannot hope to meet this target. Therefore, the Protocol established a Clean Development Mechanism (CDM), by which investment in development projects that result in carbon sequestration in developing countries will entitle the investing country to carbon credits that can be used to help meet its reduced emission targets.

The CDM was a hotly contested issue in finalizing the Protocol. Many environmental groups argued that it comprised a loophole that could relieve industrialized countries of their obligation to reduce emissions. Developing countries, too, generally resisted the Mechanism, fearing that potentially large areas in their countries could be "locked up," dramatically reducing availability to the poor of valuable natural resources needed for economic development. The challenge is to find ways of encouraging industrialized countries to invest in CDM projects that do more than just sequester carbon, but also vigorously address issues of poverty and food insecurity in the developing world.

A number of CDM projects have been proposed, but so far few offer real opportunities to the developing world's poor to improve their lives. To address that need, the World Agroforestry Centre and key partners in Kenya have developed and, with initial funding from the Global Environment Facility, are implementing a pilot CDM project in the western part of the country.

The project in western Kenya will serve as a testing ground for how such efforts might be implemented with – and to the benefit of – smallholder farmers. Project partners include the Kenya Agricultural Research Institute (KARI) and the Kenya Forestry Research Institute (KEFRI). In addition to sequestering carbon, this initiative has at its core the primary goals of reducing poverty and improving food security for people who live in the highlands of western Kenya. This area – home to some 12 million people – comprises the Kenyan portion of the Lake Victoria watershed. Centre scientists have been working to find ways to reduce the effects of poor land management on the farming and fishing industries of the Lake Victoria region for more than 10 years. Now they are melding that on-going work with efforts to mitigate atmospheric greenhouse gas build-up with complex agroforestry systems that can sequester significant amounts of carbon, both above and below the ground.

Kenya's pilot CDM project aims to scale up the adoption of improved agroforestry practices that will enhance soil fertility, rehabilitate degraded lands, and introduce value-added cropping systems to promote food security, poverty reduction, and the permanence of above- and below-ground carbon storage in agroecosystems. The project aims to demonstrate the links between sustainable agricultural development at the local level and such global environmental benefits as the mitigation of CO_2 accumulation in the atmosphere.

Measuring Success: For CDM projects to be both effective and sustainable, poor farmers must also be able to improve their livelihoods. *P Sanchez*


MADE
KENYA

Hunger and poverty


can and must be eradicated.

TREE CROP DIVERSIFICATION AND BIODIVERSITY MANAGEMENT

AGROFORESTRY SYSTEMS ARE BY NATURE DIVERSE, and yet often the diversity within a single system is limited. Paradoxically, there is no shortage of potential tree species to cultivate for the main products and services sought from trees. The shortage lies in the appreciation, availability and access to knowledge of the thousands of tree species suitable for these purposes.

Human nature leads most people to choose the biggest and the best – and when selecting which trees to grow on their farms, the 400 million farmers in developing countries are no exception. The evidence for this lies in the uniformity of choices by farmers of tree species they select. The subsequent monocultures far outweigh novel and/or complex tree cultivation practices. This is true for both small-scale and large-scale farms in the tropics, especially the further they are away from natural forests. Of course, exceptions exist, and the Java, Chagga, Polynesian, and Amazonian homegarden systems are prime examples.

But the rule persists. Trees of only a few kinds predominate in tropical agricultural landscapes. Citrus, gmelina, rubber, mango, leucaena, cocoa, sesbania, eucalyptus, and neem account for more than 95% of the trees grown on farms in the tropics. Participatory research with farmers currently underway at the World Agroforestry Centre indicates scope for diversifying, through tree planting, both small-scale farming systems and the cultivation of tree crops grown previously in plantations.

Greater diversity can enable farmers to buffer against risk. Until recently, however we knew little about how much diversity farmers actually have, how much they want and how much they need (see "Tree Biodiversity on African Farms: The Good News," p 50).

Species diversity has routinely been presented as a laundry list of identified trees, which can lead to spurious comparisons. Consider two farms, each with 100 trees. The first farm has 15 species and the second farm has 10 species. If the first farm had 86 trees of one species and one tree each of the other 14 species, it would be less diverse than the second farm if it had 10 trees of each of 10 species. Consequently, to measure diversity accurately requires measuring both species richness and evenness.

While most conservation groups concentrate on preserving biodiversity "hotspots" around the world, the majority of small-scale farmers in the tropics find themselves in biodiversity "coldspots." Quantifying on-farm diversity and relating it to the diversity of communities, of protected areas, and of the wider landscape presents methodological and social challenges. These challenges are being addressed within an integrated natural resource management context so that better informed amelioration efforts can be implemented (see "Biodiversity and Watershed Protection: INRM Research and Action", p 56).

Sustainable management of biodiversity to simultaneously allow conservation and utilisation goals to be met is a national and global responsibility. Operationally it can best be achieved through understanding, involving, and empowering the front-line biodiversity managers – farmers.

TREE BIODIVERSITY ON AFRICAN FARMS: THE GOOD NEWS

Increasing tree diversity on farms gives farmers additional ways to improve their livelihoods and improves the health of the ecosystems in which the farms are located. These advantages explain why a key goal of the World Agroforestry Centre's tree domestication programme is to intensify on-farm tree diversity.

WHILE THE NEED TO INCREASE TREE DIVERSITY on farms and in landscapes is widely accepted, little is really known about the actual degree of tree diversity on farms. Nor is much known about effective practical methods for gauging diversity.

To redress this lack of knowledge – and with an eye toward promoting diversification – the Centre undertook a thorough study designed to measure the current diversity of tree species at the farm and village level in four important African agroecosystems. In an era of rapid deforestation, improving tree diversity is a challenging goal, but the study provides a strong start – and some much needed good news: species diversity on African farms in the four study areas is significantly greater than previously thought.

Hundreds of farmers were surveyed to learn why they planted the trees they did and what they remembered about how individual trees came to be on their farms. Very often, we found, the history of a particular tree on a given farm was as involved as the farmer's own family history, with planting material brought in from as far away as the farmer had ventured seeking off-farm employment.

Trees on farms in villages both close to forests, as well as some distance away were surveyed. It has been known for some time that farmers living farther from a forest tend to plant more trees; a corresponding assumption has been that farmers closer to the forest did not plant as many because they could obtain the tree products they needed directly from the forest. Now, however, as forests become increasingly fragmented, more and more farmers – even those close to the forest – are realizing they have to plant trees on their farms to obtain the tree products they need.

Better Gardens and Homes: Home tree gardens, like this one in Tanzania, allow farmers to nurture planting material which will eventually be used on their farms. *A Njenga*

Centre scientists inventoried trees on 39 farms in Cameroon, 105 farms in Uganda, 201 farms in western Kenya, and 35 farms in central Kenya. The Ugandan farms were at varying distances within a 19-kilometre radius of the 28,000-hectare Mabira Forest Reserve. In Vihaga and Kakamega, western Kenya, the farm villages were within 32 kilometres of the species-rich 17,800-hectare Kakamega Forest National Reserve. In Meru, central Kenya, farms in three villages were surveyed within 25 kilometres of the 200,000-hectare Mount Kenya National Park and National Forest, which first appeared on the UNESCO World Heritage List in 1997.

Of richness and evenness

Although diversity is often equated with species richness – the number of different species on a farm or in a landscape – species evenness, or the frequency with which each species appears, is just as important. A species that gets low marks for evenness is threatened, perhaps even in danger of extinction.

Species richness was evidenced in the study by the large number of botanical families, to which the inventoried species belong, ranging from 42 families in Cameroon to 64 in Meru. While this is reassuring in terms of numbers, indications were that these were common rather than rare species. To determine the degree to which the various inventoried species were rare or threatened, researchers consulted the World Conservation Union's (IUCN) Red List of Threatened Plants. Of the 237 species included on the list for Kenya, only one rare species (*Euphorbia friesiorum*) and two vulnerable species (*Milletia tanaensis* and *Vitex keniensis*) were found. None of the species encountered in Uganda or Cameroon were on the IUCN list. Consequently, while on-farm tree species richness may be providing more stable productivity, it currently contributes little to conservation of threatened species.

Within the four landscapes studied, trees for firewood had the highest average on-farm diversity. Not surprisingly, there were fewer species present for trees that provide more specific requirements, such as those that have abrasive leaves used to clean utensils, or species that produce beverage products. For species providing more general service functions, such as ornamental trees, shade trees, and those used for boundary demarcation and soil fertility improvement, total richness was never below 10 different species per village.

Farmers are generally not concerned about whether their trees are indigenous or exotic, as long as they are productive. However, classifying them as such provides researchers and extension agents with insights into the preferences of farmers for local planting material. At the species level, the proportion that were native varied between 73% and 90% at the four locations, showing that, at least in terms of the mix of species, native trees predominate at each location. However, only between 24% and 70% of the individual trees found at each location were native. This means that a few exotic species accounted for most of the trees and native species were represented by only a few trees.

Are tree populations on farms large enough?

The study indicates that, while a substantial number of indigenous tree species can be found on farms, and although farmers are protecting and actively planting some indigenous trees on their farms, when farmers plant trees, most of the time they plant exotics. It remains to be determined if this is because the products of exotic trees have a higher value, if this is all that local tree nurseries offer, or if indigenous trees naturally regenerate more easily.

While farmers do not manage a whole species, they do manage individual trees or populations of trees. The fact that the census number of many indigenous species was rather low stresses the importance of evaluating effective population sizes of tree species. In Cameroon, Mabira, western Kenya and Meru, survey results showed that the population size was fewer than 10 trees for 39%, 53%, 63%, and 47% of species, respectively. If farmers are to manage trees for sustainable production, then the effective population size should be a minimum of 50 trees. This will ensure that adequate genetic diversity is maintained over time, and productivity losses due to inbreeding don't occur.

There is much to be learned about the natural regeneration of trees. Animals carrying their fruit regenerate some, while others are dispersed by wind and gravity. Isolated trees can act as steppingstones for pollen, and plants in small clusters probably receive more pollen from outside than plants occurring in larger clusters or in more even distributions. As the science of diversification evolves, so must our understanding of the complexities of geneflow, which is governed by such intangibles as wind and the paths of insects and animals.

Whether pollen and seed dispersal limitations exist and whether they lead to genetic erosion needs to be evaluated for specific species and landscapes. If substantial genetic erosion is recorded or expected under current tree management practices, farmers could coordinate the exchange of planting material within and among farming communities, or obtain more diverse material (if available) from forests, plantations or nurseries. Currently, we know that farmers will want to be self-sufficient in tree planting materials rather than regularly sourcing externally. This can only occur if sufficient numbers of nearby trees of a species occur in a landscape.

Why diversify?

On-farm diversity provides farmers with a range of options they cannot get from a single species. For instance, farmers need both strong poles and flexible branches for construction, and thus need several types of trees for this purpose. The medicinal efficacy of certain species is higher when used in mixtures. Some trees used for timber or boundary demarcation grow faster, while others have a high specific gravity. On-farm tree diversity means fruit, firewood, and charcoal are available year-round. Interestingly, the study revealed that as far as farmers are concerned, we are still a long way off their saturation point for diversity. Those with high richness on their farms wanted that richness, and even more. Not surprisingly, the study found that the larger the farm and the more well off the farmer, the greater the on-farm diversity.

The fact that farmers prefer certain species and only maintain other species in low abundance does not mean that they are unwilling to foster diversity. In western Kenya, in a follow-up survey to the tree inventories, farmers were asked to rank species by preference, and also asked which species they desired on their farms, using participatory methods including drawings of "ideal farms." Although farmers often preferred exotic species for particular use-groups (such as *Eucalyptus saligna* for construction and firewood, and *Persea americana* for fruit), they did express the desire to maintain a variety of indigenous species on their farms.

The study showed that many farmers are experimenting with new species on their farms. Wider distribution of information could result in more rapid diversification. Farmers that had experience with the performance of many species opted for diversity. Experiments that introduced new species to farmers led them to substitute some of the new species for the dominant taxa such as *Grevillea robusta*.

By diversifying their tree populations, farmers are less vulnerable to changes in market dynamics and trees species are less vulnerable to pest and disease epidemics. Whereas farmers want diversity mainly for differentiation among and within products and services, ecological research has demonstrated that there is a positive relationship between ecosystem diversity and ecosystem stability and productivity.

Biodiversity conservation in African agroecosystems

In general, the survey results demonstrate that farmers cultivate a substantial diversity of trees, especially when scaled up from the individual farm level to the village and larger spatial areas. Although farmers are not likely to conserve all indigenous species historically present in the areas where their farms are located, it is hoped that ongoing research conducted together with farmers will result in a substantial percentage of tree species being conserved by being used. Especially in areas where forests are under threat of fragmentation and extinction, conservation-through-use may offer the most realistic conservation approach for many species.

However, in promoting on-farm tree domestication, it is important not to undervalue the protection of remaining forest ecosystems. Many species are threatened as deforestation progresses. Some of these species may not be immediately useful to farmers or well suited to the ecological conditions of agroecosystems and can, therefore, only be conserved in protected forests. Moreover, evolutionary forces may be different in agroecosystems, and conservation-through-use may not completely substitute for in situ conservation. Nonetheless, in fragmented forest landscapes, farms may provide "corridors" that offer a necessary link for conservation of tree species in otherwise isolated forest fragments. Consequently, trees are needed both in agroecosystems and in remaining forest ecosystems to ensure survival of the species.

The World Agroforestry Centre promotes landscape management strategies that successfully combine both these objectives. The Centre's study shows that tree diversity on African farms is greater than previously thought, at least in the four agroecosystems included in the study, and that farmers are willing to further increase diversity when they see the value in doing so. And that is very good news indeed.

Based on: "Methodology for tree species diversification planning for African agroecosystems." R Kindt (2002) PhD thesis, University of Ghent

Fruits of his Labour: The history of a particular tree on a given farm is often intertwined with the farmer's own family history. Planting material comes from as far away as the farmer has ventured seeking off-farm employment.
A Njenga

BIODIVERSITY AND WATERSHED PROTECTION: INRM RESEARCH AND ACTION

The landscape of the developing world is littered
with failed integrated conservation and development initiatives.
It is not that the concept is fundamentally flawed,
but rather that success has been limited
by serious methodological and policy constraints.
The Centre's pioneering work to avert habitat destruction
in the Kitanglad Range Natural Park – one of the richest
biodiversity reserves in the Philippines – promises to save
the forest and provide new sources of income for local farmers.
Our success there suggests that sustainable impact
may best be stimulated by a "drip feed" approach, rather than by
large, externally funded conservation and development efforts.

LOCATED IN THE MANUPALI WATERSHED IN CENTRAL MINDANAO, Kitanglad Park supports the richest known mammal and bird fauna in the Philippines and is the habitat of many endangered, endemic, rare and economically important species of both plants and animals. Although the park is relatively small (only about 50,000 ha), it was recently found to have among the highest tree density ever reported in a tropical forest. Worryingly, however, investors and the people living down slope in the watershed are putting pressure on both the natural and managed ecosystems of the area, particularly on the remaining protected forest.

Communities near protected areas often bear high costs in foregone use or extraction from the protected area, yet they may gain little in return. To achieve the goals of protecting biological diversity and helping to improve the welfare of the people living near a protected area, rural development activities need to directly support or be linked to the objective of protection. Some types of development initiatives, such as road construction for example, can increase human pressure on the protected area. New technologies that raise agricultural productivity may also tend to increase the value of land devoted to agriculture, making it more attractive to convert reserve land into farmland.

Compensating local communities for the costs of foregone use-benefits inherent in protecting reserves like Kitanglad Park can take many forms. Improved agroforestry practices, crop intensification and irrigation, conservation farming practices, and community forestry can all contribute to sustainable increases in local incomes. But the success of these efforts is much more likely when local residents are involved in the kind of natural resource management activities that

Agroforestry protects the rich biodiversity of Kitanglad Park, Mindanao, The Philippines. *T Simons*

empower them, increase their incomes, and change their production systems in ways that better protect natural biodiversity in the agricultural landscape and reduce their need to extract resources from the protected area.

Integrating conservation and development

The landscape of the Manupali watershed is made up of three belts of land: the natural park, which consists of mostly pristine forested land, a zone of land surrounding the park that is managed as production forest by the Philippine Department of Environment and Natural Resources (DENR), and privately owned agricultural lands, which comprise a mosaic of agroforests, crops, and fallowed fields, with remnant forest in the steep ravines bordering the streams that drain the natural park. The middle band of land that borders the park has been converted mainly to agricultural fields, interspersed with grassland. Settlement here has been partially sanctioned through social forestry stewardship contracts, and eviction is not a tenable management option.

The indigenous Tala-andig people regard the public lands in the Manupali watershed as their ancestral domain. They recognize that protecting the natural biodiversity of the area is in their own self-interest. A major concern of the Tala-andig villagers is protection of the hydrological functions of the upper watershed that supplies their water. They are also very sensitive to the spiritual and cultural values of the forest. But immigrants, without these clear connections to the forest, tend to emphasize resource exploitation and extraction for cash income. The immigrant group has now become the dominant one in the area. The Tala-andig people are looking for support from local governments and institutions to provide resource management solutions that recognize their need for more secure land tenure and alternative livelihoods.

Enter the global research effort known as SANREM (Sustainable Agriculture and Natural Resources Management Programme). This programme evaluates the landscapes and lifescapes of watersheds in an effort to protect natural habitats containing unique tropical biodiversity. Kitanglad Park is one of three global sites in which the SANREM programme works. With the programme's help, a number of partners in the area have formed a biodiversity consortium that includes a local university, several NGOs and various government agencies. Convened by the World Agroforestry Centre, and with links to the global Alternatives to Slash-and-Burn Programme, the consortium promotes the use of agroforestry by communities near the park in order to combine improved biodiversity conservation with better opportunities to earn a living.

Two conditions are essential for achieving sustainable buffer zone management. The first is intensification of agriculture and agroforestry in the zone to enhance farmer incomes. Progress on this front needs to be complemented by the creation of off-farm opportunities for employment, both in the local and national economies. The second condition is community-supported enforcement of the boundaries of and access to the park. The work at Kitanglad is leading to the adoption of new agricultural practices that fit the biophysical and socio-economic conditions of the buffer zone, as well as changes in local institutions that facilitate better natural resource management. The "social contract" supporting this model explicitly links assistance in intensifying agriculture to local responsibility for park boundary protection.

Assembling the elements of a social contract

The Centre is closely involved in developing the elements of a workable social contract between buffer-zone communities and the non-local stakeholders, a critical precursor to sustainable buffer zone management. The foremost policy issue impinging on local natural resource management systems is the reality of overlapping land rights and management priorities. Three sets of overlapping management claims and systems are found in the vicinity of the park: (1) the park and production forest land administered by the DENR, (2) the ancestral domain claim of the Tala-andig people, and (3) the jurisdictions of the six municipalities that surround the park (see diagram p 61).

Our policy research focuses on understanding the ways in which these three overlapping interests can be reconciled. The

An entrepreneurial Philippine farmer and collaborator in the Centre's Landcare Initiative surveys his agroforestry nursery at Lantapan, Mindanao. *T Simons*

work is producing management options that will meet the various stakeholders' concerns. The project envisions an integrated natural resource management system for the Kitanglad buffer zone that links a park management plan with an ancestral domain management plan. These plans need to be buttressed by integrated management plans at the municipal level, and a negotiation support system that can resolve the conflicts between the three management domains. (See "Levelling the Playing Field: Negotiation Support for Integrated Natural Resource Management," p 19).

A "municipal model" for integrated natural resource management planning

Our scientific knowledge base guided the development and implementation of a natural resource management plan for the municipality of Lantapan, which borders the Kitanglad boundary. In 1995 the municipal government created the Natural Resources Management Council made up of representatives of all the major sectors of the community, including smallholder farm households and leaders from the religious, civic, business, and education sectors.

The mayor also established a local planning team that received support from the municipal environmental planning officer. A draft plan was circulated, and a series of public hearings was held. Many changes were incorporated into the plan, and the municipal council enacted it in early 1998. The initial impact of the plan has included a number of new policies and regulations related to resource conservation that have enhanced the conservation of land, water, and biodiversity. This includes a ravine habitat management component, developed by the Centre, through which communities are actively replanting trees in the degraded stream-bank areas through voluntary initiatives and efforts.

In 1998, the DENR recognized the Lantapan experience as a national model for integrated natural resource management planning in the Philippine Strategy for Improved Watershed Resources Management. The model is now being implemented in other municipalities and provinces throughout the country. It is an important step toward planning and management for natural resource protection at the local level, and a major shift from traditional top-down planning approaches.

The Landcare movement mobilizes grassroots conservation

Prior attempts to reforest the buffer zones of deforested areas in the Philippines focused on planting large blocks of trees with local wage labour paid for by DENR. Such a project was implemented in the Manupali watershed during the late 1980s, prior to the SANREM programme. Like many other such top-down attempts, it largely failed. The plantations were burned, often by the local farmers, on whose land the trees were planted. Only a few small remnant stands remain in the "reforested" buffer-zone area.

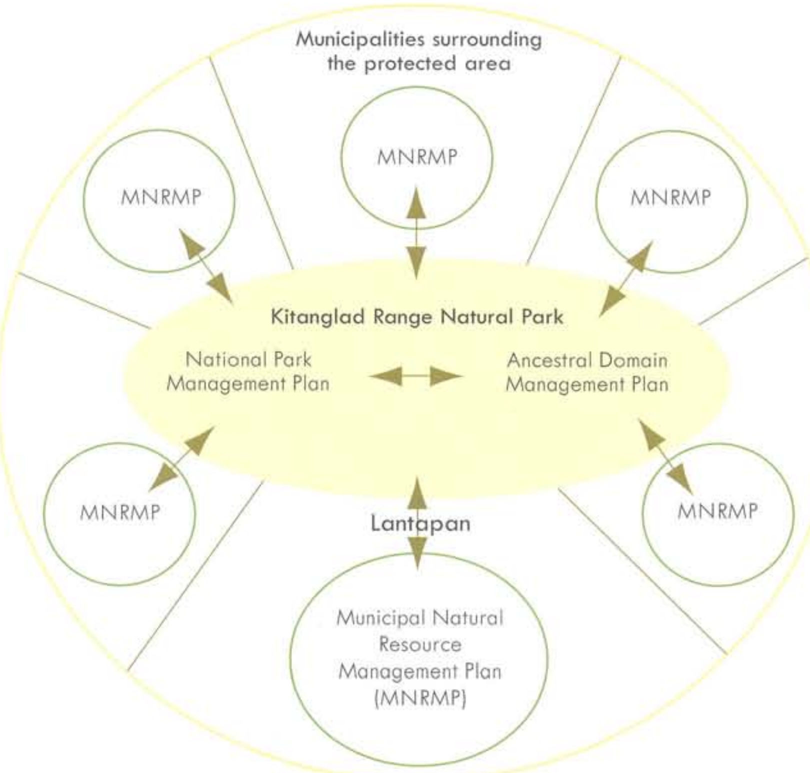
Recent market conditions, however, have induced farmers in the buffer zone and on private lands to expand the area of timber and fruit trees on their farms. The biodiversity consortium is providing improved planting material for a variety of species that will enhance incomes and reduce risk. It is also helping ensure that good management practices, well suited to local circumstances, are in place, including the introduction of smallholder nursery systems. These activities are greatly accelerating tree production in the buffer zone.

A dynamic grassroots movement of more than 60 farmer-led "Landcare groups" has evolved in the villages near the park boundary. This movement is having a significant impact on conservation in both the natural and managed ecosystems in the area. Encroachment in the natural park was reduced by 95% in a three-year period.

The movement has stimulated the development of more than 40 nurseries for timber and fruit trees, and fostered the adoption of contour buffer strips on several hundred farms. Community-wide environmental protection began by assisting with the planting of thousands of trees to protect the buffer zone, and to help alleviate severe pollution in the local river.

A legal system of secure land tenure for the farm populations inhabiting the buffer zone has yet to be fully devised and implemented. But in the meantime, the Landcare experience shows that residents believe that regulations to more formally recognize their land tenure rights will be forthcoming. Evidence for this belief is abundant:

Linkages between three types of Natural Resources Management Programmes (NRMPs):
National Park, Ancestral Domain, and Municipal Programmes

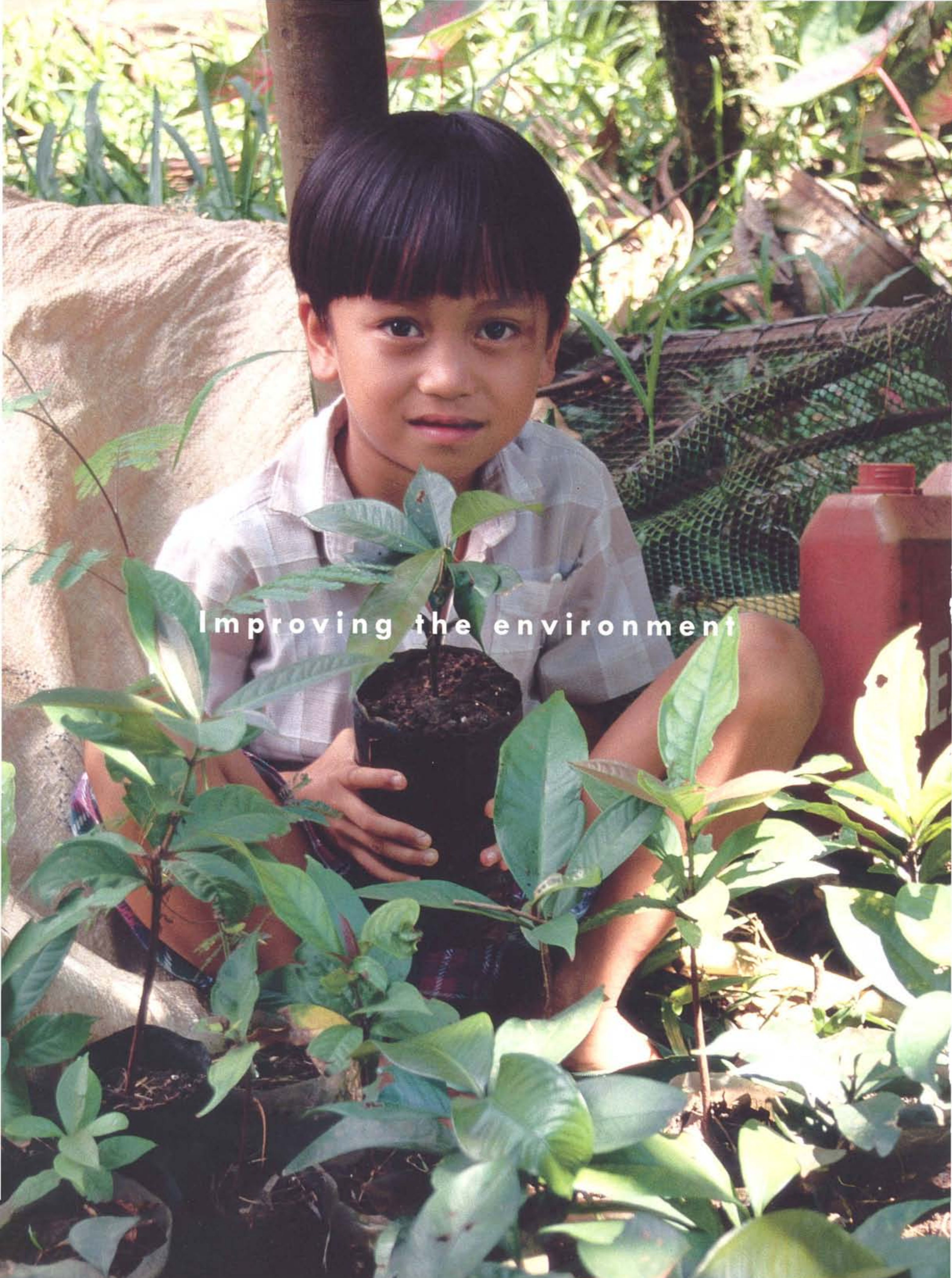


long-term investments in soil conservation are rapidly increasing, as is the adoption of various tree production systems.

The Landcare movement has significantly increased the social and political capital of the residents. It has been a contributing factor to positive developments in local natural resource management. Progress has now been achieved in assembling the elements for an effective social contract to fully protect the natural biodiversity of the Kitanglad Range Natural Park while also improving the livelihoods of the communities on the park boundary.

The sensitivity of the wider community to the environmental and religious values of the Tala-andig has also broadened and deepened. Biodiversity protection is now accepted as a local responsibility by a broad segment of the society beyond the ancestral communities, and is now pursued with robust civic pride. The development of a strong consortium of both research and development institutions, and local government entities committed to an integrated systems approach, evolved through a common vision. Its success lies in the patience of all involved to nurture that vision together.

Based on: "Landcare on the poverty-protection interface in an Asian watershed." D Garrity, VB Amoroso, S Koffa, D Catacutan, G Buenavista, P Fay, W Dar (2002) *Conservation Ecology* Vol. 6/Issue 1/Article 1 *www.consecol.org/vol6/iss1/art1*



Improving the environment


for sustainable livelihoods.

LEVERAGING THE SHARING AND APPLICATION OF KNOWLEDGE AND SKILLS

"Knowledge exists in two forms – lifeless, stored in books, and alive in the consciousness of men." – *Albert Einstein, 1949*

SIGNIFICANT STRIDES IN AGROFORESTRY AND INRM RESEARCH feed a growing body of knowledge being promoted and disseminated to individuals and institutions by the World Agroforestry Centre. The Centre works with a wide range of partners, particularly national education and extension institutions, and national institutions that provide training to others. Our challenge is to build on lessons learned from our past work, and to ensure that new knowledge and skills reach farmers.

In 2001, the Centre developed a new training and education strategy. The strategy has a number of innovative elements, all aimed at achieving a revised capacity building mission: To support, nurture, and work closely with a strategic consortium of learning institutions and individuals to extend and deepen agroforestry knowledge, and to improve the quality and relevance of teaching, research, and practice.

The Centre's future training activities will differ from its past efforts in at least six ways. First, there will be an even sharper focus on mobilizing available agroforestry capacity in national institutions to play significant roles in training – in extending the reach of knowledge and skills to farmers who need them to improve their lives and the welfare of their families (see "Strengthening Training and Education in Agroforestry," p 71).

Second, Centre staff will focus on reaching the farmers of the future. In many developing countries, the majority of young people in schools today will end up as small-scale farmers and/or marketers of agricultural products, this despite what they may study while in school. In fact, current school curricula often leave students ill prepared for such careers. If, however, these same students could more readily gain knowledge and skills in agroforestry and natural resource management while still in school, their chances for success in life will be notably improved (see "New Directions: Educating Tomorrow's Farmers Today," p 66).

Third, future activities will capitalize on advances in information and communication technologies to deliver agroforestry education and training to colleges and universities through distance learning methods. For this, the Centre will link with other global initiatives to establish virtual and distance-learning systems.

Building on the three approaches above, a fourth is to further strengthen the sharing of knowledge and experience through improved networking among stakeholders. This will help rationalize the use of available capacity in national institutions and disseminate knowledge and information more rapidly.

Fifth, Centre scientists have been remarkably successful in sharing their knowledge and skills without any special training in pedagogic or mentoring approaches. The new strategy recognizes, however, that there is room to raise the quality of capacity building work by strengthening in-house mentoring and learning capabilities.

Finally, and most importantly, the Centre's ultimate training target group is the rural poor in developing countries of the tropics. Thus, all training and education activities undertaken are organized and implemented with the goal of accelerating the flow of knowledge and skills to farmers.

NEW DIRECTIONS: EDUCATING TOMORROW'S FARMERS TODAY

Each year millions of children in the developing world are unable to continue their education beyond the primary or secondary level; many do not make it even that far. While most of these young people come from farming villages, they are given little or no formal training in agriculture while in school and often have only a passing interest in farming. Not surprisingly, poor farming families generally want to see their children succeed off-farm, and encourage them to seek employment in urban areas and send money back home. But without useful employment skills, these young people often don't find jobs. If and when they return to their villages, and in many cases to their family farms, they are ill prepared to help implement modern and ecologically sound agricultural practices that would ensure the farm's future success.

THE FUTURE OF AGRICULTURE IN DEVELOPING COUNTRIES lies with this same population of under-educated youth. Most of these young people have little knowledge of agroforestry, natural resource management, or marketing of agricultural products. But what if an agricultural education had been available? What if the possibility of helping to transform the family farm through modern farming practices encouraged these young people to work toward a viable future through farming?

A new initiative by the training and education programme at the World Agroforestry Centre, in concert with Swedish Sida's Regional Land Management Unit (RELMA), is being undertaken in the belief that agriculture – including agroforestry and natural resource management – should be integrated into primary and secondary school curricula. The underlying premise is that, by making farming both intellectually stimulating and potentially lucrative in the eyes of students, they will be more likely to see their

Tools of the Trade: This Tanzanian orphan handles a hoe with dexterity. *A Njenga*

education through and graduate with the skills they need to help move themselves and their families out of poverty.

For four days in May 2002, 60 participants from Africa, Europe and Southeast Asia met at the Centre to breathe life into the "Farmers of the Future" initiative. Their ranks included representatives from seven international agricultural and environmental aid organizations, eight non-governmental organizations, government policy-makers, university professors, and curriculum specialists from eight African nations, Thailand and the United Kingdom. When they left the workshop, Farmers of the Future had been transformed from a good idea into a well organized, highly structured initiative to strengthen the primary and secondary school curricula in countries that most depend on agriculture for their future.

Defining the problem

In April of 2002, UNESCO reported that four out of 10 primary-age children in sub-Saharan Africa do not go to school. Of those who do go to school, the report finds that only a small portion reach a basic level of skills. Sixteen countries in sub-Saharan Africa have declining enrollments and the same region accounts for one-third of the world's total out-of-school population. Yet these nations depend on agriculture for economic stability and, for the foreseeable future, these young people will continue to rely on farming and agricultural enterprises for their livelihoods.

The study of agriculture in many African school systems has had a pejorative past. In some countries, agriculture was taught in primary schools prior to independence, but was seen more as a punishment for errant pupils than a worthwhile educational pursuit, and in some countries the teaching of agriculture was discontinued immediately after independence was achieved. Agriculture was generally seen as relevant to African students only, resulting in negative connotations with both students and parents alike. In many African nations today these views still hold.

The need to change local perceptions of agricultural education was made clear in a 1999 RELMA study of education in Kenya and Tanzania. At that time, for example, the Tanzanian government wanted to provide agricultural education to students so that the majority would pursue productive lives in farming and remain in rural areas. Students, on the other hand, and their parents, want good academic educations that lead to secure urban-based jobs. In fact, parents have long helped their children to get as far away from farming as possible, in the belief that their children had little chance of making a better living from farming than they did.

For many African countries, achieving food security through successful agricultural development is a high priority. In addition, agriculture provides a major source of exports. But ecologically unsound farming practices are leading to the degradation of land resources, which will have grave consequences for food security. In Ethiopia, for example, nearly 17% of the potential GDP is being lost due to soil degradation. The need for better, more sustainable agriculture is very real, as is the need for teachers who can enthuse and educate a new generation of farmers. Long-term investment in agricultural education is essential, and governments must foster this investment.

School-community linkages

Workshop participants agreed that an important way to garner support for agricultural education is to reach out to rural communities through their children by establishing agricultural youth groups. Young people can and often do act as a conduit of information for their families. Agroforestry and effective natural resource management can flourish if the young are made an integral part of the transformation effort.

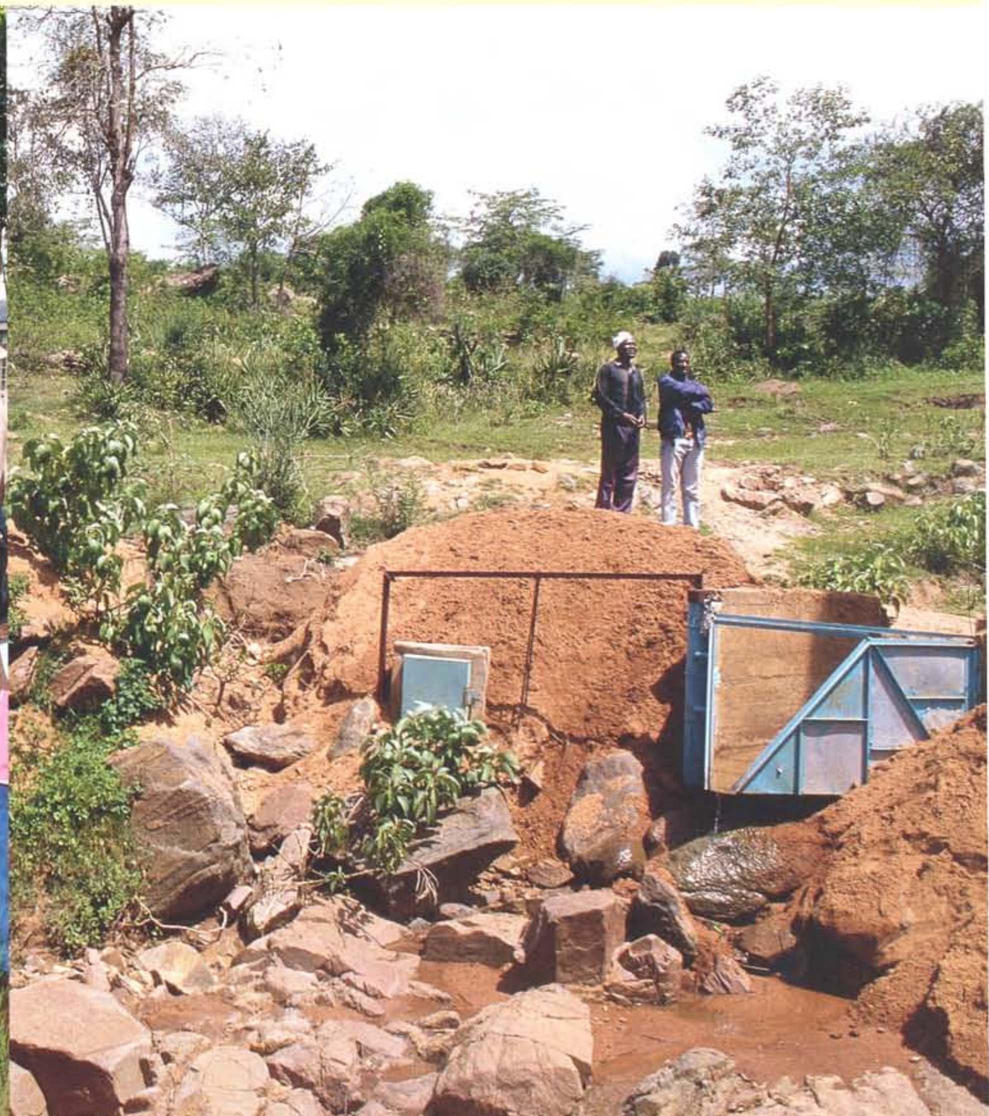
Similarly, women's groups often serve very useful advocacy roles in local communities. Young girls are the hardest to reach through educational programmes because of their comparatively low school enrollment. But the insights of women farmers have long been appreciated in development programmes, and workshop participants agreed that gender, agriculture, natural resource management, and the environment are inextricably linked. Natural resource management education should therefore focus on the different roles and responsibilities of men and women in the context of the overall social system. Curricula need to be designed to encourage girls to become involved, and stay involved.

Designing the future

Participants in the Farmers of the Future workshop left with clear roles in furthering the initiative. Teams were created to move forward on academic policy recommendations, public awareness and advocacy strategies, tracking and sharing funding information, the creation of pilot sites, furthering school-community linkages, the development of support materials, teaching and leadership competence, and distance-learning techniques. Because the workshop participants represented such a broad spectrum of education and government policy-makers, a multi-stakeholder approach to furthering the initiative is assured.

Despite their varied and diverse backgrounds and experiences in and around education and development initiatives, the Farmers of the Future workshop participants all agreed on one unassailable conviction: the future of farming in the developing world depends on the widespread adoption of improved farming practices, including agroforestry and natural resource management. Farming needs young people to champion its future and young people need the empowerment that accompanies becoming productive citizens of their communities and their nations.

Reading, Writing, and Rapidly Losing Indigenous Farming Knowledge? Making a career in farming both intellectually stimulating and potentially lucrative in the eyes of students can inspire them to see their education through. *A Njenga*

STRENGTHENING TRAINING AND EDUCATION IN AGROFORESTRY

THE MINISTRY OF FOREIGN AFFAIRS – Programme for Cooperation with International Institutes (SII) of the Netherlands' Government has been contributing to the World Agroforestry Centre's training activities for many years, mainly through sponsoring short training courses and the development of supporting teaching materials. This sponsorship enabled the Centre to implement a five-year project – which is ending in 2002 – aimed at facilitating the transfer of responsibility for basic agroforestry education to national institutions in several developing countries. A total of 355 professionals active in agroforestry education and training from 183 different institutions in 40 countries attended six regional planning workshops and seven courses focused on training-the-trainers. These courses provided attendees with knowledge and skills – both in terms of content and instructional delivery – to better teach various agroforestry-related subjects. This project also allowed the development of teaching materials for these introductory courses as well as for some specialized short courses in the areas of tree domestication and agroforestry research methodology.

In 2001, an international refresher course was held in Nairobi, Kenya, for the benefit of 40 participants selected among the participants in previous workshops and courses. The refresher course focused on recent advances in agroforestry research and development, and was taught primarily by the Centre's scientific staff, complemented by a number of external resource persons specialized in relevant areas outside the Centre's comparative advantage. In addition to updating themselves on content, participants also learned more about how to better teach complex subjects like agroforestry and natural resources management through a series of presentations and exercises related to instructional technology.

The Netherlands Government used the opportunity of this training course to conduct an external evaluation of the project as a whole. As a result of a very positive evaluation, the recommendation was made to develop a new phase of this training project with a focus on specialized training courses, taught by the Centre's scientific staff in close collaboration with its many training and education partners.

opposite, left: A Return to "Nursery" School: Participants in a World Agroforestry Centre refresher course visit an agroforestry tree nursery in Western Kenya. *opposite, right:* Eroding Vision: Revisiting erosion problems in the Lake Victoria Watershed area. *Both: A Njenga*

Greater species diversity


to buffer against risk.

BEYOND THE BOUTIQUES: INCREASING THE SCALE OF ADOPTION AND IMPACT

"…these projects reach only a small fraction of the population. Like expensive boutiques, they are only available to the lucky few." – Hans Binswanger, World Bank

THESE PROVOCATIVE WORDS FROM A RECENT PAPER published in *Science*[1] bemoan the failure to scale up successful developing country HIV/AIDS programmes to the national level. These "boutiques," often referred to in the agriculture and natural resources literature as "pilot projects," are paradoxically a source of both inspiration and frustration to scientists and development practitioners – irrespective of sector. They are often the subject of case studies, impact assessments, public awareness efforts, and are invariably used as a showpiece for visitors, ranging from students to farmers to presidents. The frustration comes when such projects invariably fail to be translated into high impact programmes at national or regional levels. In agroforestry, the challenge is to move beyond the boutiques in order to achieve scales of adoption and impact that bring better lives to millions of poor people in the near future.

It was this sense of urgency that compelled the World Agroforestry Centre to rethink its mission and approach. In 1998, the Centre set forth on a new and less-travelled path by unilaterally expanding its mandate to include a more proactive, hands-on approach to achieve greater impact. We created a Development Group to design and implement a strategy embodying creative new approaches and partnerships to extend the benefits of agroforestry to more people, more quickly, and more sustainably. Central to this effort has been a commitment to improving the understanding of the crucial factors that hasten or hinder the scaling up process in agroforestry (see "Scaling Up the Adoption of Agroforestry," p 80; and "The Science of Scaling Up," p 76).

In the southern Philippines, researchers working with farmers promoted the adoption of improved land management practices on sloping lands to mitigate erosion and open up opportunities for planting commercial tree crops. This "Landcare" approach has been proven to be effective in disseminating agroforestry practices, catalyzing community action and stimulating greater adoption and impact. We are now exploring the potential for adapting this approach to the problem of land degradation in Africa.

However, community-based approaches alone do not guarantee sustainable improvement in livelihoods. Agroforestry must be linked effectively with, and be responsive to, market demand, and smallholders must increasingly see their farms as business enterprises. For farmers, this implies the need to develop business skills, acquire better access to market information and focus greater attention on product quality and the opportunities for value adding. For research institutions, it means undertaking an agenda that reflects and anticipates trends in market demand. Market-driven agroforestry represents a significant conceptual departure from earlier approaches that focused on subsistence needs and looked at marketing as a problem rather than an opportunity. The case included here from Central Kenya illustrates the attractiveness of fodder trees – serving as a substitute for purchased inputs – when farmers are linked to markets: in this case, the growing urban demand for fresh milk (see "An Edible Idea: Increasing the Adoption of Fodder Shrubs," p 86).

The Centre is convinced that the impact of agroforestry research on food security, poverty reduction, and the environment will be realised more quickly and on a greater scale than in the past by directly engaging with farming communities, development institutions (both government and non-government), and the private sector. Research institutions in developing countries have to broaden their mandates to function as credible development and business partners. Only if farms are seen as business enterprises that are profitably serving the needs of society will the potential benefits of agroforestry research and development be realised and sustained beyond the "boutiques."

[1] Binswanger, Hans P (2000) "Scaling Up HIV/AIDS Programs to National Coverage." *Science* 228:2173–2176.

THE SCIENCE OF SCALING UP

For more than two decades agroforestry has been heralded and actively promoted as having the potential to deliver new livelihood options for farmers facing the acute problems of land degradation, poverty, and food insecurity in rural areas. The research of the World Agroforestry Centre and its many partners has shed light on both the opportunities and the limitations of agroforestry, and led to more critical assessments of its potential use. As a result, agroforestry has progressed from being an indigenous practice of apparently great potential and romantic appeal, to that of a science-based system for managing natural resources.

DURING THE MID-1990S, the farm-level impacts of agroforestry research were starting to show in limited areas in Africa and Asia. By 2000, 15,000 smallholders in western Kenya were using short-rotation leguminous fallows and biomass transfer to improve the fertility of depleted yet high-potential soils. In central Kenya, more than 10,000 farmers were planting tree legumes in fodder banks for use as an inexpensive protein supplement for their dairy cows. In Zambia, more than 10,000 farmers were using short-rotation improved fallows to restore soil fertility and increase maize crop yields. Hundreds of farmers in the semiarid Sahel region of West Africa were adopting live hedges to protect dry-season market gardens from roving livestock. And in Southeast Asia, similar success was being observed on degraded sloping lands where thousands of farmers in the southern Philippines were adopting contour hedgerow systems based on natural vegetative strips.

On-farm participatory research has played a crucial role in understanding and addressing the complexities of adoption of agroforestry practices. Farmers play an integral part in diagnosing problems, and in identifying and evaluating possible solutions. The result is better appreciation of farmer perspectives and constraints, a more focused, farmer-centred research agenda, and ultimately, higher levels of farmer adoption. The challenge now is to develop and implement strategies that will enable, not thousands, but millions of low-income farm families worldwide to benefit from improved agroforestry practices. Meeting that challenge means learning more about how agroforestry achieves positive impacts and how initiatives to scale up the adoption of agroforestry can be strengthened. And to do that, the rigor of science must be brought to bear.

opposite, left: A Growing Trend: Vegetatively propagating elite fruit trees in Cameroon. *J Beniest*
opposite, right: Wire-less Communication: Live fences control the movement of animals and people, protecting property and enriching the soil on this farm in Senegal, while providing fuelwood, fodder, and food. *G Denning*


Defining impact

Promoting and facilitating farmers to adopt agroforestry innovations is of course aimed at achieving positive impacts at the farm and landscape level. Yet there is still no clear understanding of the complexities of impact and how it should be measured. The impacts that result from adopting innovations can be broadly classified as economic, social, biophysical, and ecological – and are generally a combination of all four. To be more fully understood, impact has to be viewed from different spatial and temporal scales, as well as from the perspectives of different stakeholders.

Impact assessment is best undertaken through a framework that explicitly recognizes the existence of tradeoffs. For example, studies undertaken by the Alternatives to Slash-and-Burn Consortium in southern Cameroon demonstrated a clear tradeoff between global environmental benefits (carbon sequestration and biodiversity) and local profitability to farmers across a range of alternative land uses. The challenge is to understand the impact of adoption at these different scales (in this case: local versus global) and by different stakeholders (farmers versus the global community), and to optimize the tradeoffs across a range of assumptions. Policymakers can then use this information to apply various policy instruments (for example, market interventions, land reform, and infrastructure investments) that can affect the rate of adoption.

SCALING UP: MANY QUESTIONS REMAIN

In research, finding answers to one set of questions usually gives rise to even more questions, and the same is true when bringing the rigor of science to understanding the process of scaling up. A few key questions about scaling up that still need answering:

- How do we most effectively capture farmer innovation and ensure that scientific knowledge and indigenous knowledge are well integrated?
- What are the guiding principles for successful and sustainable farmer organizations, and how can we help such organizations to organize across villages to improve their efficiency and effectiveness?
- How can we facilitate farmer and community-based monitoring and evaluation?
- How can community-based production and marketing of seed be made institutionally and financially sustainable?
- How can we link small-scale farmer production to local, regional, and international markets?
- How can policymakers – at various levels – become effective promoters of local farmer organizations and agroforestry development?
- How can research institutions adapt functionally and structurally to be more effective partners in scaling up and, more broadly, in rural development?
- How can we devise more strategic partnerships and reduce their transaction costs?

Impact over different temporal scales is an issue that is especially relevant to agroforestry in the developing world. Low-income farmers tend to discount the potential long-term benefits of trees, opting instead for near-term practices that maximize food production and income. If the short-term effect on food production and income is negative, this can easily slow the spread of agroforestry practices that conserve and enhance the soil for the longer term. In contrast, farmers readily adopt agroforestry practices with near-term benefits, such as short-rotation improved fallows. The challenge for agroforestry research and development is to generate options that provide optimal tradeoffs between the long- and near-term needs and expectations of farmers.

Knowing our strengths

Meeting the challenges of more complex, heterogeneous, and often marginal environments requires more site-, farmer-, and community-specific solutions. To better understand these circumstances, researchers need to be closer to policy-makers as well as their more direct clients – smallholder farmers and the change agents who work with rural communities. The World Agroforestry Centre's research strategy has evolved in ways that make outputs more relevant to the real needs of the rural poor.

One of the Centre's strengths has been its ability to apply science to development through agroforestry. Rather than try to substitute for specialized institutions that have experience and expertise in development, the Centre has sought to add value to their efforts through strategically focused interventions. From being a scientific leader in agroforestry with unique global knowledge and experience in integrating trees in farming systems and rural landscapes, the Centre is now contributing to the work of its development partners by providing support, training and information, and by supplying seed.

But the work cannot stop there. Moving from having impact on tens of thousands of farm families to having impact on the tens of millions who could potentially benefit from improved agroforestry practices means knowing more about the scaling up process. A number of key issues and questions still need to be addressed (see sidebar p 78).

The developing world has no shortage of successful pilot projects. But these often well-publicized success stories have rarely been replicated on the scale needed to fully justify the investments made in them. Thus a demonstrated commitment of research institutions to development and a willingness to be held accountable for broader scale impacts are not only logical, but also social and economic prerequisites for future investments in agricultural research. As it looks to the future, the World Agroforestry Centre is building that commitment into its every effort.

Based on: "Realizing the potential of agroforestry: integrating research and development to achieve greater impact." G L Denning (2001) *Development in Practice* 11(4):407–416

Essential elements for scaling up agroforestry innovations

SCALING UP THE ADOPTION OF AGROFORESTRY

When the Centre initiated its development and scaling up activities four years ago, we adopted a "results-based" approach to the process, focusing the efforts of our scientists on bringing more benefits to more people over a wider geographical area, more quickly, more equitably, and more lastingly. A wide variety of approaches have been tried, but the combined experiences of our researchers and our many partners around the world show a strong convergence of factors that, to varying degrees, are critical to successful scaling up.

SCALING UP STARTS WITH IMPROVED AGROFORESTRY TECHNOLOGIES developed by farmers and researchers working together. This participatory approach to research is essential for identifying cost-effective options that are attractive to farmers. But why is providing different options to farmers so important?

Farmers face many different kinds of risks and they naturally seek to diversify sources of income in order to reduce their exposure. Individual technical options can, over time or through widespread use, succumb to pests or diseases. There are risks of market failures, as well as those associated with season-to-season variation in demand and supply. A variety of tree species and agroforestry options that diversify sources of income buffer farmers against these risks.

Practices that can be adapted to a range of different biophysical and socio-economic circumstances and farmer preferences are also important to successful scaling up. For example, improved fallow options in southern Africa include a range of species that can be planted by direct seeding or by growing seedlings in nurseries, and can be planted in pure stands or intercropped with maize. In addition, the different species offer different by-products, including food, natural pesticides, and wood for fuel and construction.

Farmer-centred research and extension

Research and extension efforts should begin and end with farmers, in order to generate attractive technical options, as well as respond effectively to any new problems that arise during the scaling up process. A number of farmer-centred activities are being used by World Agroforestry Centre scientists and their partners, including: participatory diagnostic surveys that help identify farmers' problems and opportunities; farmer preference surveys and market assessments that help establish priority species for research; helping farmers establish trials of their own design, in which they can test new practices and species on their own; and facilitating farmer-to-farmer learning.

Holding the Future in the Palm of her Hand: A Kenyan farmer in her community nursery. *A Njenga*

Several important lessons have emerged. First, the most effective way to reach large numbers of farmers is by working closely with a wide range of local development partners who themselves use participatory techniques and promote farmer experimentation and innovation. Second, even if numerous development partners are involved, it is generally more effective to work with established farmer groups, in addition to individuals, in order to ensure greater farmer-to-farmer dissemination and exchange of information. Third, it is important to conduct participatory research at the right scale. Research in Malawi, for example, indicates the need to involve a critical mass of the farmers in any given area – about 10% of the target group – in order to catalyze the uptake of new options. And fourth, the right farmers need to be involved. All too often, socio-economic circumstances limit the participation of the poor and women in participatory research efforts, even though they are often the key decision makers at the farm level.

Building local capacity

Strengthening local institutional capacity – not only for implementing agroforestry, but also for planning, implementing, and evaluating a broad range of development activities – is another key to successful scaling up. In Uganda, for example, participatory research helps build local capacity. Agroforestry researchers and development practitioners have helped communities conduct participatory mapping exercises to plan the planting of contour hedges on hillsides to curb soil erosion and provide fodder, stakes, and fuel wood. Farmers use the maps to calculate the numbers of seedlings they need and the numbers of seasons it will take to plant the required seedlings. They then use the information to decide how many tree nurseries are needed to supply the seedlings. Such participatory methods greatly increase farmers' motivation, willingness to participate in collective action, and sense of ownership over the development process.

Seeds and seedlings

Quality planting material and local systems for producing and distributing planting material are needed to sustain agroforestry development. High-quality, genetically diverse seed and seedlings are fundamental to success, as are participatory methods for developing such material. Several innovative systems of community-based seed supply and distribution have been tried. In central Kenya, facilitators are promoting community-based seed production and marketing through a range of partners – individual farmers, private nurseries, farmer groups, and seed vendors. And in four countries of southern Africa, farmers organized themselves to establish 800 seed multiplication plots and 6,000 nurseries in 2001 alone.

Marketing issues

Many agroforestry products, such as fruit and timber, can be sold and the potential benefits from marketing them are often huge. Most agroforestry research and development teams lack skills in marketing and product development. Farmers need to focus on market demand, that is, the needs and preferences of consumers and traders, when deciding what to produce. Facilitators need to link producers with traders and consumers to assure that there are markets for their products. Access to such expertise needs to be a high priority in scaling up.

Developing policy options

An enabling policy environment is critical for scaling up. Whereas policy research often focuses on the national level, World Agroforestry Centre studies highlight the importance of local policy makers, both traditional and governmental, in villages, districts and provinces. Agroforestry researchers and development staff work to understand and inform these decision makers about constraints to scaling up imposed by prevailing policies. For example, in parts of Kenya, ordinances require farmers to obtain a permit before cutting down trees, on the seemingly logical assumption that such measures protect trees. But they are actually a strong disincentive against planting trees, since farmers do not want to plant trees that they may not be able to harvest.

Learning from successes and failures

Pilot scaling up projects help scientists understand the constraints to, and impacts of, development initiatives under real-world conditions.

Sustainably Handling Nature's Bounty: New varieties of African plum (*Dacryodes edulis*) under development. *J Beniest*

Hypotheses can be tested concerning the influence of gender, wealth, researcher-to-farmer and farmer-to-farmer communication, and the role that community organizations play in promoting adoption of improved agroforestry practices and systems. Monitoring and evaluation serves to enhance learning among stakeholders. Feedback from farmers results in important modifications in recommendations, strategies, and policies. Surveys that monitor farmer plantings reveal farmers' preferences for tree species, in turn helping researchers to better meet farmers' needs.

Research has indicated the economic benefits to farmers adopting fodder trees and the huge potential benefits nationally if just half of Kenya's dairy farmers would adopt them (see "An Edible Idea: Increasing the Adoption of Fodder Shrubs," p 86). Such analyses provide important arguments to planners and donors for investing further in scaling up tree planting for improving farmer incomes and livelihoods.

Knowledge and information sharing

Sharing knowledge and information is vital to ensuring effective decision-making by stakeholders in the scaling up process. Farmer knowledge about individual species helps researchers select which ones to focus on, but even more important are farmer experimentation and the sharing of local knowledge among farmers themselves. In southern Africa, we facilitate farmer-to-farmer group training exercises, in which participants spend several days visiting farmers in other villages, sharing knowledge along with room and board. Continuous farmer experimentation, adaptation, and knowledge sharing are essential for ensuring that new practices are appropriate over large areas.

Strategic partnerships

The World Agroforestry Centre collaborates with more than 500 partner organizations in scaling up initiatives, but numbers alone are not what is important. Rather, it is the quality and effectiveness of those partnerships that makes the difference, that enable all involved to build on successes and learn from failures. But building effective partnerships is not easy. Transaction costs can be high, especially at first. Clarity in roles and responsibilities is needed, duplication of effort has to be minimized, and activities need to be carefully documented.

Some important partners, such as the government extension services in certain countries, may be relatively weak and have traditional, top-down approaches to working with farmers. Yet it is necessary to work closely with them, and to help them redefine their traditional role of delivering recommendations, to one of facilitating and coordinating participatory efforts to develop a range of options for farmers. Informal, biannual meetings at which partner organizations and farmers plan and review their agroforestry research and development activities are also proving to be an effective means for building sustainable partnerships. These "networkshops" lead to a sense of involvement, enthusiasm, and ownership of promising innovations.

Research on scaling up is needed

The scaling up of agroforestry practices is well underway, but in order to enhance the process, focused research is necessary. Indeed, if scaling up initiatives are to succeed, the rigor of science must be brought to bear on the process itself (see "The Science of Scaling Up," p 76). Many useful lessons are being derived from the scaling up efforts undertaken to date. Yet most of these lessons are based on informal analyses – the reflections of practitioners – rather than on rigorously planned research.

Still, in the absence of a complete understanding of the process, scaling up efforts can and should proceed. A key point to remember is that successful and sustainable scaling up normally requires more than simply transferring information and planting material to farmers. It often involves building institutional capacity in communities for promoting and sustaining innovations and the adoption process. And it surely involves adaptation, innovation, feedback and the expanded capabilities of farmers and researchers alike.

Based on: "Scaling up the benefits of agroforestry research: lessons learned and research challenges." S Franzel, P Cooper, GL Denning (2001) *Development in Practice* 11(4):524–534

Nurturing a Nursery: Tanzanian farmer carefully waters seedlings in her community nursery. *A Njenga*

AN EDIBLE IDEA: INCREASING THE ADOPTION OF FODDER SHRUBS

A significant constraint to increasing livestock productivity in sub-Saharan Africa is the low quality and quantity of feed. Research has clearly shown that fast-growing leguminous trees and shrubs, such as *Calliandra calothyrsus*, hold the potential for alleviating farmers' livestock feed problems. Fodder from these shrubs is rich in protein and, unlike grass species, the shrub leaves remain protein-rich even during the dry season.

FARMERS USE THE SHRUBS FOR HEDGES along boundaries and around the homestead, along contours, for prevention of soil erosion, and also for fuel wood. About 500 shrubs are needed to provide 6 kg of fresh fodder per day, throughout the year. Farmers use fodder shrubs either as a substitute for purchased dairy meal or as a feed supplement to increase milk production. Either way, 500 fodder shrubs add about US$ 130 per year to the income of farmers who adopt the technology, beginning the second year after planting. The potential impact of fodder trees appears to be very large. If just 50% of Kenya's estimated 625,000 smallholder farmers with dairy cows each planted 500 fodder shrubs, the net benefit per year could reach over US$ 80 million. Clearly, fodder shrubs provide great potential for increasing the income of smallholder dairy farmers.

Kenya's National Agroforestry Project

In the early 1990s, the Kenya Agricultural Research Institute (KARI), the Kenya Forestry Research Institute (KEFRI), and the World Agroforestry Centre collaborated in the National Agroforestry Research Project (NAFRP) to test calliandra and other fodder shrubs in on-station and participatory on-farm trials in Embu District of central Kenya. Calliandra was a clear success. Surveys conducted between 1995 and 1997 confirmed that the farmers were indeed adopting the shrub, expanding their plantings, and disseminating the practice to other farmers. The shrubs were in demand and an effective mechanism to spread the technology was needed.

In 1998, an initiative to introduce fodder shrubs to farmers across seven districts was established. This project was funded by the System-wide Livestock Programme (SLP) of the Consultative Group on International Agricultural

Home Grown: Fodder shrubs mean Kenya's dairy farmers no longer have to buy feed supplements to increase milk production. *A Njenga*

Research (CGIAR) and involved the World Agroforestry Centre, the International Livestock Research Institute (ILRI) and KARI.

Between 1999–2000, a project dissemination specialist worked with a number of field-based partner organizations to assist some 150 farmer groups (comprising about 2,600 farmers) to establish 250 calliandra nurseries. By the end of 2001, the number had increased to 180 farmer groups with about 3,200 farmers. Meetings were held with farmers to discuss the problems they had in feeding their cows and to explain to them the costs, benefits, and risks of planting fodder shrubs. Farmer-to-farmer visits were arranged with farmers from Embu who had already had several years of experience in growing and feeding calliandra to their dairy cows and goats. These farmers hosted others who had no such experience. Learning from farmers with experience in growing calliandra proved to be a very effective way to promote planting, enabling farmers to learn about its growth, management, and use.

Group members were taught how to produce and distribute calliandra seed. The shrub begins producing seed in its second year, but unfortunately it produces relatively little seed, and collecting it is laborious. Some farmers and private nurseries have begun selling calliandra seed and seedlings, and the numbers doing so are likely to increase as demand for the shrub increases.

The project has started disseminating other fodder shrub species, as well. Farmers in the region have planted *Leucaena trichandra*, *Morus alba* (Mulberry), and, to a lesser extent, the herbaceous legume *Desmodium intortum*. The reasons, of course, are that diversification of species reduces the risk of pest and disease attack, improves feed quality, and increases biodiversity.

The importance of farmer innovation and feedback

A key aspect of the initiative focuses on farmer feedback to project staff and researchers on their progress and problems. Such feedback has resulted in changes in official extension recommendations. For example, farmers in Kandara Division, Maragua District, conducted experiments on soaking calliandra seed before planting and found that seed soaked in cold water (at room temperature) for 48 to 60 hours had higher germination rates than those soaked for the recommended 24 hours. Researchers confirmed the farmers' findings and extension staff now recommend the longer soaking time and use of cold water.

Farmers' problems with pests and their innovations in controlling them have also led to the design of new on-farm trials. In 2001, for example, researchers and farmers compared the effectiveness of using netting to protect seedlings in their nurseries from crickets, hoppers, and aphids, compared to such locally developed practices as spraying seedlings with solutions made from tobacco, marigold, neem, hot pepper or *Tephrosia vogelii*. The findings clearly favoured the locally developed practices, demonstrating the importance of monitoring farmer innovations and feeding them back to research and extension.

The keys to successful scaling up

Informal and formal surveys have been conducted periodically to assess farmers' experiences with calliandra, the problems they encountered, and the main factors explaining adoption and successful group and nursery performance. Several factors have contributed to the remarkable achievements made so far in Embu and the central highlands of Kenya in general. First, the demand for fodder shrubs was huge, mainly because the shrubs save farmers money and require only small amounts of land and labour. The project area is noted for the dynamism of its farmers, and access to markets is fairly high, enhancing the adoption of new practices. Because the project works through partner organizations instead of directly with farmers, it is able to build on local organizational skills and knowledge, and reach far more farmers than would otherwise be possible.

Dissemination through farmer groups instead of individual farmers economized on scarce training skills and transportation. In addition, working with groups ensures greater farmer-to-farmer dissemination and exchange of information. The strong partnership between researchers, extension specialists and farmers facilitates the flow of critical information. This synergy optimizes output and yields more benefits to the farmers. Partnership with national research institutions provides farmers with knowledge, skills, and germplasm of improved fruit trees, maize, and potato varieties.

Still, important challenges remain. While the project has successfully expanded the use of fodder shrubs across the seven districts, it is still reaching only a small percentage of dairy farmers in these districts and less than 1% of Kenya's smallholder dairy farmers. Further scaling up is required, focusing on institutions working in areas of the country where smallholder dairy farmers predominate.

Commercial seed production and distribution are slowly emerging in project areas. But it is not clear if seed production will continue to grow and meet local demand. Greater emphasis is needed on promoting community-based seed production and distribution through a range of partners – farmer groups, individual seed producers, and private nurseries.

Greater diversification of fodder shrubs is needed to reduce the risk of pest and disease attacks, improve feed quality, and increase biodiversity. KARI-Embu has a strong programme for evaluating fodder trees and is increasing its emphasis on indigenous species.

More focus is needed to address the tree fodder needs of dairy farmers residing in high altitude areas (above 2,000 m above sea level) where the species that were tested in Embu do not perform well. Among the fodder species tested, only *Morus alba* can grow at this altitude, but it does so at a very slow rate and with very low yields per year.

A consortium of partners needs to be established for promoting fodder shrubs. While the SLP project was the hub of the informal network, providing seed and training, other organizations need to take over these functions in future years. Setting up periodic meetings of partners, including farmers, can help promote the exchange of skills, seed, and information, enhancing the spread of fodder shrubs.

And finally, extension materials need to be developed to promote calliandra and other fodder trees. Videos, brochures, leaflets, and posters are among the tools that will be most useful. But successful scaling up requires much more than transferring seed and knowledge about a new practice. To be sustainable, viable partnerships with a range of stakeholders must be forged. Local communities need assistance to effectively mobilize local and external resources for establishing nurseries. And effective participation of farmer groups and stakeholders in testing, disseminating, monitoring, and evaluating the practice is critical.

Based on: "Scaling up the use of fodder shrubs in Central Kenya." C Wambugu, S Franzel, P Tuwei, G Karanja (2001) *Development in Practice* 11(4):487–494

FINANCIAL REPORTS 2000–2001

INVESTOR SUPPORT, 2000

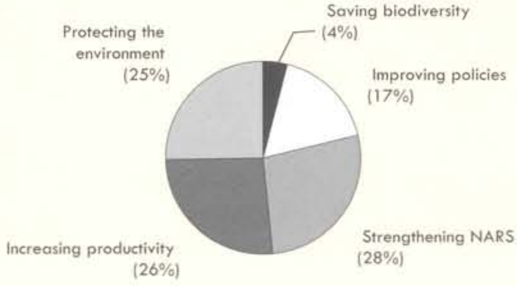
	Unrestricted US$ 000	Restricted US$ 000	Total US$ 000
World Bank	2,550	256	2,806
European Union		2,348	2,348
Canada			
CIDA	396	*1,542*	*1,938*
International Development Research Centre		352	352
Total Canada	396	1,894	2,290
Sweden	381	1,693	2,074
Netherlands	619	1,035	1,654
United States			
Unites States Agency for International Development	552	*544*	*1,096*
United States Department of Agriculture		*475*	*475*
Total USA	552	1,019	1,571
Miscellaneous	818	189	1,007
Japan	539	341	880
Switzerland	315	534	849
United Kingdom			
Department for International Development		786	786
Oxford Forestry Institute		*21*	*21*
Centre for Natural Resources and Development		*4*	*4*
Overseas Development Institute		*4*	*4*
Total UK		815	815
Denmark	264	543	807
Norway			
Norway	209	*190*	399
Norwegian Agency for Development Cooperation		290	290
Total Norway	209	480	689
France		530	530
Germany			
Duetsche Geselischaft for Technische Zusammenarbeit	245	200	445
German Development Service		*4*	*4*
Total Germany	245	204	449
Finland	314	85	399
International Fund for Agricultural Development		359	359
Asian Development Bank		340	340

	Unrestricted US$ 000	Restricted US$ 000	Total US$ 000
Rockefeller Foundation		278	278
Ford Foundation		259	259
Australia	127	102	229
Austria	200		200
Spain	25	168	193
Winrock International		154	154
New Zealand		150	150
Ireland	131		131
Kenya		117	117
Portugal	80		80
Belgium	68	5	73
Indonesia Forest Seed Project		66	66
University of Wisconsin system		37	37
World Vision		32	32
Private contributions		28	28
World Resources Institute		26	26
Kenya Agricultural Research Institute		21	21
Tropical Soil Biology and Fertility Programme		19	19
Philippines	17		17
Centre for Agriculture and Biosciences International		15	15
United Nations Environmental Programme		12	12
African Academy of Sciences		8	8
Cornell International Institute for Food, Agriculture and Development		5	5
Thailand	4		4
Sasakawa Foundation		3	3
Food and Agriculture Organization of the United Nations		2	2
World Food Prize Programme		2	2
International Foundation for Sciences		1	1
Centro Internacional de Agricultural Tropical, Colombia		157	157
International Livestock Research Institute		114	114
International Food Policy Research Institute		48	48
International Plant Genetic Resources Institute		14	14
TOTAL	**7,854**	**14,508**	**22,362**

CENTRE RESEARCH AGENDA BY CGIAR ACTIVITY IN 2000

	US$ 000	Percentage
Increasing productivity	5,470	26
Protecting the environment	5,240	25
Saving biodiversity	850	4
Improving policies	3,510	17
Strengthening NARS	5,690	28
Total	**20,760**	**100**

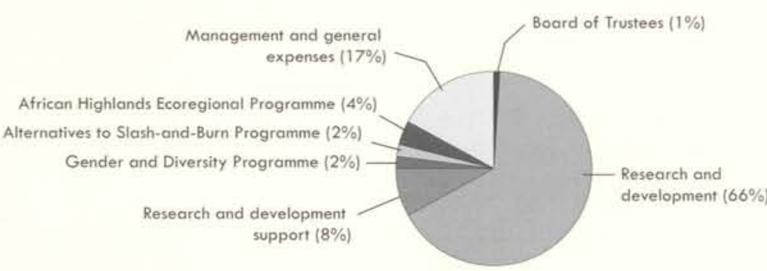
Allocation of resources by CGIAR activity



CENTRE EXPENDITURES, 2000

	US$ 000	Percentage
Board of Trustees	295	1
Research and development	13,639	66
Research and development support	1,711	8
Gender and Diversity Programme	348	2
Alternatives to Slash-and-Burn Programme	492	2
African Highlands Ecoregional Programme	770	4
Management and general expenses	3,505	17
Total	**20,760**	**100**

Expenditures 2000



INVESTOR SUPPORT, 2001

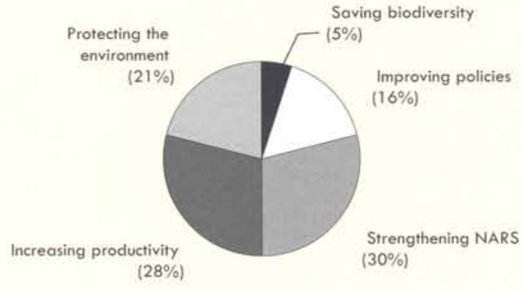
	Unrestricted US$ 000	Restricted US$ 000	Total US$ 000
World Bank	2,340	398	2,738
Canada			
CIDA	*378*	*1,564*	*1,942*
International Development Research Centre		*533*	*533*
Total Canada	378	2,097	2,475
Sweden	339	2,025	2,364
European Union		2,127	2,127
Netherlands	576	1,089	1,665
United States			
United States Department of Agriculture		*148*	*148*
Unites States of America	*598*	*874*	*1,472*
Total USA	598	1,022	1,620
Norway			
Norway	*198*	*436*	*634*
Norwegian Agency for Development Cooperation		*340*	*340*
Total Norway	198	776	974
Miscellaneous	713	183	896
Switzerland	290	564	854
United Kingdom			
Department for International Development		*782*	*782*
Overseas Development Institute		*4*	*4*
Oxford Forestry Institute		*18*	*18*
Centre for Natural Resources and Development		*2*	*2*
Royal Botanical Gardens Edinburgh		*3*	*3*
Total UK		809	809
Denmark	260	488	748
Japan	354	331	685
International Fund for Agricultural Development		603	603
Rockefeller Foundation		506	506
France		431	431
Finland	284	86	370
Germany			
Duetsche Geselischaft for Technische Zusammenarbeit	*187*	*145*	*332*
German Development Service		*3*	*3*
Total Germany	187	148	335
Ford Foundation		283	283
Ireland	253		253

	Unrestricted US$ 000	Restricted US$ 000	Total US$ 000
Spain		244	244
Austria	200		200
New Zealand		150	150
Australia	99	37	136
Italy		117	117
Belgium	99		99
International Food Policy Research Institute		94	94
Indonesia Forest Seed Project		88	88
Regional Land Management Unit		85	85
International Livestock Research Institute		71	71
Kenya Agricultural Research Institute		58	58
CARE International		57	57
International Rice Research Institute		54	54
Biodiversity Transect Monitoring Analysis in Africa		49	49
University of Wisconsin system		35	35
Asian Development Bank		31	31
International Center for Tropical Agriculture		30	30
Winrock International		29	29
World Resources Institute		25	25
Private contributions		25	25
Thailand	21		21
World Vision International		20	20
Tropical Soil Biology and Fertility Programme		17	17
Service Centre for Development Cooperation		16	16
Common Fund for Commodities		15	15
Global Mountain Programme		14	14
United Nations Environment Programme		12	12
Forest Action Network		9	9
Philippines	6		6
International Foundation for Science		5	5
Technical committee of the Global Water Partnership		4	4
Cornell International Institute for Food, Agriculture and Development		3	3
Donner Foundation		3	3
International Atomic Energy Agency		2	2
World Food Prize Programme		2	2
TOTAL	**7,195**	**15,367**	**22,562**

CENTRE RESEARCH AGENDA BY CGIAR ACTIVITY IN 2001

	US$ 000	Percentage
Increasing productivity	6,544	28
Protecting the environment	4,807	21
Saving biodiversity	1,244	5
Improving policies	3,679	16
Strengthening NARS	6,972	30
Total	**23,246**	**100**

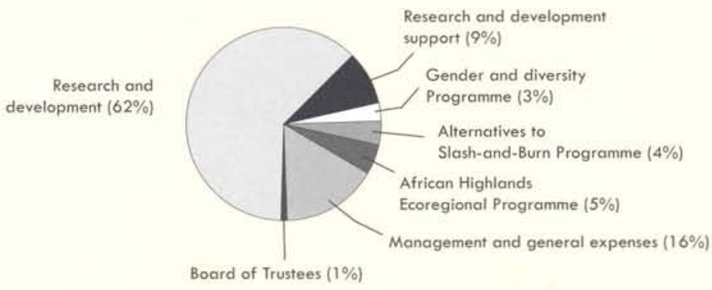
Allocation of resources by CGIAR activity



CENTRE EXPENDITURES, 2001

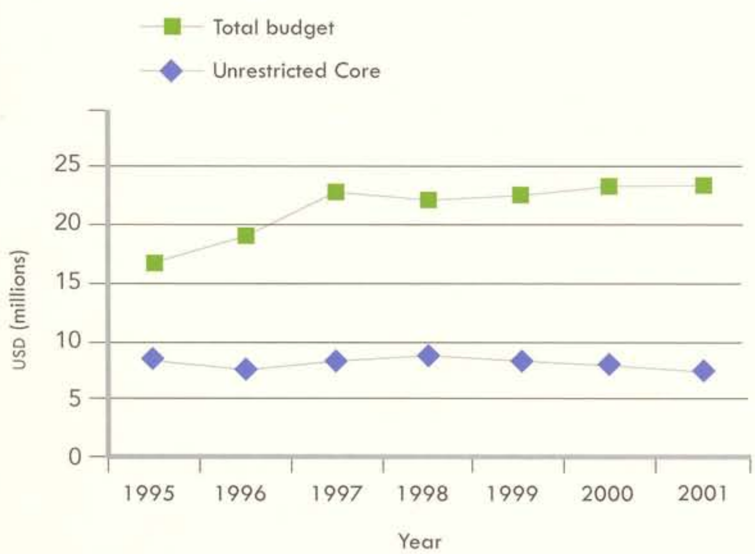
	US$ 000	Percentage
Board of Trustees	268	1
Research and development	14,452	62
Research and development support	2,032	9
Gender and Diversity Programme	563	3
Alternatives to Slash-and-Burn Programme	991	4
African Highlands Ecoregional Programme	1,165	5
Management and general expenses	3,775	16
Total	**23,246**	**100**

Expenditures 2001



CENTRE FUNDING (USD millions)

Year	*1995*	*1996*	*1997*	*1998*	*1999*	2000	*2001*
Unrestricted Core	8,147	7,603	7,787	8,337	8,048	7,854	7,195
Total	**16,622**	**18,063**	**22,186**	**21,326**	**21,431**	**22,362**	**22,562**



BOARD OF TRUSTEES AS OF JUNE 2002

PROFESSIONAL STAFF AS OF JUNE 2002

STATION

OFFICE OF THE DIRECTOR GENERAL

Dennis P Garrity USA, Director General (from October 2001) — Kenya
AN (Kijo) Waruhiu Kenya, Consultant to the Director General — Kenya
George Mbiriri Kenya, Protocol Officer — Kenya
Justina Nthenge Kenya, Internal Auditor — Kenya

OFFICE OF THE DIRECTOR OF RESEARCH

Anne-Marie N Izac France, Director of Research — Kenya
Elisabeth Feleke Ethiopia, Research Management Officer — Kenya

OFFICE OF THE DIRECTOR OF DEVELOPMENT

Glenn L Denning Australia, Director of Development — Kenya
Catherine Kenyatta UK, Development Management Officer — Kenya

OFFICE OF THE DIRECTOR OF MANAGEMENT SERVICES

Tiff Harris USA, Director of Management Services — Kenya
Jimmy Kiio Kenya, Visitors and Conferences Officer — Kenya
Alex Diang'a Kenya, Public Awareness Officer — Kenya

LATIN AMERICA

Rubén Guevara Honduras, Regional Coordinator — Peru
Julio C Alegre Peru, Senior Soil Scientist — Peru
Luis A Arévalo Peru, Research Officer — Peru
Carmen Sotelo Montes Peru, Forester — Peru
Edgar Pepe Peru, Natural Resources Economist — Peru

SOUTHEAST ASIA

Meine van Noordwijk Netherlands, Regional Coordinator — Indonesia
David E Thomas USA, Senior Policy Analyst — Thailand
Chip Fay USA, Senior Policy Analyst — Indonesia
Marian Delos Angeles Philippines, Senior Environmental Policy Economist — Indonesia
Grégoire Vincent France, Biologist — Indonesia
James M Roshetko USA, Integrated Natural Resource Management Specialist — Indonesia
Per Rudebjer Sweden, Capacity-Building Specialist — Indonesia
Dominique Boutin France, Tree–crop Specialist — Indonesia
Laxman Joshi Nepal, Ethnoecologist — Indonesia
Bruno JP Verbist Belgium, Associate Training Officer, Forester — Indonesia
Nathan Badenoch USA, Associate Policy Research Scientist — Thailand
Manuel García Bertomeu Spain, Postdoctoral Fellow, AECI Project Co-Manager — Philippines
Marco Stark Germany, Postdoctoral Fellow — Philippines
Delia C Catacutan Philippines, Natural Resource Management Research Officer — Philippines
Pratiknyo Purnomosidhi Indonesia, Associate Research Officer — Indonesia
Agustin R Mercado, Jr Philippines, Associate Research Officer — Philippines
Wie M Josephine Prasetyo Indonesia, Regional Administrative Officer — Indonesia
Betha Lusiana Indonesia, Associate Research Officer — Indonesia
Pornwilai Saipothong Thailand, Associate Research Officer — Thailand
Martua T Sirait Indonesia, Associate Research Officer, Comm. Forestry Policy — Indonesia
Suseno Budidarsono Indonesia, Associate Research Officer, Agricultural Economist — Indonesia
Ratna Akiefnawati Indonesia, Associate Research Officer/Field Manager — Indonesia
Gerhard ES Manurung Indonesia, Associate Research Officer — Indonesia
Danan Prasetyo Hadi Indonesia, Assistant Research Officer, GIS — Indonesia
Lyndon J Arbes Philippines, Landcare Facilitator — Philippines
Ma Aurora C Laotoco Philippines, Landcare Facilitator — Philippines
Gerardo C Boy Philippines, Landcare Facilitator — Philippines
Chun K Lai USA, Senior Capacity-Building Specialist (Consultant) — Philippines
Suyanto Indonesia, Social Economist — Indonesia
Johan Iwald Sweden, Associate Researcher, Agronomist — Vietnam
Min Ha Fagerstrom Sweden, Postdoctoral Fellow — Vietnam

EASTERN AND CENTRAL AFRICA

Bashir A Jama Kenya, Regional Coordinator — Kenya
Christophe G Zaongo Burkina Faso, Senior Soil Scientist — Rwanda
Markus G Walsh Germany, Landscape Ecologist — Kenya

Jean-Marc Boffa France, Tree Domestication and Biodiversity Scientist	Uganda
Anja Gadgaard Boye Denmark, Research Associate, Soil Science	Kenya
Teresa Borelli Italy, Research Associate, Soil Science	Kenya
Peter NW Kurira Kenya, Research Officer, Farm Manager	Kenya
Moses N Mathuva Kenya, Research Officer	Kenya
Qureish Noordin Kenya, Extension Specialist	Kenya
Stephen N Ruigu Kenya, Associate Research Officer	Kenya
J Patrick Kagorora Uganda, Dissemination Specialist Officer, AFRENA	Uganda
Samuel K Muriithi Kenya, Environmental Economist	Kenya
Bernard Amwine Uganda, Publications Officer	Uganda
Levand Turyomurugyendo Uganda, Biodiversity Specialist	Uganda
Benson Tumusiime Uganda, Acacia Telecentre Information Officer	Uganda
David Nyantika Kenya, Research Extension Liaison Officer	Kenya
Girma Hailu Ethiopia, Postdoctoral Fellow	Kenya
Serigne Tacko Kandji Senegal, Postdoctoral Fellow	Kenya
Cephas Nzanana Rwanda, Postdoctoral Fellow	Rwanda
Almaz Tefera Ethiopia, Postdoctoral Fellow	Kenya
Athanase Mukuralinda Rwanda, Postdoctoral Fellow	Rwanda
Benjamin Kibor Kenya, Postdoctoral Fellow	Kenya
Mwangi Hai Kenya, Postdoctoral Fellow	Kenya
Neville Millar UK, Postdoctoral Fellow	Kenya
Wilson Bamwerinde Uganda, Postdoctoral Fellow	Uganda
Margaret Mwangi Kenya, Postdoctoral Fellow	Kenya
Félicité Nsanzabera Rwanda, Postdoctoral Fellow	Rwanda
Vincent Nzeyimana Rwanda, Postdoctoral Fellow	Rwanda
Sylvie Karasira Rwanda, Postdoctoral Fellow	Rwanda
Nelson Muhayimana Rwanda, Postdoctoral Fellow	Rwanda
Sylvere Nzeyimana Rwanda, Postdoctoral Fellow	Rwanda
Else Buenemann Germany, Postdoctoral Fellow	Kenya
Eric Manimpaye Rwanda, Postdoctoral Fellow	Rwanda
Catherine Muthuri Kenya, Postdoctoral Fellow	Kenya
Nelson Wajja-Musukwe Uganda, Postdoctoral Fellow	Uganda
John Baptiste Tumuhairwe Uganda, Postdoctoral Fellow	Uganda
Marius Gunga Kenya, Postdoctoral Fellow	Kenya
David Siriri Uganda, Soil Scientist	Uganda
John Okorio Uganda, Coordinator, UGADEN	Uganda

SOUTHERN AFRICA

Freddie Kwesiga Uganda, Regional Coordinator	Zimbabwe
Andreas Böhringer Germany, Senior Scientist and Development Leader	Malawi
Paramu L Mafongoya Zimbabwe, Soil Scientist	Zambia
Festus K Akinnifesi Nigeria, Tree Scientist/ Horticulturist	Malawi
Patrick Matakala Zambia, Agroforestry Project Leader, Liaison Scientist	Mozambique
Lewis Hove Zimbabwe, Liaison Scientist	Zimbabwe
Aggrey Agumya Uganda, GIS Specialist	Zimbabwe
Olu Oluyede Ajayi Nigeria, Postdoctoral Fellow	Zambia
Caroline Jacquet de Haveskercke Belgium, Associate Scientist	Zimbabwe
Joacim Skagerfält Sweden, Associate Scientist	Zimbabwe
Esben Brandi-Hansen Denmark, Associate Scientist	Malawi
Rosa Katanga Zambia, Agroforestry Development Facilitator	Zambia
Stephen Ruvuga Tanzania, Agroforestry Development Facilitator	Tanzania
Thomson Chilanga Malawi, Horticulturist, Technology Transfer Specialist	Malawi
Jarret Mhango Malawi, Horticulturist	Malawi
Alfred Mkonda Zambia Horticulturist	Zambia
Josephine Mulando Matibini Zambia, Herbage Chemist	Zambia
Remen EA Swai Tanzania, Liaison Scientist, Indigenous Fruit Tree Research	Tanzania
Catherine Masaka Zimbabwe, Regional Finance and Administration Officer	Zimbabwe
Livai Matarirano Zimbabwe, Agroforestry Development Facilitator	Zimbabwe
Elias Kuntashula Zambia, On-farm Research Specialist	Zambia
Stephen M Maduka Tanzania, Research Assistant	Tanzania
Mbiki Mumba Tanzania, Scientist	Tanzania
Benjamin Gama Tanzania, Research Officer	Tanzania
Martin Usekwa Tanzania, Research Officer	Tanzania
Wilkson Makumba Malawi, Soil Scientist	Malawi
Lawrence Mbwambo Tanzania, Research Officer	Tanzania
Damas Shirima Tanzania, Research Officer	Tanzania
Teddy Shuma Chirwa Zambia, Postdoctoral Fellow	Zambia
Sileshi Gudeta Weldesemayat Ethiopia, Consultant	Zambia
Paxie Chirwa Malawi, Postdoctoral Fellow	Malawi
Gerson Nyadzi Tanzania, Postdoctoral Fellow	Mozambique

Donati Asenga Tanzania, Postdoctoral Fellow — Tanzania
Rashid BR Msangi Tanzania, Postdoctoral Fellow — Tanzania

SAHEL

Amadou Ibra Niang Senegal, Regional Coordinator — Mali
Claude Adandedjan Benin, Animal Scientist (Senior Education Fellow) — Mali
Cheick Oumar Traoré Mali, Scientific Officer — Mali
Brehima Kone Mali, Scientific Officer — Mali
Bakary Thiero Mali, Research Extension Liaison Officer — Mali
Mamadou Sidibe Mali, Forester — Mali
Souleymane Keita Mali, Technician — Mali
Maguette Kaire Senegal, Ecologist — Senegal
Andre B Bationo Burkina Faso, Ecologist — Burkina Faso
Larwanou Mahamanesoil Niger, Forester — Niger
Mamadou Coulibaly Mali, Finance and Administration Officer — Mali

PROGRAMME 1. NATURAL RESOURCE PROBLEMS, PRIORITIES AND POLICIES

Brent Swallow Canada, Programme Leader — Kenya
Keith Shepherd UK, Senior Soil Scientist — Kenya
Frank M Place USA, Economist — Kenya
Robert Zomer USA, Ecologist — Kenya
Eija Soini Finland, Associate Geographer — Kenya
Horst Weyerhaeuser Germany, Senior Natural Resource Management Researcher — China
Alex O Awiti Kenya, GIS Analyst — Kenya
Justine Wangila Kenya, Associate Economist — Kenya
David N Mungai Kenya, Land Use Hydrologist (Consultant) — Kenya

PROGRAMME 2. DOMESTICATION OF AGROFORESTRY TREES

Anthony J Simons UK, Programme Leader — Kenya
Zacharie Tchoundjeu Cameroon, Senior Scientist — Cameroon
Zenroku Oginosako Japan, Plant Ecologist — Kenya
Elisabeth Betser UK, Consultant, Associate Scientist – Tree Improvement — Cameroon
Roeland Kindt Belgium, Associate Ethnobotanist — Kenya
Ann Degrande Belgium, Associate Socioeconomist — Cameroon
William Frost UK, Associate Agroforester — Kenya
Ahmed S Salim Kenya, Database Specialist — Kenya
Ebenezar Asaah Cameroon, Vegetative Propagation Assistant Researcher — Cameroon
Charly Facheux Cameroon, Market Specialist — Cameroon
Peter Mbile Cameroon, On-farm Specialist — Cameroon
Edouard Kengni Cameroon, Postdoctoral Fellow — Cameroon
Marie Louise Avana Tiencheu Cameroon, Postdoctoral Fellow — Cameroon
Marie-Laure Ngo Mpec Cameroon, Postdoctoral Fellow — Cameroon
Roger Fankam Cameroon, Postdoctoral Fellow — Cameroon
Jacques Kanmegne Cameroon, Postdoctoral Fellow — Cameroon

PROGRAMME 3. ECOSYSTEM PROCESSES AND MANAGEMENT

Louis Verchot USA, Programme Leader — Kenya
Alain Albrecht France, Senior Soil Scientist — Kenya
Pia Barklund Sweden, Senior Scientist, Pests and Diseases — Kenya
KPC Rao India, Soil Scientist — Kenya
Girma Hailu Ethiopia, Postdoctoral Fellow — Kenya
Sileshi Gudeta Ethiopia, Postdoctoral Fellow — Zambia

PROGRAMME 4. ADVANCING INNOVATION AND IMPACT

Diane Russell USA, Programme Leader — Kenya
Steven C Franzel USA, Principal Scientist — Kenya
Chin Kooi Ong Malaysia, Principal Plant Physiologist — Kenya
Jens-Peter Barnekow Lillesø Denmark, Seed Supply Specialist — Kenya
Charles Wambugu Kenya, Dissemination Extension Specialist — Kenya

PROGRAMME 5. TRAINING AND EDUCATION

August B Temu Tanzania, Programme Leader — Kenya
Jan MK Beniest Belgium, Principal Training Officer — Kenya
Kebadire Khola Mogotsi Botswana, Senior Education Fellow — Kenya
Tom Vandenbosch Belgium, Associate Scientist — Kenya
Janet Awimbo Kenya, Training Officer — Kenya

ALTERNATIVES TO SLASH-AND-BURN PROGRAMME

Thomas P Tomich USA, Coordinator — Kenya
Jessa Lewis USA, Programme Associate — Kenya

AFRICAN HIGHLANDS ECOREGIONAL PROGRAMME

Ann Stroud USA, Coordinator — Uganda
Laura German USA, Social Ecologist — Uganda
Chris Opondo Kenya, Monitoring and Evaluation Regional Research Fellow — Uganda

Michael Ocilaje Uganda, Development Communication Specialist	Uganda
Olive Kyampaire Uganda, Project Officer	Uganda

GENDER AND DIVERSITY PROGRAMME

Vicki Wilde USA, Programme Leader	Kenya

RESEARCH SUPPORT UNIT

Richard Coe UK, Principal Scientist	Kenya
Peter K Muraya Kenya, Associate Scientist – Computer Applications	Kenya
Wim Buysse Belgium, Associate Expert Support Training	Kenya
Marie J Rarieya Kenya, Associate Data Processing Officer	Kenya

INFORMATION AND CREATIVE SERVICES UNIT

Kellen Kebaara Kenya, Information Officer	Kenya
Anthony M Njenga Kenya, Audiovisual Officer	Kenya
William E Umbima Kenya, Head Librarian	Kenya
Gregory O Agola Kenya, Information Systems Programmer	Kenya
Conrad Mudibo Kenya, Associate Graphic Arts Officer	Kenya
McOwiti O Thomas Kenya, Public Awareness Officer (on study leave)	Kenya

HUMAN RESOURCES UNIT

Beatrice Kimani Kenya, Deputy Head of Human Resources	Kenya
Margaret M DeSouza Kenya, Human Resources Officer	Kenya

FINANCIAL SERVICES UNIT

Laksiri Abeysekera Sri Lanka, Financial Controller	Kenya
Harkiran Lalani Kenya, Manager, Budget, and Project Administration	Kenya
Ernest Gatoru Kenya, Manager, Corporate Accounting	Kenya
Kennedy Auka Kenya, Treasury Accountant	Kenya
Muoki Nzioka Kenya, Accountant, Budget, and Project Administration	Kenya
Linus Kabutha Githuku Kenya, Manager, Financial Information Systems	Kenya
Joan Muasa Kenya, Accountant, Budget, and Project Administration	Kenya

INFORMATION TECHNOLOGY UNIT

Ian Moore UK, Information Technology Manager	Kenya
Lawrence Nguri Kenya, LAN Systems Administrator	Kenya
Juma Lumumba Kenya, Network Administrator	Kenya

PROGRAMME DEVELOPMENT UNIT

Judith Killen USA, Head	Kenya

OPERATIONS UNIT

Barnabas O Inyaa Kenya, Acting Head of Operations	Kenya
Mahmouda Hamoud Kenya, Travel Officer	Kenya
John Bruce Omyonga Kenya, Assistant Operations Officer	Kenya

STAFF PUBLICATIONS AS OF DECEMBER 2001

BOOKS AND BOOK-LENGTH PUBLICATIONS

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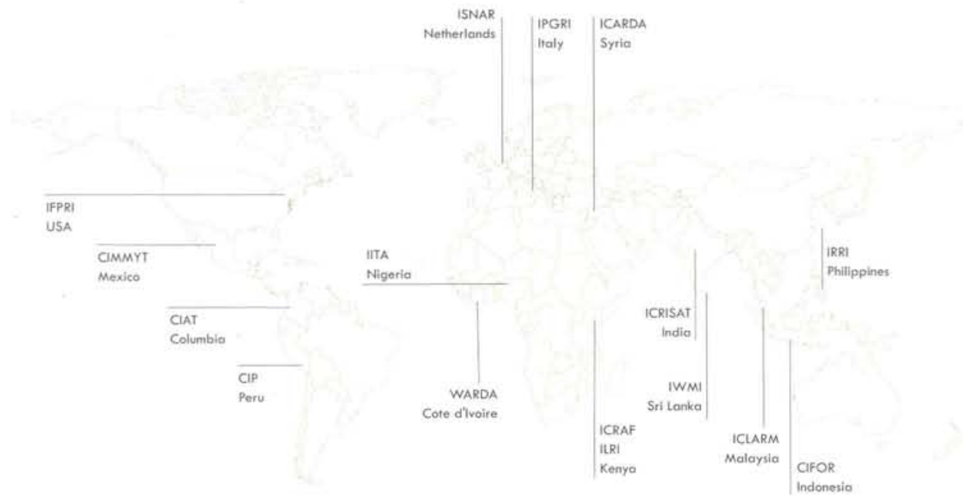

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ICRAF – International Centre for Research in Agroforestry
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CGIAR

CONTRIBUTORS

Managing Editor/Writer: **Leslie Rose**
Contributing Editors: **Glenn Denning, Tiff Harris, Tony Simons, Brent Swallow, August Temu, Lou Verchot**
Design Advisor: **Conrad Mudibo**
Design Assistance: **Bainitus Alenga, Akim Mbeche**
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PHOTO CREDITS

Front cover	*C Ong*
p 2	*J Baxter*
p 3	*J Baxter*
p 4	*A Njenga*
p 8	*left to right: J Beniest; B Huggan*
p 12	*A Njenga*
p 26	*left to right: A Njenga; T Harris; J Beniest*
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p 73	*G Denning*
p 75	*A Njenga*
p 112	*G Denning*
p 113	*T Tomich*

CONTACT US

Headquarters

World Agroforestry Centre (ICRAF)
United Nations Avenue, Gigiri
PO Box 30677
Nairobi, 00100 GPO
Kenya
Telephone: +254 2 524000 or via USA +1 650 833 6645
Fax: +254 2 524001 or via USA +1 650 833 6646
email: ICRAF@cgiar.org
www.worldagroforestrycentre.org

Regional Offices

Eastern and Central Africa Regional Programme

United Nations Avenue, Gigiri
PO Box 30677
Nairobi, 00100 GPO
Kenya
Telephone: +254 2 524000 or via USA +1 650 833 6645
Fax: +254 2 524001 via USA +1 650 833 6646
Regional Coordinator: Bashir Jama
email: b.jama@cgiar.org

Southern Africa Regional Programme

SADC-ICRAF Regional Agroforestry Programme
PO Box MP 128, Mount Pleasant
Zimbabwe
Telephone: +263 4 301807
Fax: +263 4 301327
Regional Coordinator: Freddie Kwesiga
email: fkwesiga@cgiar.org

Sahel Regional Programme

c/o ICRISAT
BP 320, Bamako
Mali
Telephone: +223 223375/227707
Fax: +223 228683
Regional Coordinator: Amadou Niang
email: a.niang@cgiar.org

Southeast Asia Regional Programme

Jl. CIFOR, Situ Gede, Sindang Barang, Bogor 16680
PO Box 161
Bogor 16001
Indonesia
Telephone: +62 251 625 415 or via USA +1 650 833 6665
Fax: +62 251 625 416 or via USA +1 650 833 6666
Regional Coordinator: Meine van Noordwijk
email: m.van-noordwijk@cgiar.org
www.worldagroforestrycentre.org/sea

Latin America Regional Programme

c/o INIA-CENFOR
Carretera Federico Basadre Km 4.2
Apartado Postal 558
Pucallpa
Peru
Telephone: +51 64 578704
Fax: +51 64 51 64 579078
Regional Coordinator: Rubén Guevara
email: ruben.guevara@cgiar.org

World Agroforestry Centre
TRANSFORMING LIVES AND LANDSCAPES

International Centre for Research in Agroforestry (ICRAF)
United Nations Avenue PO Box 30677 Nairobi, Kenya
Phone: +254 2 524000 Fax: +254 2 524001
Contact via the USA: Phone: +1 650 833 6645 Fax: +1 650 833 6646
Email: icraf@cgiar.org www.worldagroforestrycentre.org

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