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Agroforestry and the achievement of the Millennium Development Goals

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Abstract

The Millennium Development Goals (MDGs) of the United Nations (UN) are at the heart of the global development agenda. This chapter examines the role of agroforestry research and development (R&D) in light of the MDGs. It reviews some of the ways in which agroforestry is substantively assisting to achieve the goals and discusses how the agenda can be realigned to further increase its effectiveness in helping developing countries to meet their MDG targets. Promising agroforestry pathways to increase on-farm food production and income contribute to the first MDG, which aims to cut the number of hungry and desperately poor by at least half by 2015. Such pathways include fertilizer tree systems for smallholders with limited access to adequate crop nutrients, and expanded tree cropping and improved tree product processing and marketing. These advances can also help address lack of enterprise opportunities on small-scale farms, inequitable returns to small-scale farmers (especially women), child malnutrition, and national tree-product deficits (especially timber). The rate of return to investment in research on tree crops is quite high (88%); but enterprise development and enhancement of tree-product marketing has been badly neglected. The products, processing, and marketing of tree products and services, through tree domestication and the commercialization of their products is a new frontier for agroforestry R&D. A major role for agroforestry also is emerging in the domain of environmental services. This entails the development of mechanisms to reward the rural poor for the environmental services such as watershed protection and carbon sequestration that they provide to society. Agroforestry R&D is contributing to virtually all of the MDGs. But recognition for that role must be won by ensuring that more developing countries have national agroforestry strategies, and that agroforestry is a recognized part of their programs to achieve the MDGs.

Introduction

At the United Nations Millennium Summit in September 2000 in New York, world leaders agreed to a set of time-bound and measurable goals for combating hunger, poverty, disease, illiteracy, environmental degradation, and discrimination against women. These Millennium Development Goals (MDGs) (see Table 1) are now at the heart of the global development agenda. The Summit's Millennium Declaration also outlined a plan for how to proceed to achieve the goals (www.un.org/millennium). Leaders from both developed and developing countries have started to match these commitments with resources and action, signaling the evolution of a global deal in which sustained political and economic reform by developing countries will be matched by greater support from the developed world in the form of aid, trade, debt relief, and investment. The MDGs provide a framework for all nations, and the entire development community, to work coherently together toward this common end.

In preparation for the August 2002 World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa, UN Secretary-General Kofi Annan proposed the WEHAB initiative to provide focus and impetus to action in the five key thematic areas of Water, Energy, Health, Agriculture

Table 1. The United Nations Millennium Development Goals.

Goal 1. Eradicate extreme poverty and hunger	*Target for 2015: Halve the proportion of people living on less than a dollar a day and those who suffer from hunger.*
Goal 2. Achieve universal primary education	*Target for 2015: Ensure that all boys and girls complete primary school.*
Goal 3. Promote gender equality and empower women	*Targets for 2005 and 2015: Eliminate gender disparities in primary and secondary education preferably by 2005, and at all levels by 2015.*
Goal 4. Reduce child mortality	*Target for 2015: Reduce by two thirds the mortality rate among children under five*
Goal 5. Improve maternal health	*Target for 2015: Reduce by three-quarters the ratio of women dying in childbirth.*
Goal 6. Combat HIV/AIDS, malaria and other diseases	*Target for 2015: Halt and begin to reverse the spread of HIV/AIDS and the incidence of malaria and other major diseases.*
Goal 7. Ensure environmental sustainability	*Targets: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources; By 2015, reduce by half the proportion of people without access to safe drinking water; By 2020 achieve significant improvement in the lives of at least 100 million slum dwellers.*
Goal 8. Develop a global partnership for development	*Targets: Develop further an open trading and financial system that includes a commitment to good governance, development and poverty reduction – nationally and internationally; Address the least developed countries' special needs, and the special needs of landlocked and small island developing States; Deal comprehensively with developing countries' debt problems; Develop decent and productive work for youth; In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries; In cooperation with the private sector, make available the benefits of new technologies – especially information and communications technologies.*

Source: Human Development Report by UNDP 2003

and Biodiversity. The initiative provides a coherent international framework for the implementation of sustainable development surrounding these crucial issues (www.johannesburgsummit.org/html/documents/wehab_papers.html).

Advances in agroforestry can contribute significantly to the achievement of virtually all of the MDGs and the WEHAB initiative. Agroforestry focuses on the role of trees on farms and in agricultural landscapes to meet the triple bottom line of economic, social and ecological needs in today's world. Recognition of this role in overcoming key problems from local to global levels is growing. The World Agroforestry Centre (ICRAF) has identified seven key challenges related to the MDGs and WEHAB that agroforestry science and practice can materially address.

1. Help *eradicate hunger* through basic, pro-poor food production systems in disadvantaged areas based on agroforestry methods of *soil fertility and land regeneration*;
2. Lift more rural poor from *poverty* through market-driven, locally led *tree cultivation systems* that generate income and build assets;
3. Advance the *health and nutrition* of the rural poor through agroforestry systems;
4. Conserve *biodiversity* through integrated conservation-development solutions based on agroforestry technologies, innovative institutions, and better policies;
5. Protect *watershed services* through agroforestry-based solutions that enable the poor to be rewarded for their provision of these services;
6. Assist the rural poor to better adapt to *climate change*, and to benefit from emerging *carbon* markets, through tree cultivation; and
7. Build human and institutional *capacity* in agroforestry research and development.

This chapter examines these key components of the agenda for agroforestry research and development in the context of the MDGs. It reviews some of the ways in which agroforestry is demonstrably assisting to achieve the goals, and discusses how the agenda should be realigned to further increase effectiveness in helping developing countries to meet their MDG targets. We begin by focusing on the achievement of the first goal, eradication of extreme poverty and hunger, where the role of agroforestry is highly evident.

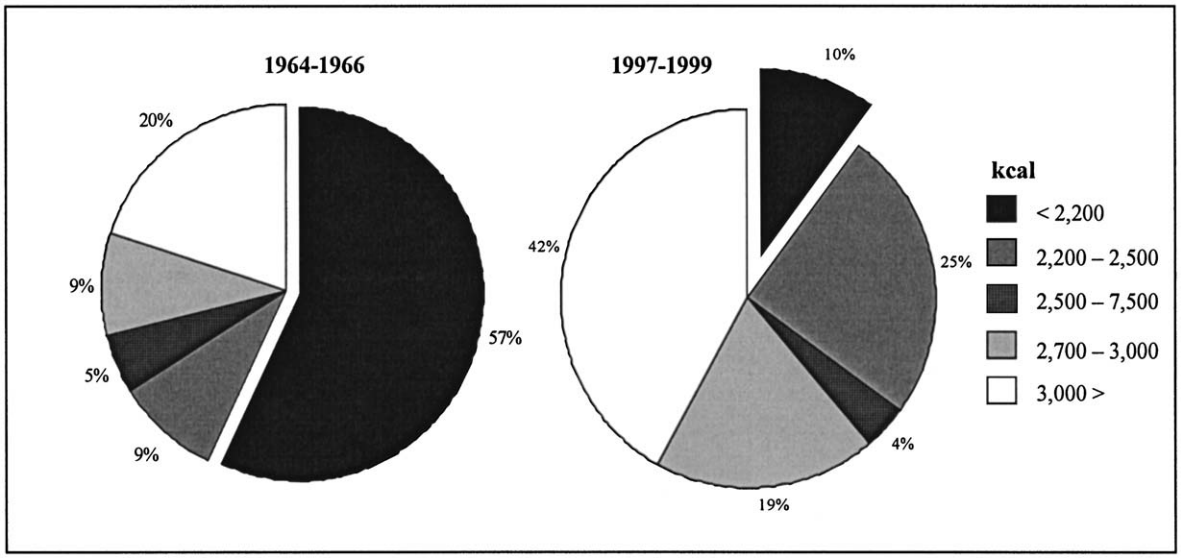

Figure 1. The world today produces enough food to feed everyone, yet hunger persists. Distribution of the world's population in terms of kilocalories per capita per day [1 calorie (cal) = 4.19 joules (J)]. Source: Bread for the World Institute (2003).

Eradicating extreme poverty and hunger

In a world of growing prosperity, there exists a massive and inexcusable failure of will to address the fundamental blight of hunger and desperate poverty that stunts the lives of the disadvantaged and excluded. The first MDG aims to cut at least in half by 2015 both the number of hungry, and the desperately poor who live on less than $1 a day. The world has made significant progress in reducing hunger and poverty in the recent past. During the last 30 years, the percentage of food-insecure people has declined by more than half, even though world population nearly doubled during that period. The percentage of world's population that is food insecure has fallen from 37% to 18%, and food availability has improved dramatically in the developing world in the past three decades. Daily per capita calorie availability increased from 2100 to 2700 (FAO 2001). Asia has gone from being a 'hopeless basket case' in the 1960s to being a 'food basket' in the 1990s, with huge declines in the numbers and proportions of the food insecure in East and Southeast Asia.

Currently, the three areas of the world with by far the greatest number of desperately poor are sub-Saharan Africa (291 million), South Asia (522 million), and China (213 million) (CGIAR 2000).

Alarmingly, the number of food-insecure people in sub-Saharan Africa during this period has more than doubled. Average per capita calorie availability in Africa is now below the minimum requirement for basic sustenance. Such trends must be reversed to achieve the MDGs. (See Figure 1)

Agroforestry and food security

Farmland in the developing world generally suffers from the continuous depletion of nutrients as farmers harvest without fertilizing adequately or fallowing the land. Nowhere is this more true than in Africa (Figure 2). Small-scale farmers have removed large quantities of nutrients from their soils without using sufficient amounts of manure or fertilizer to replenish fertility. This has resulted in high annual nutrient depletion rates of 22 kg nitrogen, 2.5 kg phosphorus, and 15 kg potassium per hectare of cultivated land over the past 30 years in 37 African countries – an annual loss equivalent to $4 billion worth of fertilizers (Sanchez 2002).

Commercial fertilizers cost two to six times as much in Africa as in Europe or Asia. Even at these prices, supplies are problematic due to poorly functioning markets and road infrastructure. Consequently, most African farmers have abandoned their use. This is having dire effects on smallholder food production. In the extensive maize (*Zea mays*)-producing belt of eastern and southern Africa, there are 12 million farm households that support some 60 million people, with farm sizes ranging from 0.3 to 3 hectares. Few farms

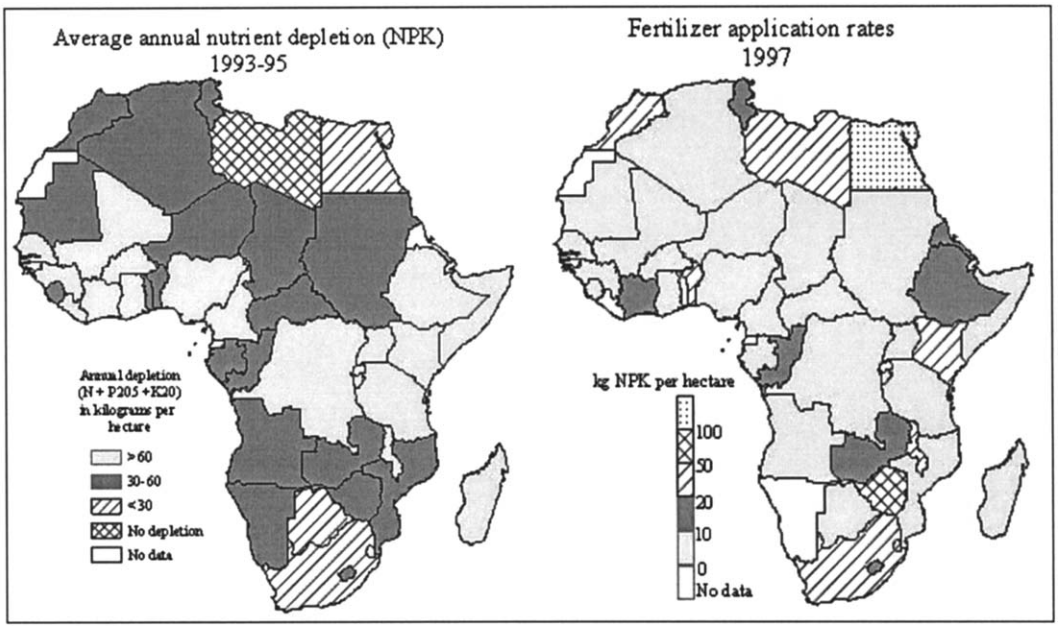

Figure 2. African soils are being depleted of nutrients due to very low average fertilizer application rates: Fertilizer tree systems are a practical option for integrated soil fertility replenishment that farmers can adopt with minimal cash cost. Sources: J. Henao and C. Baanante, 'Nutrient Depletion in the Agricultural Soils of Africa,' 2020 Vision Brief 62 (Washington, D.C: International Food Policy Research Institute, 1999) and FAOSTAT 1999. Compiled by Stan Wood, IFPRI.

Figure 3. Thousands of farmers in eastern and southern Africa are intercropping *Gliricidia sepium* and other nitrogen-fixing trees with their maize to provide crop nutrient needs and sustainably double or triple yields.

currently produce enough maize to feed the family, let alone provide a surplus for the market. For example, recent work shows that up to 90% of maize-growing families in eastern Zambia experience hunger for three to four months during normal years and there is severe famine in drought years (P.L. Mafongoya, pers. comm. 2003).

Many policy and infrastructural constraints have to be addressed to alleviate basic rural food insecurity in this region. But, in the meantime, one promising pathway is to enable smallholders to use fertilizer tree systems that increase on-farm food production. After years of experimentation with a wide range of soil fertility replenishment practices, three types of simple, practical fertilizer tree systems have been developed that are now achieving widespread adoption. These are: (1) improved fallows using trees and shrubs such as sesbania *(Sesbania sesban)* or tephrosia (*Tephrosia vogelii*), (2) mixed intercropping with gliricidia (*Gliricida sepium*), and (3) biomass transfer with wild sunflower (*Tithonia diversifolia*) or gliricidia (Place et al. 2002). They provide 50 to 200 kg N ha^{-1} to the associated cereal crops. Yield increases are typically two-to-three times that with current farmers' practices. These fertilizer tree systems have now reached over 100,000 households in the maize belt of eastern and

southern Africa, and demand for tree seed and knowledge transfer is increasing exponentially (F. Kwesiga, pers. comm. 2002). These practices tend to be adopted to a greater extent by the poorest families in the villages, which is unusual for agricultural innovations (Place et al. 2002). Accelerated efforts are under way to further adapt these options and scale them up to reach the 12 million maize growing families of the region and beyond (Franzel et al. 2002; 2004). (See Figure 3)

Promising as these approaches may be, food security will not be achieved by focusing only on increasing crop productivity. There must also be vigorous agricultural market reforms. These reforms need to be based on an understanding of what is actually happening in the rural areas and on determining why previous efforts to ensure food security have failed. Integrated approaches, rather than sectoral approaches, will be key to achieving sustained food security in the future (Omamo and Lynam 2002).

Policy research must unravel the dynamic 'poverty traps' that reinforce the low demand for and low supply of improved technologies in smallholder agriculture (see, for example, Schreckenberg et al. 2002). Besides identifying policy prescriptions, we must have pragmatic solutions that Africa's cash-strapped governments can actually implement, and that empower farmers to solve their own problems.

Roughly one quarter of the farmland in the developing world has been degraded. Agricultural reform must address the risks of land degradation due to overcultivation, desertification, declining water supplies, and loss of biodiversity. The potential of agroforestry to rehabilitate degraded land, and to conserve soil and water on the working lands of the tropics, has long been recognized (Young 1997). But we cannot assume that conservation investments will be attractive to farmers simply because they are known to protect the resource base (Clay 1996). There is much work to be done to identify soil and water conservation practices that not only make sense, but also make money for smallholders. The challenge is to make them profitable to adopt. Tree-based soil conservation systems have real promise in this regard.

Collective action through community-level support for soil and water conservation is crucial to the timely application of agroforestry-based soil and water conservation over whole landscapes. Mobilizing community involvement in evolving locally sustainable conservation farming systems through the Landcare approach has shown great promise in Australia, the Philippines, and South Africa (Mercado et al. 2001; Franzel et al. 2004). There is bright scope for investigating its application more widely in developing countries, particularly in Africa.

Under the prevalent conditions of uncertainty and sparse information, risk-averse smallholders have always tended to self-insure by diversifying their enterprises. Market failure is very common in smallholder systems. Rural areas typically have markets with high transaction costs, and this makes production diversification a favourable choice (Omamo and Lynam 2002). In such situations, integrated agroforestry systems are a suitable pathway toward improved livelihoods. This is exemplified by the agroforests of Indonesia (Torquebiau 1992; Michon et al. 1995) and the tropical homegardens in general (Kumar and Nair 2004). Unfortunately, too little research attention has been given to how the successful agroforest systems observed in some parts of the tropics can be more widely expanded for the benefit of the smallholders living in remote areas with poor market infrastructure.

Agroforestry research and development must now seriously focus on land management interventions that reach the poorest and most vulnerable land users. This requires a deep understanding of poor land users, particularly women, and the problems they face. These constraints involve poor access to technology development processes, and to agricultural information; poor bargaining power in markets and for public services; and extreme household resource constraints. Participatory technology development processes will be fundamental to identifying successful pro-poor solutions that are more readily adopted. Accelerating the formation and functioning of effective farmers' associations that serve the poor is crucial in addressing these needs.

Agroforestry and poverty alleviation

Nearly three-quarters of the poor people who live on less than $1 a day are found in the rural areas of developing countries (Dixon et al. 2001). Agricultural development is therefore key to increasing poor people's access to both food and income. The evidence clearly indicates that in developing countries, agricultural growth nearly always benefits poor people, with greatest gains going to those most in need (Thirtle et al. 2001). Empirical work points to a strong relationship between agricultural productivity and poverty (Mellor 2001). It is only with rising farm incomes that

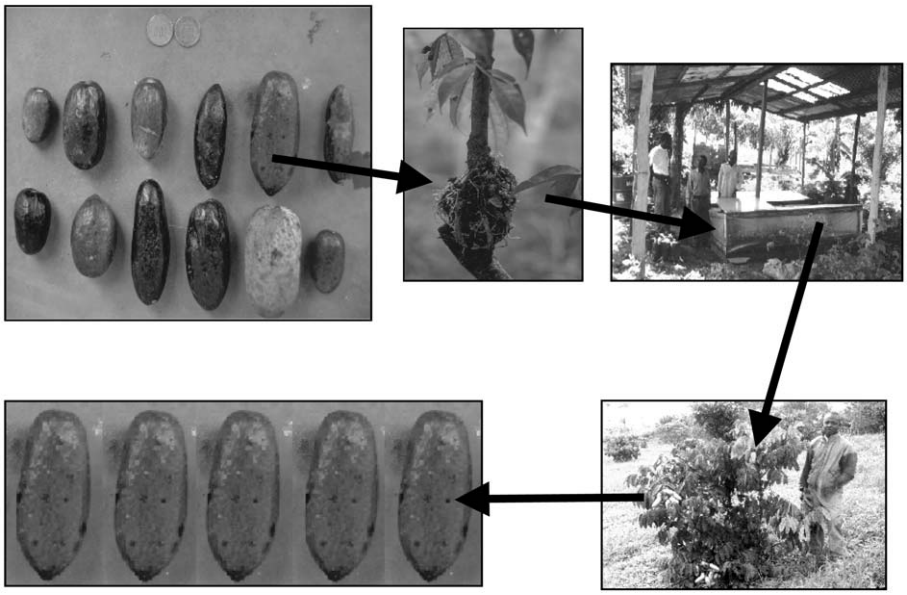

Figure 4. Creation of a cultivar: The African Plum, *Dacryodes edulis*, is one of many indigenous species of fruits now being domesticated from natural forests and improved for on-farm cultivation to create income opportunities by supplying expanding markets.

poverty can be reduced. A 1% yield increase is associated with a 1% drop in the number of people living on less than $1 a day. Although agriculture's poverty-fighting potential in developing countries is regaining wider recognition, national policies and funding trends have not reflected that promise. Agriculture continues to receive low levels of aid and investment from both donor organizations and developing country governments. Its share of total official development assistance averaged only 12% during the 1990s, while developing regions themselves spent only 4% of total expenditure on agriculture (FAO n.d.). Such trends must be reversed to achieve the MDGs.

Smallholder tree production contributes substantially to rural livelihoods and national economies, yet these contributions are not adequately quantified or appreciated. With less than half a hectare of natural forest remaining per person in the tropics, trees on farms in many countries are more important for tree product supply than trees in forests. This is true for both household and commercial purposes. Yet, obsolete policy objectives often act as a barrier to greater investment in trees on farms by farmers and entrepreneurs as discussed by Puri and Nair (2004) in the Indian context and by Scherr (2004) in the general context. Even where forest extraction gives way to tree cultivation, small-scale farmers are not sufficiently prepared to diversify and add value to their tree production. National planners are also ill-equipped to support agroforestry since few analyses have been carried out to identify the winners and losers in the cultivation and commercialization of tree products (as, for example, Shackleton et al. 2003). In many regions the enabling policies, species choice, tree husbandry skills, germplasm quality, and tree improvement lag far behind the overall demand for tree planting. Furthermore, the markets for tree products are often poorly organized and thus perform suboptimally (Russell and Franzel 2004). This causes spoilage of perishable tree products, lost income for producers, and restricted choices for consumers. The rural poor are further disadvantaged by lack of market price transparency, and the absence of processing techniques to add value to tree products.

Enhanced tree-based systems and improved tree product marketing have the potential to address key aspects of rural poverty, child malnutrition, poor access to conventional health care, national tree product deficits (especially timber), inequitable returns to small-scale farmers (especially women) from tree product marketing, and lack of enterprise opportunities on small-scale farms. Advances in these areas will contribute to seven of the eight UN Millennium Development Goals (MDG 1, 3, 4, 5, 6, 7, and 8). Work in this area focuses on the vulnerability and transformational opportunities of natural, financial, human and social capital assets of the rural poor and related stakeholders, within the sustainable livelihoods framework.

In Africa, agriculture has been growing at the rate of 3% per year since the mid-1980s. But because of increasingly competitive world markets, Africa's market share in most agricultural commodities is declining. This is combined with declining market prices for most commodities. Most agricultural development programs have focused on improving output, productivity, and exports. But as more countries adopt these programs the value of commodity exports continues to fall. Consequently, Africa is falling further behind.

A new approach is needed: a research and development strategy to reduce dependency on primary agricultural commodities, and to establish production of *added-value products* based on raw agricultural materials, with links to growing and emerging markets. For the African countries to compete successfully in the world economy, their agricultural research and development institutions must develop new skills in domestication of indigenous species (as discussed, for example, by Simons and Leakey 2004) and the processing/storage of their products, and in market analysis and market linkages. Research and extension services must adapt quickly to meet the challenges of globalization. There is an important role for 'bridging institutions' that catalyze improved integration of activity along the continuum from basic to applied, to adaptive research. They must convert technically workable innovations into commercially feasible ones.

Agroforestry research and development has traditionally focused on trees and tree production issues. Tree enterprise development and enhancement of tree product marketing has been neglected. It needs to be significantly reoriented. The frontier is to focus on the products, processing, and marketing of domesticated tree products and services (Russell and Franzel 2004).

The World Agroforestry Centre is now putting much greater attention on the development of tree products, and the expansion of their markets. With new analyses, and networking, we are building robust knowledge bases on these aspects. This complements our *Agroforestree* knowledge bases. The aim is to support new and existing tree product enterprises that favor small-scale farmers and entrepreneurs, and to improve the functioning and information of tree product markets. Increasingly, we see the science of agroforestry as a means to advance the business of smallholder agroforestry. Accelerated work on timber trees, fruit trees, fodder trees, medicinals, and fertilizer trees, is achieving greater diversity and productivity on the smallholder farm (Scherr 2004). This is opening up a range of business opportunities, not only for farmers but for the wider rural economy as a whole.

This effort will require attention to market chain and policy analysis for key tree product sub-sectors including beverage, extractives, fodder, fruit, fuelwood, medicine, and timber. Priorities concerning promising tree products will need to be made through the active involvement of producers, consumers and merchants. New products need to be identified for development with partners. The work must focus on the constraints and opportunities for pro-poor and gender-sensitive tree product enterprises and extension approaches, and building sustainable seed systems and better management approaches for the genetic resources of agroforestry trees.

Tree crops played a critical role as a springboard for economic growth in Southeast Asia during the past three decades (Tomich et al. 1994). Indeed, tree crops such as cacao (*Theobroma cacao*), coffee (*Coffea* spp.), and tea (*Camellia sinensis*) have also been mainstays of the economies of a number of African countries. But global overproduction of these few commodities has reduced their present and prospective profitability for smallholders. A new 'tree crops revolution' is needed (Leakey and Newton 1994) that greatly broadens the array of tree products that are produced, processed and delivered by developing countries to regional and global markets. These products could be a vehicle providing comparative advantage to poor land-locked countries, and countries that are not otherwise well-integrated into the global economy. These disadvantaged countries need to be more aware of the practical opportunities of tree products, and to build the market linkages that can capitalize on them.

We foresee much greater efforts to domesticate new and underutilized tree species, and to intensify their cultivation on smallholder farms (Simons 1996). Appropriate tree propagation and management methods for on-farm cultivation must be elucidated, and tree species improvement undertaken for priority taxa (Simons and Leakey 2004). Massive capacity building will be necessary to expand this work. Allied to this is the need to implement approaches to encourage sustainable tree seed and seedling systems, and the wise conservation and use of agroforestry tree genetic resources. (See Figure 4)

Does research on trees and tree crops for smallholders really pay off? Some might assume that it does not have a high rate of return. The evidence, however,

shows otherwise. Alston and Pardey (2001) tabulated the rates of return to various types of agricultural research and development from thousands of studies. From the 108 studies they assembled that estimated the rate of return to investment in tree crops research, the average rate of return was 88%. The median rate of return was 33%. Such rates of return are outstanding, and they compare favorably with the rates of return on field crops research, which averaged 74% over 916 studies.

The flow of high-quality tree germplasm among countries, for the various types of fruit, timber, fodder, and medicinal trees of potential interest to smallholders, has to date been highly constrained compared with the flow of germplasm of the basic food crops. Serious calls for greater scientific and development attention to the many highly promising agroforestry species that are underexploited and underutilized have been with us for many years (NAS 1975; NAS 1979). But the response has been inadequate. More comprehensive and active international networks are needed in the coming decade to facilitate the flow of the best varieties and the flow of knowledge of how these species may contribute new or expanded enterprise opportunities.

Timber production on farm

Smallholder timber production is increasingly appreciated as an important source of many countries' wood supplies. This is particularly true for countries with low forest cover. Kenya has had one of the few comprehensive forest inventories ever done that included trees outside forests (Holmgren et al. 1994). The authors observed that two-thirds of the country's woody biomass occurs outside of conventional forests. In Bangladesh, it is estimated that 90% of the wood used is produced on agricultural land. In India, half of the timber now emanates from private farmlands. The smallholder may well be the timber producer of the future in many parts of the developing world, and increasingly a provider of high quality tropical timbers. But there is little understanding or documentation of these trends. Data for trees on farms are not collected, and are thus not included in national or global forest inventory data (Bellefontaine et al. 2002). This has to be redressed if the significance of agroforestry is to be better appreciated. The World Agroforestry Centre and the Forestry Department of the Food and Agriculture Organization of the United Nations (FAO) are working together to draw international attention to the need to estimate trends in farm-grown timber. That will provide a basis for greater focus on smallholder timber production systems.

Agroforestry for health and nutrition

Advances in agroforestry have many links with improving the health and nutrition of the rural poor. The expansion of fruit tree cultivation on farms can have a significant effect on the quality of child nutrition. This is particularly important as indigenous fruit tree resources in local forests are overexploited. Currently, eastern Africa has the lowest per capita fruit consumption of any region in the developing world. Work with national partners to domesticate a range of nutritious wild indigenous fruits that are popular in eastern, western, and southern Africa seeks to save these species from overexploitation, and develop them for local and regional markets. These efforts will contribute to the fourth Millennium Development Goal on reducing child mortality.

Recognition is growing that there are many complex linkages between agroforestry and the fight against HIV/AIDS (MDG 6). Forty million people are currently living with HIV. Some countries including Brazil, Senegal, Thailand and Uganda have shown that the spread of HIV can be stemmed. But most of sub-Saharan Africa is experiencing a disastrous AIDS epidemic. The global infection rate among adults is 1.2%, but it is 8.8% in sub-Saharan Africa. Sixty-eight percent of AIDS victims reside in this region. AIDS and associated diseases such as pulmonary tuberculosis are now the leading cause of death on the continent, accounting for up to 80% of all adult deaths in the parts of eastern and southern Africa that have prevalence rates of 20% to 30% (Mushati et al. 2003).

On one hand, HIV/AIDS poses significant threats to agroforestry. HIV/AIDS can reduce the economic incentive for farmers to undertake long-term investments. It undermines local knowledge about tree production, and makes property rights to land and trees less secure for the most vulnerable segments of the population. It dissipates labor and financial resources that would be needed to establish and maintain agroforestry practices. On the other hand, there is potential for agroforestry to generate much-needed income, improve nutrition, reduce labor demands, and stabilize the environment in AIDS-affected communities. The range of threats and the various opportunities have yet to be thoroughly explored, and incorporated into the

research and development agenda. This is an urgent imperative.

Tree medicinals

Natural medicinal plants are the source of treatment for many diseases and ailments of the poor throughout the developing world (Rao et al. 2004). In Africa, for example, more than 80% of the population depends on medicinal plants for their medical needs. Two-thirds of the species from which medicinals are derived are trees. The vast majority of these tree products are obtained by extraction from natural forests. There is also increasing interest in natural medicines in the developed world, creating new or expanded markets for these products. This puts further extraction pressure on the forests. Many of the medicinal tree species are now overexploited. Some species are so depleted that their gene pools are greatly eroded (e.g., *Prunus africana*), and some are in danger of extinction. Meeting the expanding demand for medicinal trees can only be assured through greater efforts to domesticate them and promote their cultivation on farms. Vigorous research partnerships between agroforestry and the medical sciences will be crucial to ensure that the key tree medicinals are effectively developed for farm cultivation.

Agroforestry and the advancement of women

Sixty to eighty percent of the farmers in the developing world are women. In 1990, women subsistence farmers accounted for 62% of total female employment in low-income countries (Mehra and Gammage 1999). Rural women in developing countries grow and harvest most of the staple crops that feed their families. This is especially true in Africa. In sub-Saharan Africa, women account for 75% of household food production (UNDP 1999, as cited in Bread for the World Institute 2003). Food security throughout the developing world depends primarily on women. Yet they own only a small fraction of the world's farmland and receive less than 10% of agricultural extension delivery.

Because women are in charge of household and staple crops, female farmers often fail to gain from export-oriented agriculture. Women may have trouble diversifying their crops because they have difficulty obtaining the credit and land needed to shift to nontraditional exports. These realities have major implications for agroforestry research. Much more needs to be done to understand the kinds of traditional and nontraditional agroforestry products that are accessible to women, and to get research attention focused on them. This also applies to value-added processing activities and marketing. Greater attention to how women are affected by land and tree tenure practices is leading to awareness of the need to address these inequities. For example, women in Cameroon are very keen on cultivating *Dacryodes edulis* as its marketing season coincides with the need to pay school fees and buy school uniforms (Schreckenberg et al. 2002).

Trees are a medium for long-term investment on the farm. Thus, the propensity to cultivate them is particularly sensitive to property rights (Place and Otsuka 2002). Policy research in agroforestry must continue to strengthen our understanding of these linkages. We need to assist in identifying the means by which women's land rights can be made more secure to enhance the intensification of farming in general, and the acceleration of tree cultivation in particular (Place and Swallow 2002).

Building capacity and strengthening institutions

The second Millennium Development Goal focuses on achieving universal primary education. One in six children in the developing world do not attend school, and one in four start school but drop out before they can read or write. Education is a powerful weapon against poverty. It is therefore important to explore and implement practical and innovative measures in which the interrelated issues of education, food and health in rural areas can be tackled together. The *Farmers of the Future* initiative is an emerging global consortium spearheaded by the World Agroforestry Centre and FAO to promote the incorporation of agroforestry and natural resource management into basic education to enhance its quality and relevance for rural youth (Vandenbosch et al. 2002). The concepts of sustainable agriculture are taught through the lens of experiential learning that focuses on working trees for the farm. This can make a major impact, particularly on those that return to the farm after a few years of schooling.

Networking to strengthen agroforestry education at the tertiary level has been progressing for many years (Temu et al. 2003). There are now 123 member colleges and universities in the African Network for Agroforestry Education (ANAFE), and 35 member universities in the Southeast Asian Network for

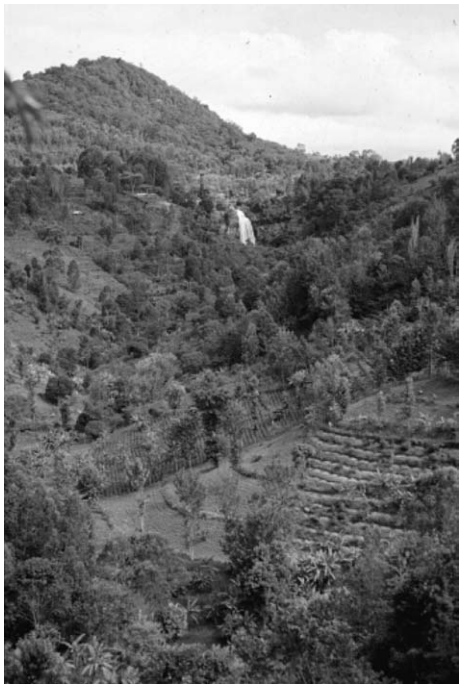

Figure 5. Landscape mosaics that incorporate working trees enable smallholders living in upper watersheds to farm productively while preserving watershed functions and conserving natural biodiversity.

Agroforestry Education (SEANAFE). These networks assist the member institutions to incorporate agroforestry and multi-disciplinary approaches to land use in their curricula. The networks are fighting against the tendency for developing country agricultural universities to be marginalized, particularly in Africa (Omamo and Lynam 2002).

Ensuring environmental sustainability

The seventh MDG aims to ensure environmental sustainability, and to integrate the principles of sustainable development into country policies and programs to reverse the loss of environmental resources. Smallholder agroforestry systems generate environmental benefits of value to communities, national societies, and the global community. The environmental services that are of greatest relevance are watershed protection, biodiversity conservation, and climate change mitigation and adaptation. Thus, a major agroforestry research and development agenda is emerging in the domain of environmental services. The goal is to identify agroforestry systems and landscape mosaics that meet farmers' needs for food and income while enhancing these services. Policy reform and institutional innovations will enhance the adoption of effective technologies and resolve conflicts among stakeholders.

Pro-poor strategies to enhance watershed functions

There is a general impression that natural forests are crucial to protect watershed functions, particularly in upper catchment areas. This impression, which is part fact, and part fallacy, has led to severe conflicts between national governments and poor upland farming communities throughout the developing world. The real key to flood control and sustained water supply is maintaining the infiltration properties of the soil. This can be accomplished in working landscapes with an appropriate density of vegetative filters. Thus, agroforestry is in the center of the debate concerning how people can farm in watersheds while sustaining catchment functions that impact on downstream populations. New knowledge on suitable types of tree farming systems, their configuration in the landscape, and their location relative to lateral flows of water and soil is providing a foundation for options that enable upland communities to farm sustainably while protecting watershed services (Swallow et al. 2001). These management principles need to be refined for different spatial scales and contexts. Recent work by the World Agroforestry Centre's Southeast Asia Program, is identifying and applying policies, incentives, and institutional mechanisms that can enhance the adoption of win-win technologies and resolve persistent conflicts (van Noordwijk et al. 2003). (See Figure 5)

More effort is needed to link known tree-farming options to watershed level interventions, and to increase policy support for soil and water conservation efforts. For this we need more effective methods for wide area assessment of severity of land degradation. Here we can exploit the recent development of techniques for rapid monitoring of land quality across whole landscapes, such as the reflectance spectroscopy method that was recently developed (Shepherd and Walsh 2002).

Conserving biological diversity in working landscapes

The well being of the land is directly tied to the well being of its inhabitants. Only when rural people and poor farmers have a way to earn sustainable, stable livelihoods will the planet's biodiversity be safe. It is futile to attempt to conserve tropical forests without

addressing the needs of poor local people, nor is it desirable (ASB 2002). As much as 90 percent of the biodiversity resources in the tropics are located in human-dominated or working landscapes. Agroforestry impinges on biodiversity in working landscapes in at least three ways. First, the intensification of agroforestry systems can reduce exploitation of nearby or even distant protected areas (Murniati et al. 2001; Garrity et al. 2003). Second, the expansion of agroforestry systems can increase biodiversity in working landscapes. And third, agroforestry development may increase the species and within-species diversity of trees in farming systems.

A new paradigm is emerging that integrates protected areas into their broader landscapes of human use and biodiversity conservation, particularly in agricultural areas that now constitute the principal land use in most of the developing world (Cunningham et al. 2002). The issue of how best to achieve a balance between production and biodiversity conservation is moving to the centre of much of ICRAF's work, particularly in Southeast Asia (van Noordwijk et al. 1997). It has become the basis for the concept of *ecoagriculture,* which refers to land-use systems managed for both agricultural production and wild biodiversity conservation (McNeely and Scherr 2003). Agroforestry is uniquely suited to provide ecoagriculture solutions (McNeely 2004). But much more must be done to understand and refine suitable options for widespread use. The global program on Alternatives to Slash-and-Burn has been on the forefront of identifying and applying such solutions in humid forest areas (Tomich et al. 1998).

Climate change mitigation and adaptation for rural development

Agroforestry will play a major role in the two key dimensions of climate change: mitigation of greenhouse gas emissions and adaptation to changing environmental conditions. Despite some efforts to reduce the impacts of climate change, the process will not be halted. Farmers will need to adapt to more extreme drought and flooding events, as well as the elevation in temperatures that are predicted to occur in coming decades. People differ in their vulnerability to such climate changes. The poorest rural populations in the regions with least responsibility for causing climate change are nevertheless likely to be most negatively affected. Agroforestry needs to play a role in increasing the resilience of smallholder farmers to climate change and other stresses. However, research on its prospective role in adaptation is only now getting under way.

Agroforestry was recognized by the Intergovernmental Panel on Climate Change as having a high potential for sequestering carbon as part of climate change mitigation strategies (Watson et al. 2000). Methods are now needed to determine the sequestration potential of specific agroforestry systems in particular agroclimatic conditions. Carbon offsets through tree farming will be a secondary product of smallholder agroforestry systems. A key question is how smallholders can benefit from carbon sequestration projects (Montagnini and Nair 2004). Methods are being developed to pursue carbon projects that will improve livelihoods and provide positive incentives to smallholder agroforesters.

Policies to harmonize environmental stewardship and rural development

Environmental policy related to agroforestry needs to address three main challenges: provide policy makers and civil society organizations with science-based evidence on the tradeoffs and complementarities between land use choices, the resulting environmental services, and the livelihoods of smallholder farmers; provide policy options for harmonizing environmental policy and concerns for sustainable rural development; and increase access to information about policy options. These challenges need to be tackled at international, national and local levels. Success depends on gathering field-based evidence in locations around the developing world, and synthesizing and interpreting it in ways that connect to the needs of national and international policy processes. Agroforestry can champion the perspective of smallholder farmers in these policy debates.

One growing aspect of this work is the development of mechanisms to reward the rural poor for the environmental services they provide to society (RUPES 2003). This will require methods to quantify these services in ways that are adaptable to rural smallholder-occupied landscapes, coupled with practical modalities for successful environmental service agreements.

Conclusion

Global targets are important mechanisms for the community of nations to come to grips with the com-

plex development challenges of the early 21st century. This chapter has reviewed the ways that agroforestry research and development can contribute to achieving the Millennium Development Goals. National poverty-reduction-strategy papers (PRSPs) are one of the main tools by which individual countries articulate and monitor their plans to address the MDGs. To date, relatively few countries have incorporated an agroforestry perspective into their PRSPs, or have developed national agroforestry strategies. However, several developing countries have done this, and the results are promising. For instance, there are some notable examples from southern Africa. A growing number of donors are taking explicit steps to assist other countries to tackle this job. This creates a major opportunity for the world agroforestry community to be more proactive in drawing serious attention to the many benefits of greater investment in expanding the cultivation of trees on farms.

The role of agroforestry is also capturing ever-greater domestic recognition in the developed world, particularly in North America and Europe. This awareness is enhanced by the growing concerns in the north to evolve multifunctional rural landscapes, and to transform farm subsidies toward the conservation of soil, water and biodiversity in lieu of commodity payments. Growing appreciation of the role of agroforestry in the developed countries will enhance understanding and support for its expansion in the developing countries. This will better ensure that the needed investments are forthcoming to deliver on the promise of agroforestry to contribute substantively to achieving the Millennium Development Goals.

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