Multifunctional Agriculture and Opportunities for Agroforestry: Implications of IAASTD

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Abstract To explain the relationship between agroforestry and multifunctional agriculture, this chapter presents some of the key messages from the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) vis-à-vis the objectives of agroforestry. Multifunctional agriculture has been proposed as a paradigm for productive and sustainable agriculture, which is especially appropriate for poor smallholders in the tropics. Agroforestry, like multifunctional agriculture, has the objective of promoting economically, socially, and environmentally sustainable rural development. This chapter briefly summarizes some of the major global issues of land degradation, poverty, malnutrition, and hunger and examines how agroforestry can play a substantial role in the delivery of a better future. To illustrate these points, an integrated rural development project in Cameroon is presented as a good example of how agroforestry can rehabilitate degraded land, diversify farming systems with domesticated indigenous trees, and create business and employment opportunities in rural communities, which substantially improve the livelihoods of rural people.

Keywords Land rehabilitation • Livelihoods • Natural resources management • Poverty alleviation • Sustainable rural development

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P.K.R. Nair and D. Garrity (eds.), *Agroforestry - The Future of Global Land Use*, Advances in Agroforestry 9, DOI 10.1007/978-94-007-4676-3_13,

Introduction

The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) has reviewed the very complex sets of social and bio-physical issues associated with the economic, social, and environmental sustainability of modern agriculture. The IAASTD reports examine the ability of agriculture to deliver high yields of good quality food at acceptable prices; the reduction of poverty, hunger, malnutrition (including obesity), and environmental degradation; the improvement of rural livelihoods; as well as the mitigation of climate change, against a background of increased economic growth. The reports, which were accepted by 61 governments at an intergovernmental plenary in Johannesburg, South Africa, on April 11, 2008, present the philosophy of "multifunctional agriculture," which recognizes the "inescapable interconnectedness of agriculture's different roles and functions" in rural development. The reports see the application of this philosophy as the means to make significant progress toward this list of highly complex and interacting development targets (McIntyre et al. 2008) and suggest that agriculture is at a "crossroads" and in need of redirection (Kiers et al. 2008). Leakey (2010) has suggested that agroforestry is an appropriate model and delivery mechanism of this new agricultural paradigm – one that is socially and environmentally sustainable, pro-poor, and promotes economic development and growth; this point has also been emphasized in several of the papers in the introductory section of this volume (e.g. Leakey et al. 2008).

Some of the major issues addressed by the IAASTD reports are:

- The scale of natural resource degradation (affecting 2.6 billion people and 2 billion ha of farmland), depletion of soil fertility (nitrogen, phosphorus, and potassium – NPK – deficiencies affecting 59, 85, and 90% of crop land, respectively), loss of biodiversity (valued at $1,542 billion/year), depletion of water resources (2,664 km^3/year), and agroecosystem function, against a background in which new land for agriculture is increasingly scarce. This situation that makes the rehabilitation of farmland an imperative has arisen from the overexploitation of natural capital rather than basing production on its effective management to generate "interest." Agricultural research and development has inadequately addressed the cycle of land degradation, which is responsible for a "yield gap" between the biological potential of Green Revolution crops and the yield that poor farmers typically manage to produce in the field.
- Over the last 60 years, agricultural intensification has resulted in:
  - Substantial gains in crop and livestock production. These are due to advances in breeding (e.g., genetic gain, stress resistance), husbandry (e.g., fertilizer, irrigation, mechanization), policy (e.g., Intellectual Property Rights, variety release processes), microfinance (e.g., credit, provision of inputs), education and communication (e.g., farmer-field schools), and market and trade (e.g., demand, incentives). World cereal production, for example, has more than doubled since 1961, with average yields per hectare also increasing around 150% (with the notable exception of sub-Saharan Africa).

  - Improved livelihoods of many farmers and the economic growth of developed countries. In real terms, food has become cheaper (although currently prices are increasing), and calorie and protein consumption has increased. On a global scale, the proportion of people living in countries with an average per capita intake of less than 2,200 kcal per day has dropped from 57% in the mid-1960s to 10% by the late 1990s.

- Advances in biotechnology, which are recognized as important tools for scientific progress, especially the role of genomics and marker-selected breeding, but there are concerns about the release of transgenic organisms before their impacts on the environment are better understood.
- The incidence of poverty (3.2 billion people with an income of less than US$2/day), malnutrition and nutrient deficiency (two billion people), and hunger (0.9 billion people) remain at unacceptable levels, despite the very significant improvements in agricultural production. In addition, one billion people are affected by obesity due to poor diet.
- Agricultural production and governance have focused on producing individual agricultural commodities rather than seeking synergies and optimum use of limited resources through technologies promoting integrated natural resources management.
- Modern public-funded agricultural knowledge, science, and technology (AKST) research and development has largely ignored the needs of poor smallholders and the improvement of traditional production systems based on "wild" resources which, traditionally, have played an important role in peoples' livelihoods.
- Agriculture is responsible for 15% of greenhouse gas emissions.
- There are numerous organizational and conceptual "disconnects" between agricultural disciplines and organizations, especially those responsible for environmental services and sustainable development.
- Since the mid-twentieth century, the globalization pathway has dominated agricultural research and development as well as international trade, at the expense of the "localization" benefits of many existing small-scale activities of farmers and traders that are aimed at meeting the needs of poor people at the community level. The formation of some recent public-private partnerships illustrates a mechanism for addressing the balance between globalization and localization.
- Agricultural professionals have often lacked the resources and skills base to adequately support the integration of agricultural, social, and environmental activities that would support the promotion of multifunctional agriculture.

There have been many research approaches to the addition of ecological principles to well-recognized areas of agronomy, livestock husbandry, and natural resources management – collectively described as Integrated Natural Resources Management (INRM). Through INRM, agricultural science has begun to address sustainability challenges with strategies that recognize the more socially relevant, pro-poor approaches to agriculture that relate to production, livelihoods, and ecosystem service functions. However, there is a need to further revitalize farming systems, rehabilitate natural capital, and increase income generation opportunities in ways that meet the needs of local people. This requires further development and upscaling of socially and environmentally sustainable agricultural practices that achieve simultaneous impacts at different points in the cycle of land degradation and social deprivation (Leakey 2010).

Toward Multifunctional Agriculture

To build on the positive outcomes of the last 60 years of agricultural intensification, it is important to find ways of restoring soil health by enhancing fertility and diversifying the farming system to promote more resilient risk management. The achievement of this would reduce dependency on purchased inputs and increase the biodiversity necessary for improved agroecosystem function at the plot and landscape level (see Fig. 1). The inclusion of trees within these systems would increase the number of niches in the agroecosystem in ways which make them less damaging to the environment, provide environmental services, and help to counter climate change. Due to the diversity of moist and dry tropical forests and woodlands, there are many species available to play these important ecological roles in a developing agroecological succession (Leakey 1996). If this diversification includes indigenous species with market potential that meet the everyday needs of local people, this would importantly also strengthen and support local culture while generating much needed income.

Fortunately, there are examples from around the world of low-input, socially relevant, pro-poor approaches to rural development that relate to production, livelihoods, and ecosystem service functions. Some of these approaches are based on an understanding of agroecology and soil science, but, currently, few of them provide a complete package. Many of these low-input, resource-conserving technologies are based on integrated management systems such as reduced- or no-tillage, conservation agriculture, ecoagriculture, agroforestry, permaculture, and organic agriculture. Of these, agroforestry seems to be particularly relevant to the delivery of multifunctional agriculture. Like the other systems, it can address the issues of soil fertility management, the rehabilitation of degraded farming systems, loss of biodiversity above and below ground, carbon sequestration, and soil and watershed protection. However, in addition, agroforestry can also provide five crucial outputs that are not provided by the other systems, namely, (1) useful and marketable tree products for income generation, fuel, food and nutritional security/health, and the enhancement of local livelihoods; (2) complex mature and functioning agroecosystems akin to natural woodlands and forests; (3) linkages with culture through the food and other products of traditional importance to local people (Leakey 2010); (4) farms serving as carbon sinks rather than contributing to climate change as carbon sources; and (5) an enhanced agricultural matrix in fragmented landscapes which promotes movement of forest species among the forest fragments (Perfecto and Vandermeer 2010). These processes are all part of creating healthy landscapes and "sustainagility" (van Noordwijk et al. 2012). The above characteristics of agroforestry are very similar to

Fig. 1 A landscape in South Vietnam illustrating diversified and multifunctional agriculture based on tree crops

those of multifunctional agriculture as described by IAASTD (McIntyre et al. 2008). Likewise, they both share the objective of simultaneously promoting the social, economic, and environmental benefits of agriculture[1] for land users.

Typically, farmers in developing countries, who do not have access to other sources of income or social support, still have to provide food, medicines, and all their other day-to-day needs from their natural resources, just as they did in the past as subsistence farmers. But now, as a result of deforestation on the one hand and modern farming systems on the other, local communities do not have access to all the species that used to provide the products needed for everyday survival. However, there are many indigenous tree species producing nutritious fruits, nuts, and leaves (Leakey 1999a; Saka et al. 2008) that have the potential to be crops producing marketable food, fodder, and nonfood products (Leakey et al. 2005). Thus, through the integration of trees in farming systems, it is possible to produce a wide range of food and nonfood products. In this way, it is possible to create highly productive farming systems, rich in biodiversity (Leakey 1999b), yielding both staple foods and marketable tree products, while also providing the ecological services traditionally obtained by long periods of unproductive fallow. There is, however, another environmental benefit from the integration of trees in farming systems. Large perennial trees have a high volume of standing biomass, and through litter fall and root turnover, they also enrich the soil with carbon (Minang et al. 2012). This long-term and effective sequestration of carbon gives farming systems which include trees the capacity to reduce CO_2 emissions to the atmosphere and so to play an important role in the mitigation of climate change (Nair 2012). Studies suggest that the conversion of degraded farmland to mature agroforest could increase carbon per hectare from 2.2 to 150 Mg over a potential area of 900 million ha worldwide (World Agroforestry Centre 2007).

After two decades of research and development, about 50 tree species are being domesticated as new crops for integration in agroforestry systems (Leakey et al. 2012) as an incentive mechanism for farmers to improve their own livelihoods. Tree domestication is increasingly engaged in modern scientific technologies to assess and analyze the opportunities to bring improved agroforestry tree products (AFTPs) into new markets based on compounds extracted from tree products. Some of these tree species are currently the subject of participatory domestication programs using local knowledge to improve the yield and quality of their products (Leakey et al. 2003; Tchoundjeu et al. 2006) in ways that empower local communities, promote food self-sufficiency, generate income and employment, and nutritionally enrich the diets of rural people in tropical countries. This is now a global initiative which brings together agricultural science and technology with traditional knowledge in an integrated package capable of helping to meet sustainability and development goals (Leakey 2012). Through these projects, there is growing evidence that agroforestry can help rural communities in the tropics to be self-sufficient and to support their families on an area of less than 5 ha, as well as to lift themselves out of poverty, malnutrition, and hunger (Schreckenberg et al. 2006; Degrande et al. 2006; Asaah et al. 2011). However, to be fully sustainable, it will be important to develop Intellectual Property Rights instruments to protect the innovations developed by the smallholder farmers.

Agroforestry is widely practiced, especially in the tropics, with more than 1 billion ha having 10% or more tree cover worldwide (Zomer et al. 2009). Agroforestry practices are numerous and used by 1.2 billion people, while the tree products are also important for the livelihoods of millions of other people, for example, in urban areas in developing countries. Many of the benefits from agroforestry products arise from local and regional marketing. Nevertheless, with more than 38% of the global crop area severely degraded, and so many people suffering from poverty, malnutrition, and hunger, there is a need to expand the use of agroforestry practices in support of multifunctional agriculture. One of the ways that agroforestry can mitigate these problems would be to improve crop husbandry and close the yield gap.

Filling the Yield Gap: A Special Role for Agroforestry

To be productive for more than a few years, high-yielding staple food crops on land cleared of much of its natural vegetation typically require large inputs of fertilizers, pesticides, and often irrigation, especially in the tropics. The dependence of this type of agriculture on fossil fuels and fossil water is unsustainable. In many parts of the world, poor farmers have cleared the forest vegetation to make way for crops but do not have sufficient access to these agrochemicals, principally due to their high cost relative to farmer income, but partly also as a result of availability. As a consequence, the farmers are trapped by their inability to purchase fertilizers and other inputs. Thus, other ways have to be found to maintain and restore soil fertility and sustain crop production.

The yield gap can be filled through good land husbandry to rebuild natural soil fertility and health and diversification into perennial cash crops that meet social and market needs. Poor smallholders (70% of the 3.2 billion people living on less than US$2 per day) have to be self-sufficient for food, micronutrients, medicines, and all their other day-to-day needs. But, modern farming systems lack all the traditionally important species that used to provide all the products needed for everyday survival. Making matters worse, in the event of failing to provide these household needs, government-funded social-security systems to fall back on do not exist. Part of the solution to rural development and sustainable living is therefore for farming to provide the livelihood needs of the local communities. Fortunately, indigenous and culturally important species do still have local markets. If these traditional species can be domesticated as new and genetically improved crops, there is enormous opportunity to diversify and intensify agriculture with productive trees selected to meet the needs of the community for food and nutritional security, as well as to supplement diets with the micronutrients that boost immunity to diseases. Then, if the markets can be expanded by matching the product value chain to the needs of traders for more uniform and higher quality products with improved shelf life, there is the further prospect of opening up a pathway out of poverty based on either employment or business opportunities. As the trade in indigenous tree products is typically the prerogative of women (Kiptot and Franzel 2012), these opportunities are excellent for promoting gender equity in rural and urban communities. This combination of social and economic advancement with the environmental restoration possible from diversifying agriculture with perennial tree crops points the way forward to closing the yield gap.

Using the example of maize (*Zea mays* L.) production in eastern and southern Africa, the following three-step approach has been suggested as a way to address the yield gap (Leakey 2010). It is based on the use of agroforestry fallows, tree domestication, and the marketing of AFTPs as a way to deliver multifunctional agriculture:

Step 1: Adopt agroforestry technologies such as 2-year improved fallows or relay cropping with nitrogen-fixing shrubs that improve food security by raising maize yields fourfold from around 1 Mg ha^{-1} (Buresh and Cooper 1999; Kwesiga et al. 1999). Likewise, stands of *Faidherbia albida* (Del.) A. Chev. trees play a similar role in the so-called Evergreen Agriculture (Garrity 2012; Swaminathan 2012). This allows the farmers to reduce the area of their holdings planted with maize and so make space for other crops, perhaps cash crops which would generate income. An additional benefit arising from improved fallows with leguminous shrubs like *Sesbania sesban* (L.) Merr. and *Desmodium* spp. is the reduction of parasitic weeds like *Striga hermonthica* Benth. and the reduced incidence of insect pests like the stem borers of maize (Cook et al. 2007).

Step 2: Adopt the participatory domestication of indigenous trees producing marketable products so that new, locally important, and nutrient-rich cash crops are rapidly developed as a source of income and products of day-to-day domestic importance and help empower women and maintain culture and traditions (Cooper et al. 1996; Sanchez and Leakey 1997). Sale of these products would allow the purchase of fertilizers and so, potentially, the increase of maize yields up to 10 Mg ha^{-1}. Consequently, the area under maize could be reduced further to allow more cash cropping. Filling the yield gap will also maximize returns on past investments in food crop breeding.

Step 3: Promote entrepreneurism and develop value-adding and processing technologies for the new tree crop products, so increasing availability of the products throughout the year, expanding trade, and creating employment opportunities – outputs which should help to reduce the incidence of poverty.

Case Study of Agroforestry Delivering Multifunctional Agriculture in Rural Communities

The "*Food for Progress*" program in Cameroon – a winner of the prestigious Equator Prize[2] – is an example of an agroforestry project based on the above three steps and delivering economic social and environmental benefits (Tchoundjeu et al. 2010; Asaah et al. 2011). It involves more than 10,000 farmers and over 200 communities in the west and northwest regions of Cameroon, as well as entrepreneurs in local towns. The project is centered on five rural resource centers which are providing a wide range of training to farmers engaged in agroforestry and the domestication of indigenous fruits and nuts. This capacity building also empowers local farmers to help themselves through an understanding of group dynamics; the use of microfinance (short and small-scale loans); community project management; skills in trade, marketing, and business; and the management of local infrastructure development (e.g., installing water pipes and village standpipes, digging wells, building bridges, and storage sheds for crops). The community-level training in agroforestry includes topics such as the restoration of soil fertility by the use of nitrogen-fixing trees and shrubs, tree propagation and nursery management, and tree domestication using simple low-technology horticultural techniques. This has led to the growth of more than 120 satellite tree nurseries in surrounding communities supported by Relay Organizations (NGOs, CBOs [community-based organizations], etc.) that provide further training and mentoring in the villages. Improved fallows with nitrogen-fixing trees and shrubs for soil fertility enhancement have doubled or tripled staple crop yields.

One of the constraints to better food processing is the availability of local equipment. To overcome this, local metal workers have been supported to develop appropriate equipment for drying, chopping, and grinding a range of foodstuffs, including tree products not previously processed. This has created employment for metal workers and allowed local entrepreneurs to extend the shelf life and the quality of the produce they sell in local markets. These products are selling at higher than usual prices and in a few cases are being sent abroad.

For the farmers, income generation from the sale of plants from village nurseries has risen dramatically as the project gathers momentum with plant sales at the

Rural Resources Centers in Cameroon generating a total of USD 145, 16,000, and 28,350 after 2, 5, and 10 years, respectively. Meanwhile in town, the fabrication of about 150 discharge mills and 50 dryers has generated income in excess of US$120,000 (Asaah et al. 2011; Leakey and Asaah in press), while the women who have set up businesses for grinding crops like cassava (*Manihot esculenta* Crantz) have also increased their income substantially. The largest of these groups was run by ten women who employed eight workers and processed about sixty-six 180 kg bags of dried cassava flour per day throughout the year. Profits from bags selling at US$40–$54 per bag, depending on the season, were said to be more than US$2.5 per bag.

The most important and exciting thing about this project has been the wide range of positive livelihood impacts that the farmers are saying have truly transformed their lives. These require further quantification and verification but include substantially increased income, new employment opportunities, retention of youths in the villages due to career opportunities, improved nutrition, improved health from potable water and better diets, and the ability to spend money on children's schooling, home improvements, wells, etc. Additionally, women indicated reduced drudgery in their lives from not having to collect water from rivers and farm produce from remote farms, as well as from mechanical processing of food crops. All these things mean that they had more time to look after their families and engage in farming or other income generating activities.

These impacts strongly suggest that by promoting self-sufficiency through the empowerment of individuals and community groups through the provision of new skills in agroforestry, tree domestication, food production and processing, community development, and microfinance, it is possible for communities to climb the entrepreneurial ladder out of poverty, malnutrition, and hunger. This case study illustrates the use of agroforestry to deliver multifunctional agriculture in ways that break the cycles of land degradation and social deprivation that have kept nearly half the world's population in poverty (Leakey 2010) and so to steer a path toward social, economic, and environmental sustainability. What is needed now is to disseminate this approach to millions of other poor people in Africa and other tropical countries. There are many ways of doing this, but one very interesting and hugely important one is already in progress in West Africa. It involves Unilever, a multinational company that has recognized the need to use participatory domestication and community agroforestry for the development of several species of *Allanblackia* trees as a new oil crop (Jamnadass et al. 2010).

Opportunities for Enhanced Adoption of Agroforestry

The IAASTD proposal, approved by 61 countries, that agricultural development should be redirected toward multifunctional approaches to agricultural production presents a great opportunity for agroforestry if it becomes recognized as a highly desirable delivery mechanism for the new paradigm (Leakey 2010). To achieve this potential, there is a need to:

- Develop policies to promote agroforestry as a key delivery mechanism for multifunctional agriculture.
- Use multifunctional agriculture to improve public knowledge and understanding of the importance of agroforestry.
- Scale up agroforestry R&D to levels that could have significant economic, social, and environmental impacts. Given that there are 1.8 million needy farmers involved in some sort of agroforestry activity on over 1.0 billion ha of land, any meaningful initiative should have a good chance of rapid adoption.

Attaining political will to implement this upscaling of sustainable rural development will require a better understanding of what agroforestry is and what it can do. An improved public image should lead to political action. Linking agroforestry clearly to multifunctional agriculture should produce mutual benefits and improve the lot of billions of poor and disadvantaged people, as has been illustrated on a small scale in Cameroon (Tchoundjeu et al. 2010; Asaah et al. 2011).

Conclusion

Multifunctional agriculture based on agroforestry meets many of the needs of poor people, but the redirection of agricultural knowledge, science, and technology in support of it will require a paradigm shift with greater emphasis on:

- Integrated approaches to land use management involving participatory approaches to planning and implementation
- Less exploitative approach to natural resources, especially soils and water, and a lower dependence on inorganic inputs and fossil energy
- Good husbandry to support agroecosystem health, restoration of degraded land, and the reduction of the "yield gap"
- Increased involvement of local user groups in actions to improve natural resources management
- Diversification of agriculture for improved soil amelioration, pest and disease control, and new marketable products
- The domestication of new nutritious and marketable crops from local species, especially trees, to diversify diets and the local economy
- Enhancement of rural livelihoods by meeting the needs of local people and supporting culture and tradition
- Better integration of agricultural sectors, government departments and institutions, communities, and stakeholders to overcome "disconnects" in policy and practice
- Public-private partnerships involving diverse stakeholder groups at the local level to support sustainable production, and in-country processing and value adding

End Notes

1. Leakey RRB (1996) Definition of agroforestry revisited. Agrofor Today 8:5–7.
2. http://www.equatorinitiative.org/

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