5 Lessons from sub-Saharan Africa

Delivery mechanisms for mobilizing agricultural biodiversity for improved food and nutrition security

Hervé B. D. Bisseleua and Amadou Ibra Niang

Introduction

Recent international fora have emphasized the importance of biodiversity for food security and health. The World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa, 2002, emphasized the interconnections among five focal areas (WEHAB) including health, agriculture and biodiversity necessary for achieving long-term sustainability. A Decision (CBD Decision VII/32) of the Conference of the Parties (COP7) of the Convention on Biodiversity taken in Kuala Lumpur, 2004, specifically calls for a strengthened focus on biodiversity for food and nutrition. A resolution accompanying the adoption of the World Health Organization Global Strategy on Diet, Physical Activity and Health (WHO, 2004), includes explicit reference to traditional and indigenous diets.

The global struggle against poverty and hunger cannot be won without increased collaboration in the conservation, and sustainable and fair use of agricultural biodiversity. Diversity can also help improve productivity by raising yield stability, contributing to pest and disease control, and improving the environment (Flood, 2010). Meeting the Millennium Development Goals (MDGs) will require political will, financial commitment and a readiness to attempt innovative solutions. The very fact that 10 years after the adoption of these goals, most African countries have been unable to make proportionate progress in the elimination of hunger and poverty indicates the need for an overall change in the manner in which we have addressed this challenge to date. Without such a change we will not achieve the goal of a hunger-free world.

Agricultural biodiversity plays a central role in household food security and income generation, and thus in achieving MDG1 of halving the proportion of hungry and extremely poor people by 2015. However, its wider use to address nutritional deficiencies and other aspects of poverty, all of paramount importance, is yet to be fully realized. Today, undernutrition still persists in the vast majority of African countries, affecting in particular, women and children. This translates into a low consumption of essential micronutrients, the result of which is a high prevalence of micronutrient deficiency related diseases, and reduced capacity to fight the debilitating effects of diseases such

as malaria and HIV/AIDS (Underwood, 2000). Reducing undernutrition has therefore become a key objective of the MDGs and many African countries and international development organizations around the world are helping Africa to achieve this objective. This chapter outlines a cross-cutting approach to using agricultural biodiversity for food and nutrition in Africa with examples taken from the Millennium Villages Project.

Linking agricultural biodiversity conservation and nutrition in sub-Saharan Africa (SSA)

The world has made great strides in reducing hunger, yet the problem of malnutrition, particularly the 'hidden hunger' caused by missing micronutrients, constitutes a formidable challenge for the future. Biodiversity has a crucial role to play in mitigating the effects of micronutrient deficiencies, which are debilitating hundreds of thousands of people in sub-Saharan Africa, particularly children and women. In the developing world, people turned to fashionable 'modern' foods and abandoned the traditional diet as 'backward' and 'poor'. In the West, however, people are looking to some traditional diets, for example those of East Asia and the Mediterranean, as a source of inspiration about nutrition and health. Indeed, many of the epidemiological connections between diet and health have come from an observation of traditional peoples and the peculiarities of their food intake and health. The importance of plant sterols, omega-3 fatty acids, and other dietary components in reducing diseases has been established largely through the study of traditional diets that are associated with longevity and good health (Johns and Eyzaguirre, 2007).

Farmers and others, however, are well aware of these types of differences and often describe certain kinds of food, and indeed certain varieties or landraces, as having particular nutritional or therapeutic value. Ethiopian farmers, for example, recognized certain varieties of sorghum as having value for sick children and nursing mothers (NRC, 1996). The Luo people of western Kenya say that the leafy vegetables that form an important part of the traditional diet protect against gastro-intestinal helminthes and other disturbances (Johns et al., 1995).

A 2001 survey of household agricultural production in Mali revealed that the poorest rural household produces little more than cereals (rice, millet and maize) and spent almost 50 per cent of their total household expenditures on vegetable crops and legumes. Studies also revealed that the poorest families purchase food in the market often, resulting in a diet with very little diversity. Therefore, the likelihood of nutritional status being improved is tied to the improvement of diet diversity where nutritious food is available.

There is certainly some evidence that a varied diet is beneficial (Tucker, 2001). In Kenya, Onyango et al. (1998) demonstrated that diversity in the diet has clear beneficial effects on the development of young children up to three years old. However, the challenge is to collect this type of nutritional and health information using sound anthropometric methods and then to relate it to other kinds of analyses such as epidemiological and biochemical investigations.

Food composition provides an important link for biodiversity and nutrition, which are generally considered to be unrelated fields. Even though the terms genetic resources, ecosystems and biodiversity may not be part of the mainstream nutrition vocabulary, nutrition improvement activities have long embraced the concepts. In the nutrition science community, biodiversity has always been considered in the context of food and nutrients, with a focus on wild and gathered species or varieties, and underutilized and underexploited food resources. For instance throughout Africa, in the Millennium Villages Project (MVP)[1] areas of East and West Africa, hundreds of species of leafy vegetables – some cultivated, some gathered from the wild – find their way into people's diets. In many cases they contain considerably more minerals and vitamins than introduced crops such as cabbage (Bisseleua, personal communication). In addition, it leads us logically to one of the basic principles of nutrition/dietary diversity. Food composition is therefore a useful vehicle to explore certain synergies and develop common ground between biodiversity and nutrition.

Agricultural biodiversity in the wider context of the Millennium Development Goals

Livelihoods and economies in Africa depend critically on the ecosystem that land and its associated biodiversity provide. The populations of most African countries depend on agriculture for their livelihoods and still are barely able to feed themselves (Rouxel et al., 2005). Poverty and hunger are related and accelerated by food insecurity. The food security situation depends largely on domestic production which, in turn, depends on the amount of agricultural biodiversity available. However, this biodiversity is threatened by socio-economic and climatic determinants (Rouxel et al., 2005; Faye et al., 2010). Agriculture's contribution to fighting poverty in Africa goes beyond people simply having enough nutritious food to eat or sell.

The continent's economies still rely heavily on earnings from agriculture, and it is still the main source of livelihood for hundreds of millions of farmers. The success or failure of the national harvest has direct impacts on the fiscal performance of most countries across the continent. Despite this, agriculture has historically received low attention. As a result, farming in sub-Saharan Africa is characterized by a subsistence system of low inputs, low outputs and low investment.

Food production and vegetable and fruit consumption per capita in Africa has been declining in recent decades. Recent changes in lifestyle, particularly urbanization, have led to high consumption of fats and refined carbohydrates and relatively less consumption of fruit and vegetables. This has further complicated the nutrition problem in Africa with increased incidences of obesity, diabetes, cardiovascular disease, high blood pressure and cancer. Ironically, although the continent has to struggle with these nutrition problems, it is blessed with a high diversity of underutilized micronutrient-dense vegetables and fruits. In spite of the fact that the vegetables are easily accessible and adapted to local conditions,

they have been neglected in research and extension and their consumption has been declining over the years, as has the range of vegetables consumed. The range has fallen from hundreds consumed regularly to only a few, and often mainly exotic species. Coupled with reduced consumption are parallel losses of local knowledge and landraces.

Recognizing these shortcomings and the potential of agricultural biodiversity to improve income and livelihoods and to fight against mineral and vitamin deficiencies, the MVP developed a field-based approach to enhance the role of these vegetables in improving the nutritional status and livelihoods of vulnerable groups, particularly women and children. This was to be achieved through promotion, increased production and consumption, improved processing, landrace improvement and sustainable management of the genetic resources. The project reported significant achievements, among them increasing agricultural production and enhancing ecosystem function by restoring and maintaining soil productivity, improving crop diversification and the diversification of farming systems; developing living genebanks to conserve genetic diversity; improving land productivity and land use diversity; providing high quality agricultural inputs, improving irrigation systems, training farmers and strengthening farmer cooperatives.

A series of activities were carried out to enhance agricultural biodiversity and commercialize agricultural production. These included diversifying crop production, introducing modern irrigation techniques, and adding value to agricultural products to increase their market value. Now, traditional staple foods grow alongside new high-value, nutritional crops and agro-forestry tree species, including groundnuts (*Arachis villosulicarpa*), soy beans (*Glycine max* L.), okra (*Abelmoschus esculentus, A. caillei*), green leafy vegetables such as amaranth (*Amaranth viridis*), jute mallow (*Corchorus olitorius*), black nightshade (*Solanum americanum*), cassava (*Manihot esculenta*) and pumpkin (*Cucurbita pepo*) leaves, and fruit trees such as jujube (*Ziziphus mauritiana*), tamarind (*Tamarindus indica*), baobab (*Adansonia digitata*), moringa (*Moringa oleifera*), citrus (*Citrus* sp), mango (*Mangifera indica*) and papaya (*Carica papaya*).

In Tiby, Mali, West Africa, activities aimed at providing diversified crops to farmers included the introduction of high value and nutritious crops and improved varieties of beans, groundnuts, cowpeas, melons, okra, shallots, and other garden vegetables, coupled with agricultural input distribution and training in farming methods and the management of diversity in crop lands. Training methods focused on seed bed preparation and planting, seed and germplasm production (Figure 5.1a), vegetable gardening, annual crop production, integrated pest and disease management, management of agro-forestry nurseries, post-harvest management and marketing. On-farm demonstration plots were established within the communities to demonstrate appropriate farming practices and to showcase positive effects of agro-forestry and horticultural technologies. The impacts of these combined initiatives on agricultural production have yielded considerable reductions in levels of chronic undernutrition among children under five (MDG annual report, 2010).

Figure 5.1 (a) Seed and germplasm production methods are part and parcel of the MVP diversity strategy (left); (b) pedal pumps are used to irrigate fields in Kenya (right). By Hervé Bisseleua

Four new high yielding varieties of rice (G4 of Wassa, Nionoka and Adny11 and R1 of Wat310) were introduced in Toya, Mali and farmers have devoted nearly two-thirds of the area under cultivation to rice (*Oryza* sp.), sorghum (*Sorghum* sp.) and millet (*Pennisetum glaucum*). In addition to that, to reverse desertification and provide a diversity of nutrients to the communities, the project introduced in the community gardens of Toya improved traditional vegetable varieties (onion, tomatoes, okra, potatoes, cucumber, melon, amaranths and black nightshade) and agro-forestry landraces (jujube, tamarind and moringa). Agro-forestry tree species were grown in community gardens in association with traditional vegetable species providing households with products having a diversity of nutrients and micronutrients.

In Bonsaaso, Ghana, West Africa, emphasis was placed on perennial crops. Nurseries and plantations of the cocoa tree (*Theobroma cacao*) were established in association with maize, cassava and banana (*Musa* sp.). The seedlings raised in these nurseries were also used to rehabilitate old cocoa plantations during the 2010 major planting season. Improved oil palm (*Elaeis guineensis*) plantations were established in place of poor yielding old plantations. During the cropping season 2009–2010 a total of 37.6 tons of oil palm fruits were harvested, generating an average annual income of GHS 3,205.50 to farmers. In addition, oil palm and cocoa farmers received training in the management of agricultural biodiversity in their cocoa and oil palm fields as well as information and development of cooperatives.

In Mayange, Rwanda, cassava farmers, whose entire plots had been wiped out by a virus, were given disease-resistant cuttings, and today more than 1,000 ha of land are cultivated with cassava. A new processing plant to mill raw produce into high-value flour has been built with an initial investment, which now also employs seven permanent staff and up to 50 casual weekly workers. The farmers' increased yields and their newly refined product have allowed them to expand their sales to Rwanda's capital, Kigali, and to neighbouring Burundi. The cooperative now regularly attends nationwide trade shows, and

it was given an award by the District in recognition of its promotion of cassava production. However, the project proponents believe that there is still room for improvement – as a young organization, the cooperative needs help to boost its capacity to manage its newly-flourishing business in a more effective manner.

In Sauri, Kenya, 41 drip irrigation systems are now in operation, some of which have been paid for by private sector investors offering credit to farmers. The systems are expensive, however, and most farmers have opted to use pedal pumps (Figure 5.1b), which are cheap but effective enough to irrigate up to one hectare. Distribution of these pumps will be scaled up to benefit 990 farmers, who will be encouraged to grow mainly horticultural crops including tomatoes, onions, cabbages, African leafy vegetables and bananas that are propagated by tissue culture, to be marketed through their cooperatives. Women are given an equal chance to benefit, and all farmers received training on water management techniques, and accessing new markets for selling their produce.

Planting soy beans in Ruhiira, Uganda, has had a double benefit – the plant locks nitrogen into the soil, in an area where nutrients had been depleted, and it provides healthy food for people who have been affected by malnutrition. In 2010, the project proponents advised people about the benefits of soy bean, and encouraged them to plant it under integrated soil fertility management programmes, designed to boost productivity and diversify agriculture. At the same time, soy has a higher market value than maize, meaning that farmers earn more income by selling their harvests. More than 8,000 farmers in Ruhiira have been trained in soy bean cultivation, and most have been provided with improved, disease resistant seeds. Radio programmes and cooking demonstrations were used to alert the community to the plant's benefits, and a significant number of households now use part of their harvest in their own meals.

These combined interventions are perhaps best appreciated in Mwandama, Malawi. With hybrid maize seeds, fertilizer and topdressing provided to village farmers, Mwandama now boasts a record maize yield increase of up to 5.6 mt/ha, compared with Malawi's national average of 1.2 mt/ha. Drip irrigation schemes have been introduced to increase agricultural productivity for business, and to expand cultivation of high value crops, mostly vegetables and fruits. These allow farmers to earn enough profit through market sales to offset the extra irrigation cost. The initiative also teaches farmers how to produce the quality and quantity of these cash crops required year-round by nearby markets.

Taken together, the efforts made in the MVP's agriculture sector – improving harvests, diversifying diets and increasing business opportunities for farmers – have all contributed to the overall food security and health of the villagers.

Drylands, climate change, food security and the MDGs

The drylands region of the Sahel, one of the poorest areas in the world, has long been plagued by drought and desertification. These extremes of climatic variability have not only caused the deaths of many people but also hampered the production systems (Funk and Brown, 2009). Few climate change coping

mechanisms are used currently by farmers in the Sahel. The most widely used strategies are the traditional agro-forestry parkland systems where trees, crops and livestock are combined in the same landscape (Rouxel et al., 2005; Faye et al., 2010). However, these systems are threatened by poor regeneration of the trees and the high pressure on the resources posed by rapidly growing human and animal populations (Garrity et al., 2010). While many response options have been developed in the Sahel by national and international research organizations, they are generally limited to specific sectors and have focused mostly on the biophysical aspects with very low technique adoption rates by rural communities (Reij et al., 2009).

Sahelian countries depend on agriculture to feed themselves to an even greater extent than many other countries in Africa. The food security situation in the Sahelian countries depends largely on domestic production which, in turn, depends on the amount of rainfall that these countries receive. The Sahel was struck by a devastating series of droughts in the 1970s and 1980s that affected most countries, causing immense human suffering due to a serious food shortage. These droughts demonstrated the fragility of food security, where the majority of food production is based on rainfall associated with climatic events. The region needs a multidimensional effort focused on poverty alleviation, with an integrated approach that both reverses soil depletion and preserves existing biodiversity as a means to overcome regional biophysical constraints and promotes income-generating, high-value agricultural products. Activities should aim to propose concrete solutions to reduce the risks farming households face due to climate change and its effects on drylands. To do so, rural communities should be helped to identify and invest in the most effective and sustainable coping mechanisms to reduce these risks and to invest in these mechanisms in a sustainable way.

However, over the past three decades, the Sahel has experienced an environmental renaissance, in terms of the development of vegetation and improvement of production systems. Experts link this phenomenon not only to an increase in rainfall but also to changes in land and tree use legislation which have incentivized farmers to plant and maintain trees in their farmlands (Garrity et al., 2010). Hundreds of thousands of farmers have transformed large swathes of the region's arid landscape into productive agricultural land, improving food and nutrition security and the livelihoods of millions of people. Sahelian farmers achieved their success by ingeniously modifying traditional agro-forestry, water, and soil management practices, specifically in Niger and Burkina Faso, primarily because of farmer-managed natural regeneration. Recent data has shown that more than 4.8 million hectares are greener today than 20 years ago in the regions of Zinder and Maradi in Niger, primarily because of farmer-managed natural regeneration of trees in densely populated and agriculturally overexploited areas (Reij et al., 2009).

This transformation resulted from a combination of incentive changes in government policy combined with village-level institutional innovations in managing land, along with successful changes in farmer practices. These

experiences deserve careful attention as a basis for developing regional and national initiatives that could possibly result in a new era of transformative change across the Sahelian landscape. Lessons from success stories and case studies models in implementing the Sustainable Land Management practices have not been adequately synthesized to spearhead further expansion of the practices throughout the Sahel. The next section reviews these experiences, and their broader implications for sustainable food security in the Sahel, as manifestations of Climate SMART Agriculture, a fresh approach to achieving food security and environmental resilience through agricultural systems that increases productivity while enhancing adaptation and mitigation.

Fertilizer trees, conservation farming and the conservation of agricultural biodiversity

The challenge facing African agriculture is to produce more food while at the same time combating poverty and hunger. The risks that come with climate change make this task more daunting. However, hundreds of thousands of rain-fed smallholder farms in Zambia, Malawi, Niger, Mali and Burkina Faso have been shifting to farming systems that are restoring exhausted soils and are increasing food crop yields, household food security, and incomes using a type of conservation agriculture termed 'Evergreen Agriculture'.

Evergreen Agriculture is defined as combining agro-forestry with conservation agriculture through the integration of particular tree species into annual food crop systems (Figure 5.2). The intercropped trees sustain a green cover on the land throughout the year to maintain vegetative soil cover, bolster nutrient supply through nitrogen fixation and nutrient cycling, generate greater quantities of organic matter in soil surface residues, improve soil structure and water infiltration, increase greater direct production of food, fodder, fuel, fibre and income from products produced by the intercropped trees, enhance carbon storage both above and below ground, and induce more effective conservation of above- and below-ground biodiversity (Garrity et al., 2010; Reij et al., 2009).

In Zambia, maize and other food crops are intercropped within an agro-forest of the fertilizer tree *Faidherbia albida*. The Malawi Agro-forestry Food Security Programme (AFSP) integrates fertilizer, fodder, fruit, fuel wood, and timber tree production with food crops on small farms on a national scale. The agro-forestry trees include *F. albida*, *Gliricidia sepium*, *Tephrosia candida* and *Sesbania sesban* resulting in 100 to 400 per cent yield increase in food crops. It is estimated that currently about 500,000 Malawian farmers have *Faidherbia* trees on their farms (Phombeya, 1999). The majority of these stands were developed through assisted natural regeneration of seedlings that emerged in farmers' fields. Throughout Niger, studies have revealed a dramatic expansion of *Faidherbia albida* agro-forests in millet and sorghum production systems via assisted natural regeneration (Reij et al., 2009; Tougiani et al., 2009). Burkina Faso farmers developed a unique type of pit-planting technology (*zai*) along with farmer-managed natural regeneration of trees on a substantial scale resulting in

Figure 5.2 Intercropping of *Leucaena leucocephala* and *G. sepium* with green leafy vegetables in MVP farmer's field. By Hervé Bisseleua

a significant increase in cereal production by an average of at least 400 kg/ha, an increase of 40 per cent to more than 100 per cent (Reij et al., 2009).

Such complex landscapes characterized by highly connected crop–non-crop mosaics are best for long-term conservation, biological control and sustainable crop production and insure such landscapes from environmental perturbations (Tscharntke et al., 2007). They provide a number of important resources for pollinators, parasitoids and predatory arthropods such as permanent vegetation cover suitable as refuges from disturbance, as well as resources such as alternative prey, pollen and nectar (Bianchi et al., 2006). Such consideration of the landscape context ensures sustainable agricultural biodiversity conservation that is based on rich beneficial invertebrate communities and their capacity to reorganize after disturbances.

Conclusion

Africa is seriously threatened by food insecurity, land degradation and climate change. African farmers need science-based interventions. Special emphasis should be placed on measures to preserve local biodiversity using a farmer-centred approach of participatory action-research and development and based on coping strategies to climate change and desertification. Research programmes should analyse issues related to the desertification processes; look for ways to integrate crops of high nutritional value into existing farming systems; identify measures to further reduce climatic risks for each coping strategy while preserving biodiversity. This may include diversification of farming systems with trees and crops that are high-value and nutritious, and less susceptible to drought, and

incorporate water and soil management and rehabilitation techniques, among others. In addition, new technological solutions should be tested using holistic, system-wide approaches that encompass socio-economic constraints of poor farming households and the need to improve their livelihoods; and finally, elements of sustainability and replicability should be analysed to ensure the long-term use and success of these methods and practices. For these technologies to be sustained over time, it will be important to identify, develop and promote higher market potential for the agricultural commodities that will strengthen farmers' management knowledge and skills. The Millennium Villages Project is tackling these critical issues head-on with a focus on achieving the MDGs: the world's commitment to end extreme poverty and ensure environmental sustainability by the year 2015.

Note

The Millennium Villages Project simultaneously addresses the challenges of extreme poverty in many overlapping areas: agriculture, education, health, infrastructure, gender equality, and business development and offers an innovative integrated approach to rural development.

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