AIRCA

WHITE PAPER

Transforming rural livelihoods and landscapes: sustainable improvements to incomes, food security and the environment

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Cover photo: Vegetable soybean is becoming a popular crop in northern India. AVRDC

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Summary

A growing world population, combined with economic and social development, will continue to lead to increased demand for the outputs of agriculture – food, fodder, fuel and fibre. Simply increasing the amount of land dedicated to agriculture to meet this demand is neither desirable nor feasible. Instead, it has become essential to grow more with the same, or fewer, inputs of water, energy and chemicals; lose less of what is produced; maintain the long-term health of the land, ecosystems, people, plants and animals involved in agricultural production; and deliver prosperity. These are the ingredients of sustainable agricultural intensification.

Capturing the synergies and managing the trade-offs involved in sustainable intensification means tackling these challenges at the landscape level. Landscapes encompass a diversity of interactions between people and environment, and between agricultural and non-agricultural systems. Healthy landscapes not only exhibit healthy ecosystems, but also sustain productive agriculture and communities.

In economically sustainable rural communities, agriculture is perceived as a respected profession that provides an adequate living, and farmers are motivated to stay in the rural landscape rather than seeking higher income in the cities. Sustainable agriculture therefore requires farms that operate at an economically viable scale, and farmers who can make informed decisions about the production and marketing of their output. Thus, any landscape strategy must also have a vision of how to help communities make businesses out of their activities in the environment. In some areas, this may not be possible through farming alone, so additional sources of sustainable, environmentally friendly value must be created. Financial mechanisms, incentives and training are needed to connect farmers to markets and ensure that they obtain a fair share of this value.

Women play essential roles in agriculture – providing inputs, managing production, stewarding natural resources and generating off-farm income – but often benefit less than men. High-value agricultural production chains are usually run by male-dominated institutions, while women are often limited to local markets where they sell low-quality and residual products. All landscape-level interventions therefore need to attend to this imbalance through gender mainstreaming, in order to maximize the benefits of agriculture to women farmers, providing incentives to increase their productivity.

The need for integrated action to deliver sustainable agricultural intensification at the landscape scale has stimulated the formation of the Association of International Research and Development Centres for Agriculture (AIRCA, www.airca.org), a nine-member alliance focused on increasing food security by supporting smallholder agriculture and rural enterprise within healthy, sustainable and climate-smart landscapes. The member organizations all have a proven track record of research, development and implementation, working closely with farmers, extension systems, national research institutes, non-governmental organizations (NGOs) and the private sector across a wide range of crops and ecosystems. This paper sets out our combined experience of successful approaches, opportunities and challenges in moving farmers from a subsistence to a business basis – and their communities from poverty to prosperity.

Through sharing AIRCA's knowledge and experience in creating healthy landscapes, we seek to raise awareness of the benefits of landscape approaches among potential stakeholders in the agricultural and environmental sectors. We make the following recommendations to increase agricultural productivity in a responsible and sustainable manner, while also achieving healthy development at the landscape level:

- **Scaling out** of integrated management approaches to seed selection, soil fertility, water utilization, agronomy and pest management and preserving and utilizing crop diversity, in order to arrive at

crop selections, cropping systems and practices of land management which are balanced and optimized in the context of the local environment and needs for income, food and nutritional security.

- **Capacity strengthening** at local and regional levels to improve productivity, market access and landscape management in an inclusive manner by involving women, young people, indigenous communities and marginalized groups, and incorporating traditional knowledge.
- **Policy development** and implementation at local, national and regional levels to capture the economic value of outputs from landscapes, but also to balance these against the long-term values of ecosystem services, biodiversity and interventions at the landscape scale.

To achieve these aims and improve the health of humans, plants, animals and landscapes in an integrated manner, a broad range of core competencies are required. We encourage the creation of innovative funding mechanisms that will stimulate and facilitate the formation of integrated partnerships between research and development organizations, countries and regional networks in order to deliver practical solutions with impact at the necessary scale, the capacity to sustain these interventions over time, and the development of sound policy to underpin them.

A multifunctional landscape in Myanmar. Photo: INBAR

1. Introduction

There are powerful forces driving change in agricultural systems around the world. The demand for food is rapidly increasing, and meeting it requires more efficient and environmentally friendly food production. Central to this expanding demand is a population predicted to grow from seven billion to more than nine billion by 2050. Concurrent economic and social development will trigger disproportionate pressure on the agricultural sector to produce not only greater quantities of basic foodstuffs, but also more protein, animal feed, biofuels and fibres. Growth in population and in the incomes of a large portion of the expanding population will cause demand for agricultural production to increase at an even higher velocity than the rate of population growth.

Simply increasing the amount of land dedicated to agricultural production is not easily accomplished, nor often advisable. In some parts of the world, land is scarce and under intense pressure as the expanding human population leads to the conversion of agricultural land to housing and commercial uses. In other areas, land is abundant, but is often environmentally fragile or poorly suited to agriculture. Furthermore, agriculture is a 'thirsty' industry, and securing adequate water for irrigation is becoming progressively more difficult in the context of competing demands on water supplies. Clearing land to expand agricultural production contributes to greenhouse gas emissions, exacerbating climate change and resulting in more erratic weather patterns (Foley et al., 2005), which make it difficult for farmers to manage their operations according to traditional practices and timelines.

How the world responds to the growing demand for food has wide-ranging implications. Agriculture is of pivotal importance, not only providing food and income for the rural poor, but also meeting the food needs of growing urban populations. Higher outputs must be accomplished by increasing the productivity of the agricultural sector, especially for smallholders in developing countries. But it must also be achieved sustainably in the context of the environment within which smallholders operate, by minimizing negative impacts on air, water, soils, biodiversity and other ecosystem services.

A Bangladeshi farmer uses an applicator to deep-place urea briquettes into a rice field.
Photo: IFDC

2. Objectives of this paper

Growing demands for food can only be met through an innovative systemic approach to agricultural development (McNeely and Scherr, 2001; Campos, 2012). As climate change increases the pressure on agriculture, trade-offs among different land uses will intensify, as will competition for arable land, water, minerals and other natural resources. The identification and optimization of these trade-offs can best be achieved by considering the landscape in an integrated way in order to develop land use plans that strike an appropriate balance between social, environmental and economic concerns.

This paper seeks to set out the rationale for healthy landscapes, and the steps which must be taken to sustainably support diverse crops, animals and people in the long term. A broad vision of healthy, sustainable and climate-smart landscapes stimulated the formation in October 2012 of the Association of International Research and Development Centres for Agriculture (AIRCA, www.airca.org), an alliance with nine founding members (see Box 1).

AIRCA's focus is on increasing global food security through the development of interdisciplinary solutions to the existing and emerging challenges of smallholder agriculture. Supported by more than 60 member countries comprising over 70% of the world's population, AIRCA members have activities in all major geographic regions and ecosystem types.

AIRCA's approach emphasizes:

- direct interactions with farmers and their organizations, as well as public extension services, NGOs and the private sector, to promote the successful uptake of new or more sustainable technologies and management practices;
- scientific assessment of the effectiveness of existing management practices and technologies;
- research and development on staple and non-staple food crops for diversified and sustainable diets and production systems; and
- the need to integrate activities concerning the health of people, plants, animals and landscapes when working to intensify agricultural productivity.

A mother and her two daughers carrying water home in rural Yemen. Photo: Dorte Verner

Box 1. AIRCA founding members

AVRDC	The World Vegetable Center
CABI	CAB International
CATIE	Tropical Agricultural Research and Higher Education Center
CFF	Crops for the Future
ICBA	International Center for Biosaline Agriculture
ICIMOD	International Centre for Integrated Mountain Development
icipe	African Insect Science for Food and Health
IFDC	International Fertilizer Development Center
INBAR	International Network for Bamboo and Rattan

One of the key objectives in establishing AIRCA was to enable the founding members to speak with a collective voice and more effectively engage with regional and international networks and policy-makers. AIRCA's concern with healthy landscapes resonates well with current thinking in the fields of agriculture and the environment, as seen during the United Nations Conference on Sustainable Development held in Rio de Janeiro in June 2012. Growing interest encouraged us to move the debate forward by publishing this paper on the value of healthy landscapes for increasing agricultural sustainability and food security for smallholder farmers.

The specific objectives of this paper are to:

- review ways of improving the productivity, livelihoods and food security of smallholder farmers while also sustaining ecosystems and natural resources;
- consider the processes and mechanisms necessary to promote adoption of healthy landscape approaches among rural communities;
- show how decision-makers can support healthy landscapes through proper policies, institutions, management and research;
- identify key issues and challenges in moving forward; and
- set out AIRCA's approach and recommendations for the promulgation of healthy landscapes.

Farmers harvesting potatoes in Bolivia. Photo: CABI

3. Improving smallholder productivity

Increasing the amount of land dedicated to agriculture cannot be easily accomplished and could have significant global impacts on biodiversity and ecosystem services, particularly water resources, terrestrial carbon and climate change mitigation. A far better approach is to produce more food on the same or less land in a way that minimizes negative impacts on air, water, soils and biodiversity. If combined with rural income diversification, off-farm income can provide capital to support improved farming practices, reducing unsustainable land use in pursuit of increasing food production.

Poor farming practices in the developed and developing worlds often degrade the natural resource base threatening ecosystem health. The large industrial farming systems of the developed world rely on high levels of chemical inputs, mechanized labour, irrigation and a limited range of hybrid seed varieties mono-cropped over large areas for lengthy periods. Such systems often have negative impacts on water availability and quality, insect, plant and tree populations, are vulnerable to disease, and even the government budgets which fund accompanying farm subsidies. In the developing world, small rainfed farms are cultivated by hand with retained seed on marginal land. These systems, lacking the purchased yield-enhancing inputs of most developed-world systems, can also lead to environmental degradation through nutrient depletion and soil erosion. Viable future solutions to improving smallholder productivity must avoid these pitfalls.

3.1 Soil fertility management

Dwindling soil fertility and the loss of biological productivity due to land degradation are major constraints to agricultural production in many developing countries; without investment in nutrients – either organic, mineral or both – crop productivity declines. A series of recent studies by *icipe* have also shown that soil fertility not only affects plant growth and vigour, but also the level of pest infestation and damage and the performance of natural enemies (Khan et al., 2012).

Faced with falling soil fertility, many farmers expand their cultivated area, encroaching on prairies, forests and wetlands, thus accelerating landscape degradation. Maintaining fertility and intensifying productivity in existing agricultural zones is an important way of reducing pressure on natural areas. Sustainable field management – and, by extension, landscape management – can be achieved by using both external and internal sources of nutrients (for example, both fertilizer and intercropping with legumes) to maintain productivity. But there are no one-size-fits-all solutions: increasing agricultural productivity while decreasing environmental damage requires site-specific approaches that take into account climate and ecological conditions.

In high-input industrial agriculture, and in rapidly developing countries such as India and China, yields can be maintained by using fertilizers more efficiently, through applying the right kind of fertilizer, at the right time and rate, in the right place (International Plant Nutrition Institute, 2013). However, smallholder farmers in developing countries often do not have access to state-of-the-art technologies, inputs and innovations that could help increase productivity. Appropriate strategies for these farmers to increase yields sustainably include:

- light tillage soil preparation;
- integrated soil fertility management (ISFM), which balances mineral and organic nutrients in relation to crop-specific needs (see Box 2);
- intercropping and inter-annual crop rotations that take advantage of interactions between different crops, such as legumes and cereals, and the principles of pest management;
- use of improved seed varieties, often based on local landraces, using either conventional or transgenic breeding methods;
- appropriate fertilizer use, based on the specific nutrient requirements of a given crop, the availability of nutrients in the soil, and a balance of macro-, secondary and micro-nutrient applications; and

- minimization of pesticide use by combining appropriate soil fertility measures, which ensure healthy plants that resist insects, with integrated pest management techniques.

The diversity of appropriate strategies for sustainably increasing smallholder production highlights the importance of closer linkages between centres with expertise in agronomy, water, insect ecology and pest management, and soil science in improving crop productivity.

3.2 Water utilization, prevention of and adaptation to salinization

Globally, as demand for water from cities, industry and agriculture rises, irrigation makes up two thirds of total water withdrawals (Molden, 2007). In many areas, the limits of water use have already been reached. Climate change is likely to mean not only more droughts and floods, but also a shift in hydrological patterns. Sustainable utilization of water resources in an economically and environmentally sensitive way is critical to building climate-resilient and sustainable agriculture.

Box 2: Integrated Soil Fertility Management (IFSM)

ISFM is an important aspect of the work of IFDC. It has proven to be a viable method to increase agricultural productivity while protecting the environment and maintaining and improving soil. ISFM strategies centre on the combined use of mineral fertilizers and locally-available organic amendments such as crop residues, compost and green manure to replenish lost soil nutrients. This not only improves both soil quality but also the efficiency of other agricultural inputs. In addition, ISFM promotes improved crop management practices, measures to control erosion and leaching, and techniques to improve soil organic matter maintenance. At plot level, IFDC's work has shown that ISFM can more than double yields and greatly increase net financial returns per hectare, as shown by this summary of yield increases in the Great Lakes Region of Africa.

Summary of yield increases due to ISFM in the Great Lakes Region of Africa

Country	Crop	Farmer practice (yield, kg/ha)	Recommended ISFM practice (yield, kg/ha)	Increase in net returns due to ISFM (US$/ha)
Rwanda	Potato	8,000	19,500	1,600
	Maize	2,200	4,100	700
	Wheat	1,400	3,500	700
Burundi	Potato	3,200	15,900	2,200
	Rice	1,500	3,600	400
	Beans	400	1,600	300
	Wheat	300	2,200	500
Democratic Republic of the Congo	Potato	6,600	19,100	2,200
	Rice	2,300	7,000	2,600
	Beans	200	800	100
	Maize	1,000	3,600	600

Source: International Fertilizer Development Center (unpublished).

Note: Returns reflect two cropping seasons/year.

In most rainfed systems, available water management can be made more effective to increase productivity. Simple, and relatively inexpensive, techniques such as mulching, polythene sheeting or drip irrigation can significantly reduce water requirements in most environments. Discontinuing the cultivation of crops with very high water requirements will in some cases require the removal of subsidies (for the production of cotton, for example), while switching to practices that enable farmers to produce more with the same or less water are likely to need either government encouragement or financial support. In commercial farming environments, water accounting and pricing systems can be used to give farmers an incentive to minimize water usage, while telemetry and precision agriculture techniques can help apply just the right amount of water, in the right place at the right time.

Alongside demand management strategies, supply augmentation is also important. Non-conventional water (NCW) is an underexploited resource for agriculture and aquaculture as increasing demand and limited supplies of conventional water (mainly fresh water) constrain food security in many regions. The two major sources of NCW are wastewater from domestic, municipal and industrial contexts, and saline water from groundwater, drainage and surface sources. Although potential biological and non-biological contamination of NCW remains a concern, in some arid and semi-arid countries it is becoming the major source of water for agriculture as conventional sources of good quality water decline, or are diverted for other uses.

Salinity is a widespread phenomenon, in both irrigated and dryland regions of the world. The extent of salinization, because of irrigation practices (or malpractices) has increased significantly during the last two decades. How much land is affected by salinity can only be estimated since the level of salinity is interpreted in different ways. However, overall it is estimated that more than 1 billion hectares globally (one third of all agricultural land) is salt-affected, of which 77 million hectares are affected due to poor irrigation practices and other forms of management (secondary salinization). Approximately 24% (38 million hectares) of the irrigated lands in the top five countries that practice irrigation extensively (China, India, Pakistan, the Soviet Union and the United States) have been damaged by salts. If these data are extrapolated globally, 60 million hectares are salt-affected.

Not only is agricultural land salt-affected. Both the quality and quantity of irrigation water is also constrained. In some cases, there is not enough fresh water available to sustain any irrigated agricultural production system, whereas, in other cases, the quality of available water is not suitable

Land affected by salinity in Tajikistan. Photo: ICBA for optimum agricultural production. The Central-West Asia and North Africa region is among the largest dryland areas suffering from irrigation-induced salinity. Countries in this region that have a high per capita renewability of water are those that get water from the Nile and Euphrates river systems, whereas most of the other countries accessing groundwater use <300 m^3/year, considerably lower than the benchmark of 1,000 m^3/year used to define water scarcity.

The practical approach to deal with such situations and have an economical production system is to use the salt-affected land and water in an 'alternative agricultural production system' – the biosaline agriculture concept (see Box 3). This is the development of sustainable production alternatives for salt-affected lands that are deemed unsuitable for conventional farming and include: (1) more effective soil/water management and improved salt-tolerant crops, and (2) domestication of halophytes for commercial and/or environmental cultivation. The ultimate goal of this discipline is to help provide food and water security for future generations by conserving and rehabilitating scarce resources, substituting them for more abundant saline ones in newly emerging agro-ecosystems. The system is economically feasible for producing food, feed, fuel and fibre crops.

Box 3. More crop per drop – squeezing out valuable water resources

Based on the salinity problems in different agro-ecological zones globally, the International Center for Biosaline Agriculture (ICBA) has been working in a range of ways to identify resilient agricultural production systems in farming areas affected by salinity and shallow water tables, and to optimize management practices to increase yields.

In Central Asia and Caucasus, ICBA works with farmers to test salt-tolerant crops on their farms. Similar models have used in Jordan and Tunisia, where national governments have disseminated project outputs in a community-based expansion programme. In Turkmenistan, ICBA is working with farming communities to reclaim marginal lands by using NCW resources and indigenous salt-tolerant tree species.

Alfalfa forage crop irrigated with treated waste water in Jordan, 2011. Photo: ICBA

3.3 Crop diversity

New crop varieties that are resilient to drought, submersion, heat, pests and diseases will be essential in growing more food. The main carbohydrate staples of rice, wheat and maize are a focus of much investment through the CGIAR international research centres (e.g. the International Rice Research Institute and the International Maize and Wheat Improvement Center [CIMMYT]), national systems (the Brazilian Agricultural Research Corporation, the Indian Council of Agricultural Research and the Chinese Academy of Agricultural Sciences) and the private sector. In addition, other international research centres – including AIRCA members AVRDC, CATIE and CFF – hold valuable collections and carry out development programmes on an important range of fruit, vegetables, high cash value agricultural products and lesser-known crops.

For many rural communities, growing and selling relatively high-value products such as fruit, nuts, vegetables, non-timber forest products and medicinal herbs offers an important route to food security. In remote areas of the Hindu Kush region of the Himalayas, for example, where it is difficult to grow enough staples for the entire year, people have the opportunity to harvest and trade fruit, nuts and medicinal herbs. A major impediment in developing these activities is poor linkage to markets and value chains. Box 4 shows how CFF is working to meet these challenges.

Globalization of trade and food systems has favoured a few major crops, which have come to dominate agricultural production, processing and commerce. Inevitably, demands for research – and hence funding – have concentrated on these same commodities. In Ethiopia, for instance, use of improved seeds is limited to two crops, wheat and maize (International Fund for Agricultural Development, 2008). As a result of these imbalances, not only have a number of food species fallen into disuse, but other species used for fibre, medicine, fodder and construction material have been similarly affected. However, these neglected and underused plant species are part of a rich economic, social and cultural diversity.

Agrobiodiversity not only holds the key to conserving underused food species, but also helps to keep options open for adaptation to climate change and other emerging challenges. The implementation of agricultural practices and cropping systems with high agrobiodiversity – creating interacting patches of different crop associations, similar to a quilt – generates multiple benefits for the effective management and long-term conservation of natural resources. One example is CATIE's long-term Central American Cocoa project, which optimizes the integration and management of annual and perennial components according to both the production goals of farm households and the agronomic requirements and ecological functions of crops. This, together with avoiding the use of harmful chemicals, permits the effective protection of water, soil and agrobiodiversity, sustaining ecosystem productivity and reducing greenhouse gas emissions.

3.4 Losing less of what we grow

While new varieties that enable us to grow more will be an essential part of the solution for future food security, it is a shocking fact that a very large proportion of food crops grown today are lost to pests and diseases. For example, global losses of attainable rice yield are estimated at 37%, coupled with an average loss of a further 16% of postharvest yields by smallholders in developing countries (Oerke, 2006). Pre-harvest losses to pests for five major food crops are shown in Table 1.

Table 1: Pre-harvest crop losses due to pests in five major crops worldwide

Crop	Average Actual Losses (%)	Range
Wheat	28.2	14 – 40
Rice	37.4	22 – 51
Maize	31.2	18 – 58
Potato	40.3	24 – 59
Soybean	26.3	11 – 49

Source: Oerke (2006)

Box 4. Linking farmers to markets for specialty crops

In India and Viet Nam, CFF works with producer organizations, NGOs and national research institutes to provide resource-poor farmers with the tools and knowledge to improve production, post-harvest management and marketing of underused traditional crops. This supports income diversification, increasing the sustainability of household livelihoods.

Focusing on grains like foxtail millet (*Setaria italica*) and kutki (*Panicum sumatrense*), and indigenous fruits such as blackberry (*Carissa carandas*), jackfruit (*Artocarpus heterophyllus*), jamun (*Syzygium cumini*), mahua (*Madhuca longifolia*) and longan (*Dimocarpus longan*), CFF has helped disadvantaged producers to have better market access and a broader range of options for using marginal land. Methods included improving processing techniques in rural food processing parks, the selection of elite farmer varieties in community germplasm orchards and the dissemination of results in village crop fairs.

After three years of project interventions, there was a significant – and in some communities, even dramatic – increase in household income, and an expansion of the area under traditional crops. This was attributed to the availability of improved germplasm, enhanced skills and awareness of market opportunities and product development, and an increase in farm-gate prices.

Capsicums and peppers in a Ghanaian market. Photo: Crops for the Future

Other staples of major importance for food security – including barley, banana, cassava, sorghum, yam and millet – also suffer significant losses. Losses of fruit and vegetables, particularly post-harvest, can also be very substantial and threaten nutritional security (Mhlanga et al., 2010; Hodges et al., 2011).

Whereas the introduction of a new crop variety may take 15 to 20 years, reducing losses offers the potential for quick wins with technology we have at hand today. For example, Integrated Pest Management (IPM) can provide cost-effective and sustainable solutions contributing to enhanced agricultural productivity, biodiversity conservation and improved livelihoods. IPM involves the use of cultural, biological and mechanical methods, alongside targeted interventions with fertilizers and pesticides when justified, as outlined in the Food and Agriculture Organization of the United Nations (FAO) International Code of Conduct on the Distribution and Use of Pesticides (FAO, 2010). Biocontrol can be divided into two categories, namely classical and inundative. Classical biocontrol agents are exotic species that are introduced with the aim of establishing self-perpetuating populations throughout the range of the target species, providing permanent control with no negative impacts on the environment, as long as adequate safety testing has been carried out. The cost of classical biocontrol programmes is low relative to other approaches. It often requires a one-off investment and the benefits can be reaped by many stakeholders, independent of their financial status and irrespective of their contribution to the initial research. The cost–benefit ratios vary from 1:20 to 1:500. For example, the introduction of a biocontrol agent for the control of cassava mealy bug (*Phenacoccus manihoti*), an introduced pest which was reducing cassava yields by up to 84% in many parts of Africa, resulted in a yield increase of 2,500 kg/ha in tropical production regions, with benefits in the region of US$4.5 billion for the continent. This represents a cost–benefit ratio of 1:149, with benefits expected to rise each year (Herren and Neuenschwander, 1991).

Inundative (or augmentative) biocontrol involves the mass production and large-scale release of predators, parasites, fungi or viruses in response to outbreaks of crop pests. It is estimated that less than 0.5% of land under culture globally is under augmentative control but that the associated cost–benefit ratio is 1:2 to 1:5, which is similar to that of insecticides (Bale et al., 2008). Uptake has historically been higher in the developed world, but its use is becoming more widespread in the developing world. For example, egg parasitoids of the genus Trichogramma are now released on more than 10 million ha of agricultural land worldwide (Bale et al., 2008) where they have successfully controlled pest species in cotton, maize and sugar cane (Wang et al., 2005). In Asia, Trichogramma has been shown to decrease the Asian corn borer in maize by up to 63% resulting in an increased yield of 28% (Zhang et al., 2010).

Post-harvest losses are increasingly recognized as one of the most critical constraints affecting the food security of resource-poor farmers in many developing countries; annual post-harvest losses of cereals from sub-Saharan Africa, for example, are valued at around US$4 billion (Hodges et al., 2011). A lack of infrastructure for transporting, storing or processing produce not only contributes to decreased availability of nutritious food, but also spells income losses. Box 5 shows how CABI has worked with coffee farmers to improve post-harvest processing and increase incomes.

Box 5. Improved coffee processing gives access to price premiums

In recent work funded by the Common Fund for Commodities (CFC), CABI has been helping coffee farmers in Rwanda and Ethiopia improve the effectiveness of their methods for drying coffee cherries. Farmer field schools were used to teach farmers new processing techniques, and producer clubs enabled them to achieve 30% price premiums for the better product that resulted.

But many of the farmers could not afford the capital outlay to buy the simple equipment needed to improve the drying process. To address this, a second phase of the project, supported by CFC, Rabobank Foundation and Rabo International Advisory Services, National Coffee Development Authorities, government ministries, and the International Coffee Organization, developed a sustainable credit guarantee scheme so that farmer groups could purchase the driers and be supported with adequate extension services and close mentoring.

Post-harvest losses translate into both increased poverty and hunger. Assuming only a 1% reduction in post-harvest losses, annual gains of US$40 million are possible, with the producers as the key beneficiaries (Mhlanga et al., 2010). Methods to cut these losses will contribute to adding significantly to available food supply and supporting improved incomes. Consequently, crop protection technologies that address post-harvest losses and that are integral to a holistic approach to crop management should become a vital instrument for tackling food insecurity and poverty reduction.

3.5 Integrated crop management

The integrated crop management approach seeks to draw together individual agricultural practices – such as seed selection, soil fertility, water utilization, agronomy and pest management – to arrive at a strategy for growing a target crop that is balanced and optimized in the context of the local situation (see Box 6). This involves not just technical considerations, but should also take into account the economic situation of farmers, the climate and ecosystems within which they operate (Tamiru et al., 2011), and the available markets for crops.

3.6 Supporting good health and better nutrition

The drive for self-sufficiency in staple crops in many countries has led to neglect of the nutritional benefits to be gained from more diverse crop production. The genetic uniformity of agriculture and the growing dominance of a limited number of staple crops, discussed in Section 3.3, have negatively affected the global diversity and nutritional value of diets. The over-consumption of carbohydrates and widespread deficiencies in zinc, iron, vitamin A and other nutrients present significant nutritional challenges all over the world. A more diversified diet, high in vegetables and fruit, could improve the health of both rich and poor communities in rural and urban settings around the world (Keatinge et al., 2010; Michaelsen et al., 2009). Box 7 illustrates AVRDC's work in this area.

Growing a range of vegetables in home and community gardens improves access to a variety of nutrient-rich foods. Policy-makers have tended to overlook household and community gardening as a food production and nutrition improvement strategy. This kind of vegetable production also advances the position of women in society: female home gardeners gain stature in their communities for their cultivation skills and for the income they contribute to their households from the sale of surplus produce (Keatinge et al., forthcoming). In many countries, women are responsible for producing and marketing vegetables, and have a major role in processing fresh produce for value-addition after harvest (Keatinge et al., 2012).

In addition to common fruit and vegetable species, a range of other plants from the world's 12,000 edible species have important nutritional qualities. For instance, moringa (*Moringa oleifera*), kangkong (*Ipomoea aquatica*), bitter gourd (*Momordica charantia*) and jute mallow (*Corchorus olitorius*) can be excellent sources of essential micronutrients. Moringa leaves have 38 times the amount of ß-carotene, 24 times the amount of vitamin C, 17 times the amount of vitamin E, folates and iron, and 8 times the amount of antioxidant activity exhibited by commercially available tomatoes (Ojiewo et al., 2013; Keatinge et al., 2011). Other less well-known food species are not only nutritious, but also adaptable to environmental stresses, such as droughts, flooding, poor soils and biotic pressure. Amaranth, for example, a staple food of the Aztecs which has been cultivated for its leaves and grains for 8,000 years, is extremely robust, growing even under the harshest of conditions. Other hardy species include drought-adapted millets, sorghum and many green vegetable and tree species.

Many less well-known species have the potential to play a much more important role than they do today in sustaining livelihoods and human health and wellbeing, as well as in enhancing ecosystem health and stability. There is a need for policy change in research and extension in many developing countries to alter the exclusive focus on 'major or strategic food commodities', which deprives less well-known but useful crops of the attention and support they deserve.

Box 6. Integrating plant and soil health

A good example of an integrated approach is the 'push-pull' agricultural strategy, widely adopted in East Africa (www.push-pull.net). Production of maize in sub-Saharan Africa is constrained, among other factors, by stem borers, the parasitic weed striga (*Striga hermonthica*) and poor soil fertility. The 'push-pull' technology involves intercropping maize with the legume desmodium (*Desmodium uncinatum*) while Napier grass (*Pennisetum purpureum*) is planted around the maize crop. Desmodium produces volatile semiochemicals which repel stem borer moths from maize crop ('push'), while green leaf volatiles released by Napier grass attract the moths ('pull'). Most of the stem borer eggs are laid on the Napier grass, on which the larvae fail to develop due to the inferior plant quality of the grass, leaving the maize crop protected. Desmodium roots produce a number of chemicals, some of which stimulate striga seed germination while others inhibit their attachment to the maize roots, thereby reducing the striga seed bank to almost nil after five to six years of continuous maize production under 'push-pull'. Nitrogen fixation by desmodium reaches around 180 kg/ha per year and covers almost the full nitrogen requirements of the maize crop. Napier grass and desmodium provide high-quality fodder for livestock, allowing small farmers in particular to increase milk and meat production. This ecologically intensive approach to the management of pests, soil fertility and livestock production has now been adopted by over 60,000 smallholders farmers across East Africa (Cook et al., 2007; Hassanali et al., 2008; Khan et al., 2012).

A small-scale farmer admires her better-quality maize crop in Western Kenya.
Photo: Santiago Escobar / *icipe*

Box 7. The benefits of producing vegetables at home and in school

AVRDC works to increase the consumption and production of vegetables in tropical developing countries. As a partner in the United States Agency for International Development-funded Horticulture Project, it is promoting home gardens in Bangladesh and India. Training classes for farmers combine information about the nutritional value of eating vegetables daily with practical demonstrations of home gardening methods, and have succeeded in diversifying family diets and increasing supplies of local food

Parul Begrum of Shikarpur village in Barisal, Bangladesh was one of 250 women farmers who received training in producing vegetables at home. Six weeks after planting seed of amaranth, spinach, okra, gourd, beans and cucumber, Parul harvested more than 78 kg of vegetables – far exceeding the needs of her five-person family. She distributed some of the surplus produce as gifts and sold the rest to neighbours. Villagers have now started to visit her garden to purchase fresh vegetables, meaning that she is contributing actively to the family income.

AVRDC also works to support school gardens, which directly engage students in growing their own food, preparing meals and understanding the process of how food arrives at the table, as well as offering daily lessons in agriculture, biology, economics and resource management. School garden harvests enrich cafeteria meals, providing nutrition that may be lacking in students' home diets. In 2012 the Philippines, which has the lowest vegetable consumption in Asia, mandated the creation of school gardens in all public schools, modelling its programme after an AVRDC school garden pilot project in Luzon.

Grafting tomatoes in Bangladesh provides income for women. Photo: AVRDC

4. How healthy landscapes support agriculture

Agricultural production systems interact with landscapes in many ways and at many levels of scale, from plot to farm, and from landscape to watershed and beyond. While the main goal at the farm level may be to produce food or fibre, at the landscape scale there is a need to balance competing land use trade-offs. While integrated approaches to improving productivity, such as those described above, can deal with some of these trade-offs at the farm scale, others require collective action at the landscape scale. An example of how actions at different scales can contribute to sustainable land management is shown in Box 8.

A major challenge for agriculture and natural resource management is to achieve interdisciplinary, multi-scale research and outreach, recognizing that a focus on the production system, farm or forest management unit is not sufficient to ensure sustainability (Sayer and Campbell, 2001). Vitally important processes – ecological, hydrological and geomorphological – operate at larger scales; one of these scales is the landscape. A healthy landscape is managed to maintain or restore the benefits of these large-scale processes (DellaSala et al., 1995). Landscapes are social constructs, and large-scale social changes involving broad cross-sector coordination and the collective action of major stakeholders are needed to respond to ongoing global changes. In certain regions, effective ecosystem management, biodiversity conservation and sustainable development may require transboundary approaches, since landscapes may cross several regional or national borders. An example of transboundary landscape management work is shown in Box 9.

4.1 Multiple interactions

Agricultural systems are multifunctional; they produce not only crops, but also environmental services, landscape maintenance and traditional knowledge. Likewise, agriculture is supported by multifunctional landscapes, providing a stream of ecological goods and services to the agricultural sector, which include land, water, flora and fauna, microbes and air quality. These are critical to increasing agricultural productivity, especially for smallholder farmers in developing countries. The potential of natural

Box 8. Tackling erosion in the Birris micro-watershed in Costa Rica

CATIE and its partners promote adaptive co-management of watersheds and biological corridors in fragmented agricultural landscapes in Central America through formal and informal decision-making platforms. An example of this approach is the Birris micro-watershed in Costa Rica, which feeds a private hydroelectric power plant.

Tree cover in the watershed has diminished because family farms have become fragmented as they are passed from one generation to the next. The subsequent need to make maximum use of small productive areas by intensifying cropping has led to increased irrigation. This in turn has led to topsoil erosion, which has contributed to sedimentation in the dam at the hydroelectric plant.

Participative analysis of different land use scenarios showed that a combination of private actions (such as soil conservation measures) and collective action (such as payment for reforestation of private land at high risk of erosion) was the preferred choice to optimize economic costs and benefits. This strategy also offers climate change adaptation and mitigation benefits to local stakeholders and society as a whole.

resources to meet the needs of people for food, materials and income under current conditions are determined by the characteristics of a landscape. Habitat loss and fragmentation, loss of genetic diversity, local species extinction and invasion by exotic species affect the availability and resilience of ecosystem services such as pollination, availability of clean water, soil protection and nutrient cycling – all of which may negatively affect the cost and the sustainability of agricultural systems in the landscape. Climate change is likely to exacerbate the effects of these phenomena.

Healthy landscapes provide a sustainable stream of ecological goods and services to the agricultural sector. More ambitiously, proper management of agricultural activity is critical to maintaining and restoring healthy landscapes. To achieve this, the concept of multi-functionality needs to be implemented through strategies where ecosystem services and protection of the long-term quality of the land are financially and technically integrated with agricultural production.

Box 9. Integrated landscape planning for conservation and development

ICIMOD is a regional intergovernmental learning and knowledge sharing centre serving the eight member countries of the Hindu Kush Himalaya (HKH) region. It aims to influence policy and practices in order to meet the environmental and livelihood challenges emerging in HKH. It advocates biodiversity conservation and sustainable development by promoting regional cooperation in seven transboundary landscapes across the region.

The HKH region provides water, biodiversity and ecosystem services for 1.5 billion people living downstream. The landscape approach has been taken as a framework to address conservation and livelihood challenges which cross national borders in this vast, remote system.

One example is the Khangchendzonga Landscape initiative, which aims to promote transboundary biodiversity and cultural conservation, ecosystem management, climate change adaptation and sustainable development. During the consultative planning process, special emphasis was given to identifying appropriate land cover for biodiversity conservation, while at the same time mapping land use to identify sustainable livelihood practices. Agriculture-based livelihood opportunities include cultivation of high-value products and their associated value chains, agroforestry, use of agrobiodiversity for crop diversification, and use of agro-based products in ecotourism.

A view of Lakuri Bhanjyang, Lalitpur District, Nepal. Photo: Karen Konniff, ICIMOD

A good example of a resource suitable for multifunctional, climate-smart landscapes is bamboo. For example, bamboo groves in Zhejiang province of China provide bamboo shoots (a popular and nutritious vegetable), culms through selective harvesting (a quality wood for anything from chopsticks to construction materials) and protection against erosion (through the plant's rhizomes). Importantly, cultivating bamboo provides carbon sequestration: one hectare of bamboo in Zhejiang stores more than 40 tonnes of carbon in its biomass, which does not change between years because the average annual harvest of 8 t/ha of culms is replaced by fast-growing new culms which emerge from the rhizomes (Kuehl et al., 2011). Box 10 shows illustrates INBAR's work promoting the use of bamboo for household energy in Africa.

4.2 Preserving ecosystem services

Successful management of healthy landscapes helps to protect the balance between the carrying capacity, water utilization and quality, soil health and biodiversity. This is an important balance: it is hard to get right and easy to disrupt.

Work in Allahabad, India, has shown that planting bamboo on land degraded by brick mining helped to prevent further erosion, restore fertility and raise the water table, both for the benefit of the bamboo but also for other crops, from jatropha to medicinal plants (Kuttyand Narayanan, 2003). However, at the same time, intensification of bamboo management in China has also resulted in the degradation of water and soil, and loss of biodiversity (Buckingham et al., 2011). Action research is now in progress in China to turn this around and work towards systems that ensure both environmental health and long-term carrying capacity (Lou and Henley, 2010).

In the United Arab Emirates (UAE), the cultivation of Rhodes grass (*Chloris gayana*) as a forage crop accounts for 60% of agricultural water use, causing environmental damage and groundwater mining. ICBA, in a long-term collaboration with the Abu Dhabi Farmers' Services Centre (FSC), an intermediary between government organizations and the UAE farming community, is researching improved varieties and management practices and non-conventional forages for replacing Rhodes grass, as well as working on capacity development for extension services and farmers.

Recognizing that on-farm trials with farmers' participation will speed up the selection and introduction of new crops to diversify production systems, the ICBA/FSC team have developed demonstration and model farms. Interaction with the farmers during field visits and open days have enabled the exchange of scientific knowledge of salinity levels and yield correlation and the nutritive value of forage crops, as well as policy discussions regarding alternative new forage crops and the supporting roles key institutions.

4.3 Protecting biodiversity

Expanding agriculture and growing populations are not the only threats to biodiversity. Faster and less-restricted travel and trade are contributing to the threatening spread of plant, human and animal pests and diseases around the world. Invasive alien species pose major threats to biodiversity and agriculture, human and animal health, water resources and economic development. Today, invasive species are considered the second most important factor affecting biodiversity change after landscape degradation.

The impact of these species on agriculture is significantly greater in developing countries, where many farmers have limited livelihood options. In Africa, for example, the parasitic weed *Striga hermonthica* (see Box 6) has spread rapidly, causing maize losses valued at more than US$1 billion annually, impacting on the lives of 300 million Africans (van Wilgen et al., 2008). Invasive plants are also having an impact on natural pasture throughout Africa, with one study indicating that, without management, as much as 71% of the continent's natural pasture could eventually be lost to invasive species (van Wilgen et al., 2008). Biological and mechanical control strategies are often the only viable options to control the spread of invasive plants at the landscape scale, but the involvement of local communities in systems of vigilance, management and eradication are an essential part of any successful solution.

Box 10. Bamboo for household energy in rural Africa

Although usually associated with Asia, many species of bamboo are also native to African countries. They grow extraordinarily fast and, unlike most tree species, will grow again after being cut down. Thus a bamboo ecosystem can be productive while continuing to store carbon. INBAR has demonstrated that using bamboo resources to make charcoal can take pressure off other forest resources, avoiding deforestation and thus the release of previously sequestered carbon into the atmosphere. Charcoal production, which requires relatively low capital investments, is a common way for rural African families to earn additional income. Poor electricity coverage means that up to 90% of Africans rely on biomass – that is, wood or wood-based charcoal – for energy purposes. Unfortunately, wood for charcoal production is usually harvested unsustainably, and the vast charcoal production industry is one of the principle drivers of deforestation in African countries. The degraded ecosystems that remain after wood has been harvested can no longer support the energy needs of a community. In some places this means that even when food is available, there is no fuel for cooking and it cannot be eaten. This is a real dilemma for food security.

INBAR is developing bamboo firewood and charcoal as an alternative energy source in Ghana and Ethiopia (Kuehl and Peterson, 2012). It facilitates exchange of knowledge and technology between Asia and Africa to introduce bamboo charcoal to rural communities, and supports training and capacity building for sustainable management of bamboo resources. At the local level, demonstration kilns, community-level training sessions and educational workshops serve to raise awareness of bamboo as an effective energy source. At the national level, INBAR is increasing the range of useable bamboo species available in Ghana and Ethiopia, establishing micro- and small enterprises, and supporting government and civil society organizations in the development of the bamboo charcoal value chain.

Over 600 hectares of new bamboo have been planted in Ethiopia and Ghana since 2009, 10,000 hectares of existing stands have been placed under management, 4,000 individuals have been trained in production processes, and 550 tons of bamboo charcoal have been produced. More than 10,000 households have started using bamboo for fuel – a significant step towards sustainable, renewable energy use.

Cultivating bamboo provides both a carbon sink and an alternative source of charchoal. Photo: Tesfaye Hunde, Ethiopia

5. Building local support for the landscape approach

Healthy communities are essential to both healthy landscapes and sustainable agricultural systems. In these communities, farming must be strengthened as a respected and profitable rural profession such that it remains attractive to future generations. Present and future farmers who follow sound business practices and make prudent decisions on the use of resources while sustainably optimizing income, will create a solid foundation for rural stability both economically and environmentally. This will in turn support a slowing – or even a reversal – of migration to urban areas.

Building healthy human communities involves more than simply making economic or infrastructural improvements. It requires reinforcement of connections and relationships, ensuring respect for local knowledge and wisdom. Also critical is encouraging broad and inclusive participation in the structures and processes of decision-making for the sustainable use and care of natural resources. The dissemination of knowledge and the adoption of new technologies is more effective, and research more targeted and relevant, when farmers and communities are involved as active participants in the planning and implementation of research and development programmes. Such activities must support the development of local skills and knowledge in ways that enhance the overall wellbeing of individuals and households, while promoting social justice and gender equality.

5.1 Building support and helping farmers put research into use

Communicating to a wide variety of actors the goals of, methods for and approaches to the creation of healthy landscapes is essential to achieving collective impact and action. Information and knowledge for leaders, decision-makers, farmers, value-chain actors and the general public must be prepared using appropriate content, formats and communication channels. Scientific and technical knowledge, policy documents, extension materials for farmers and public messages all need to be regularly updated and made cheaply and efficiently available to stakeholders. Rapid developments in information and communication technologies now offer many more options for delivering messages with broad reach, high impact and good frequency.

Fruits and vegetables produced in home gardens. Photo: CATIE

For change and innovation to take place, modifications of the patterns of interaction and behaviours of a wide range of private and public sector actors are needed in order to allow communities to benefit from available capacities, skills and products. At the same time, good communication is essential to facilitate the exchange of information and knowledge within and between communities, organizations, actors and countries, and to inform policy and planning. Innovation also requires high-quality communication products that are tailored to the particular needs of different target audiences (men and women, illiterate and literate, young and old) and to relevant communication channels. Increasingly, farmers' organizations are becoming important platforms for reaching farmers, learning from them and inducing best practices. Involving farmers' own organizations gives sustainability and better effectiveness to development interventions.

Web-based portals, such as the Africa Soil Health Consortium website, do not target farmers directly but provide access to products and information for intermediaries such as extension staff, NGOs and researchers involved in dissemination and capacity-building activities. Sharing products in digital formats that allow them to be adapted to suit different contexts helps reduce duplication of effort. Further development of appropriate communication channels, that complement each other and provide farmers with different types of information, will increase impact.

It is widely recognized that the ratio of extension workers to farmers in developing countries is very low, and that both radio and mobile phones can complement face-to-face communication. However, there is a trade-off to be made between the numbers of farmers reached and the quality of the interaction. While radio and mobile phones may be useful in raising awareness among large numbers of people, intensive methods such as farmer field schools are likely to be more effective at delivering complex messages, and thus have greater impact. Appropriate communication strategies recognize the complementary roles of different channels and find ways in which they can work together. Information alone is not sufficient – farmers also need knowledge and advice to assess the options available to them and select the best approach for their local situation.

Communication is a two-way process. Mechanisms to deliver information and advice can also be used to gather feedback on the changing nature of problems and contributions to solving them. The Plantwise initiative (www.plantwise.org) establishes plant clinics to provide advisory services to farmers and help them grow better-quality crops. But the clinics also gather information on the patterns of pests and diseases that are causing farmers problems, and this information can be used to inform key messages, which can be delivered through complementary channels. This approach is catalysing new patterns of interaction between different extension service providers and other stakeholders to create more effective national plant health systems.

5.2 Mainstreaming gender

Sustainable livelihoods and a healthy landscape depend upon the integrated management of natural resources; this requires consideration of the social as well as the ecological dynamics of natural resource use (Gutierrez-Montes et al., 2012; Valdivia, 2001). Mainstreaming gender is not the same thing as prioritizing women. It entails understanding the implications of planned interventions for both women and men, and taking these into account in project decision-making, implementation, and monitoring and evaluation (M&E).

Given the critically important role that women play in farming and natural resource management, their participation is required in decision-making processes; without it, vital information might be missed. For example, replacing traditional shade tree species with high-yielding timber species in smallholder perennial crop systems like coffee or cocoa could put money in the pockets of men, but it might deprive women and children of the nutritional resources, fibres and medicine harvested from existing shade tree species. It also could have negative effects on other ecosystem services and goods.

In South Asia and sub-Saharan Africa, where the majority of the world's poor people live, women are mostly responsible for home gardens and household food preparation. Improving their skills in these areas makes a major contribution to their empowerment. Horticultural gardens provide women with opportunities to earn some income by selling excess produce. For example, Bushamuka et al. (2005) indicate that 85% of women who participated in the Helen Keller International Homestead Food Production programme in Bangladesh (www.hki.org/working-worldwide/asia-pacific/bangladesh/#homestead) stated that they had considerably increased their contribution to household income and had thereby increased their status and decision-making power.

5.3 Respecting indigenous communities and their knowledge

Indigenous populations continue to be marginalized and represent large pockets of extreme poverty where acute and hidden hunger persist, and where economic development has been negligible. When food security is defined as the limited or uncertain ability to grow or purchase nutritionally adequate and safe foods, the indigenous poor can be seen as one of the most food insecure groups of people in the world. Their lack of integration into non-indigenous society and a shortage of income generating-opportunities force indigenous communities to rely on subsistence agriculture on marginal lands. Developing approaches that respect and support them must form part of any healthy landscape strategy.

This requires that indigenous traditions and uses of natural resources, as well as associated management practices, are acknowledged and valued. Local and traditional knowledge needs to be considered at the same level of importance as technical and scientific knowledge within a dialogue that facilitates the achievement of a shared environment with sustainable systems. In Central America, where indigenous people make up 16% of the total population, scientists are working with farmers who manage agroforestry systems, in which multi-purpose trees in can reduce crop losses due to climatic changes. These systems maintain or improve biodiversity, soil fertility and water use. They also produce a large percentage of the firewood consumed by households – in contrast with conventional systems where firewood is harvested from adjacent forests.

Indigenous leafy greens are packed with nutrients. Photo: AVRDC

In the Eastern part of the Hindu Kush Himalaya region, shifting cultivation is a common practice among indigenous people. While the sustainability of the practice is under question, there are techniques within it that support crop diversification and resource conservation, and thereby resilience. It is important to understand and build on the positive aspects of the practice, rather than condemning it outright.

5.4 Providing evidence of impact

Winning support for landscape strategies will depend on successful demonstrations that such approaches have a positive impact on the target communities, their agricultural output and the environment around them. Local people, national governments and international donors will all have different criteria by which they judge success and make decisions about continued support. The scope and scale of landscape activities make M&E more complex and challenging than for a single crop- or location-specific intervention. An initiative seeking to demonstrate the Healthy Landscape concept will have to develop a robust M&E.

Efforts have been made in recent years to streamline and increase the monitoring and evaluation rigour of project interventions by donors and international research centres throughout the world. All major projects have protocols and mechanisms in place for undertaking customized performance M&E activities of newly introduced technologies. Depending on the objectives of an individual project, M&E protocols are developed to track the effectiveness and efficiency of project resources distributed to beneficiaries and, most importantly, for obtaining baseline (*ex-ante*) and outcome (*ex-post*) data aimed at comparing changes in specific parameters for treatment and control groups before and after the intervention. A culture of M&E needs to be inculcated widely at the practitioner level in order to support rigorous internal and external peer review at the project level, as a precursor to substantive *ex-post* impact assessment studies.

A comprehensive set of tools is needed to determine the impacts of actors living in a landscape, and thus inform the decision-makers and practitioners in a timely manner about these impacts and the corrective measures that are needed to secure the long-term health of that landscape. Defining an appropriate counter-factual against which to test proposed landscape approaches is likely to be a particular challenge. A prioritized list of both disruptive and constructive activities taking place in the landscape, along with well-thought-through impact pathways to manage such activities, has to be identified. A set of locally adapted and managed indicators has to be developed and mainstreamed in all planning and management initiatives in the landscape to measure progress towards climate-smart practices in a context of adaptive co-management. This implies developing general guidelines and methodologies as a framework for choosing these site specific indicators, and a significant training need for local and national partners.

Gender disaggregated data are essential to any effective M&E. It is needed not just at impact level, but also output level, and M&E activities should be planned with women and men, and younger and older people in mind. The analysis should not only consider disaggregated data, but also examine these data in the light of differing gender roles and divisions, gendered access to resources, information and education, and power relations within households.

6. How governments can help

Governance structures, institutions and policies are needed that are based on the experiences and needs of smallholder farmers and which able to provide a supportive framework for the sustainable management of healthy landscapes. The human and environmental benefits provided by healthy landscapes are experienced at different levels of social organization and across different geographies. Consequently, policies, institutions and governance structures at multiple levels – local, national and regional – need to be developed with community participation and broad stakeholder involvement, and linked together in a strategy for the long-term protection of the goods and services provided by healthy landscapes, for the benefit of smallholder farmers. These structures and policies also need to provide access to markets, financial support and private sector partnerships that can help the communities within a landscape create sustainable businesses activities.

6.1 Integrated policy approaches

There are inherent challenges and trade-offs in implementing a shift in agricultural practices. It is essential to adopt an integrated policy approach rather than to focus on one particular sector. For long-lasting change to occur, research and development activities need to support policy in its broadest sense. Interventions that work well at pilot levels may not be sustainable if appropriate incentives are not in place for actors to change their behaviour in the long term. It is important to understand how policy influences change and to integrate activities into research and development programmes that address policy constraints as well as organizational and technical constraints. Multi-stakeholder processes that help organizations and individuals reflect on what they do and better understand how policy influences what happens at a farm level can support sustainable change.

Integrated policy approaches in less-developed countries mean that environmental and production goals must be balanced with equity and poverty alleviation concerns to advance towards healthy landscapes and improved human wellbeing. The sustainability of such initiatives depends on an

Training university students to identify and collect *Orius spp* in a tomato field in Nicaragua.
Photo: Yelitza Colmenarez, CABI

adaptive and integrated design and implementation (i.e. taking into consideration the social and ecological complexities), a demand-responsive approach (lower dependency on external subsidies), the inclusion of economic incentives to induce decisions towards social wellbeing, the active participation of stakeholders at different decision-making levels (as opposed to traditional top-down approaches) and the promotion of cross-cutting policies that reap multiple benefits (e.g. deal with the water, food and energy nexus). We need to be innovative in developing healthy landscapes built around medium-input/high-output agriculture, secure livelihoods, and sustainable and inclusive value chains. This requires political vision and will, a substantial increase in investments in agricultural research and development, equitable negotiations among diverse stakeholders, and joint learning and action to identify and scale innovative solutions (Campos, 2012).

6.2 Financial and market mechanisms

Rural smallholders are often unable to access markets effectively due to their inability to consistently supply adequate volumes of good-quality produce to the more competitive, better paying market segments. Poor access to finance for investment and working capital, coupled with underinvestment in agriculture by the government and private sector, has perennially limited the ability of smallholder farmers to improve the productivity and quality of their produce. For farming to remain an attractive occupation, farmers need access to the knowledge, skills and resources to make a business out of agriculture. Micro-finance plays a key role in providing working capital to smallholder farmers, especially women. While micro-finance institutions and approaches have some limitations, best practices learnt in many developing countries can be implemented for positive benefit.

Linking smallholders to functional markets is therefore crucial to realizing sustainable livelihoods for the rural communities. This must be done by empowering smallholders to respond to the demands of the market in terms of volume, quality, consistent supply and traceability. New ways of working with rural communities, such as forming viable producer business groups and building their skills in marketing, will help them get a better share of the value they create by meeting these market requirements.

6.3 Private sector involvement

Agriculture involves making everyday decisions in response to unpredictable conditions and unknown risks. The poorer the farmer, the greater the risk and impact of making a wrong decision or failing to get advice on time. Enabling farmers to improve productivity requires them to have access to the necessary information and inputs to change their practices. Farmers rely on many different sources for information and inputs; in the absence of the necessary support from government or local extension services they will often rely on local agro-dealers. These businesses can be an important partner in helping to ensure that the community gets good-quality advice that is in the interest of the farmer, and they provide a solid customer base for the dealer, bringing long-term rather than short-term gain. Similarly, there can be mutual benefits derived from working with wholesalers and manufacturers in the agro-input supply chain who can help ensure that farmers in the target landscape will have access to good-quality seeds, fertilizers and chemicals in appropriate package sizes, together with the right technical information to make best use of them.

Even with good advice, the initial cash outlay and financial risk of new approaches may seem to be too much for a farmer whose family depends on farm income. As a result, smallholders often stick with tried and trusted varieties or approaches. One way that the fear of crop losses can be mitigated is through crop insurance (Hazell et al., 2010). Novel micro-insurance initiatives, such as Kilimo Salama (http://kilimosalama.wordpress.com), pioneered by the Syngenta Foundation, help reduce risks by selling insurance against the effects of adverse weather along with their seeds. In the last few years, pilot micro-insurance schemes have been established in Ethiopia, Kenya, Malawi, Rwanda, Tanzania and other countries. Mobile phone technologies are stimulating innovation by making these novel offerings of micro-credit and crop micro-insurance possible by reducing the acquisition and transaction costs, as well as offering novel payment methods (e.g. M-Pesa in Kenya).

7. Key issues and challenges

7.1 Capacity building

Designing and managing a healthy landscape is an all-encompassing task. It requires well-thought-out science-based decisions for the legal/institutional framework, public and private policies (local and national), land use planning, agriculture and forestry production practices, education at all levels (including policy-makers and high-rank managers, technical and professional personnel, farmers and the general public). Scientific and technical knowledge is required to design and orient the implementation of good practices in all these fields of intervention. The integration of new scientific knowledge with traditional knowledge, through participatory action research, is required. Research that was not carried out in the landscape has to be carefully validated and adapted to local circumstances.

7.2 Climate resilience

Climate change increasingly affects the economic, social and ecological sustainability of agricultural systems as well as the dynamic equilibrium of agricultural landscapes (Intergovernmental Panel on Climate Change, 2001). Risks need to be assessed at the level of crops, farms and landscapes. Development and research strategies must take into account these assessments and incorporate risk-reducing activities. These can include developing crop varieties that tolerate higher temperatures or drier conditions, promoting indigenous varieties that are well-adapted to climate extremes, adopting cropping systems that diversify production or improving infrastructure, such as water storage facilities.

Climate change adaptation also requires the development of mechanisms to monitor changes and track the spread of pests, diseases and invasive species in order to make science-based projections regarding impacts and threats (Keatinge et al., forthcoming), together with the use and protection of natural resources that are essential for providing ecosystem services beyond the farm scale (e.g. for biological corridors). To achieve change, impact perceptions and current or previous local adaptation practices need to be understood in order to ensure appropriate development, validation and incorporation of new approaches. This must also be set within the context of national policies and institutions. The adaptive co-management of watersheds or rangelands provides examples of existing mechanisms for climate proofing (Finegan et al., in press).

A beekeeping trainer checks hives in Nepal. Photo: ICIMOD

7.3 Global to local perspectives, transboundary issues

Different ecosystem services provided by a healthy landscape operate at different scales, and thus the boundaries for developing and using them vary. Natural pest control from diversified land use, for example, can be effective at the farm scale, while household water supplies are usually managed at a municipal level, biodiversity issues may be rewarded regionally, and carbon capture benefits the whole world and hence is global. Both local and global perspectives are of key importance, and successful approaches to create healthy landscapes depend on adequate consideration of transboundary factors as well as socio-economic and biophysical issues.

While neighbouring countries may work together to seek to control the spread of a new pest, disease or invasive species, sharing of intellectual property rights for germplasm or innovative technologies could become a contentious issue. Similarly, payment for ecosystem services to upstream land managers by downstream users, a tricky negotiation in any circumstance, is particularly complicated when national frontiers are involved. For biological control agents, compliance with the Access and Benefit Sharing arrangements of the Convention on Biological Diversity is becoming increasingly complicated.

Carbon credits are probably one of the clearest examples of a global service; carbon capture, delivered in one place, can compensate carbon emission from the other side of the world. Unfortunately, the price of agricultural and forest products from healthy landscapes often compares negatively with the price of comparable products from unsustainably managed landscapes. Furthermore, local markets are often informal, while international markets are much more regulated. There is a significant need for international standards – technical, environmental and even social – that open both local and global markets, and stimulate healthy production landscapes.

7.4 Urban migration

Meeting the needs and hopes of the rural population for higher incomes and a better quality of life is necessary to retain human capital in a healthy landscape. Families that move permanently to urban areas or overseas generally do not maintain their crops. This results in a loss of both germplasm and traditional knowledge about uses and practices. Men and young people in particular, who are confronted with the impossibility of providing adequate support for their families, consider permanent or circular migration as an option. The women, old people and young children who are left behind in rural areas must depend on an increasingly marginal subsistence farm enterprise, with seasonal labour shortages, abandoned fields, disintegration of community life and a loss of traditional ecological and farming systems knowledge. Furthermore, the money earned through seasonal migration is often used to buy livestock rather than being invested in crops, leading to the conversion of cropland to pasture or problems of overgrazing and rapid degradation within a landscape.

Within the context of integrated land use planning, one issue which needs attention is how to optimize land use in urban areas in order to minimize land wastage. With increasing population and limited rural economic diversity and employment opportunity, rural–urban migration and increasing demand for urban services is putting agricultural land under pressure; horizontal growth of cities is consuming prime agricultural lands in many developing countries. Policy and planning reforms are needed to conserve productive land in urban development. Integrating urban and peri-urban agriculture with landscape planning can also contribute to green zones and intensive agriculture.

7.5 Changing dietary and nutritional demands

Economic and social development, coupled with rural–urban migration, has resulted in significant changes to dietary preferences that can have profound impact upon agricultural demand. As incomes rise, the growing urban middle class increases the demand for meat, poultry and dairy products. Meeting this shift in consumer preference can alter land use from arable to pastoral, reducing grain supply and raising prices as a result of competition between demands for human food and animal feed, and increasing pressure on scarce water supplies. These changes can result in considerable adverse impacts upon the livelihoods of poor farmers and significant alterations to the landscapes in which they farm.

However, the issue of healthy diet and nutrition is not only a matter of availability of food products and raw materials. The role of traditions, cultural orientations and awareness may be equally important. Some societies, for example, prefer animal products to vegetable- or fruit-based foods, in turn negatively affecting the production and market systems of the latter. This may be a strategic issue of public awareness-raising and educational intervention.

Many low- and middle-income countries are facing the so-called 'double burden of disease' (Abegunde et al., 2008; Yach et al., 2006). While these countries continue to deal with the problems of infectious diseases and undernutrition, they are also experiencing an upsurge in non-communicable disease risk factors such as obesity, particularly in urban settings (Lopez, 2004). This double burden is increasingly found among the poorer sectors of society, where it is not uncommon to find overweight and obese adults living with underweight children, amid widespread micronutrient deficiencies (FAO, 2012).

However, these changes can also create opportunities. Consumption of more fruit and vegetables as part of an overall strategy to overcome malnutrition is particularly important, as they are sources of a range of vitamins, minerals and other beneficial dietary components that reduce the risk of obesity and chronic diseases, including diabetes, cardiovascular diseases and cancer (Yang and Keding, 2009). Growing vegetables in home gardens is the most direct way for many rural and urban poor families to obtain a variety of nutrient-rich foods, and provides an alternative to vegetable production at commercial scale, which competes for water supplies with industrial and residential users. Taking a broader landscape approach can help these communities capture such opportunities responsibly, by avoiding practices which degrade the environment or put consumer health at risk such as the use of untreated human waste water, compost with high heavy metal contents and indiscriminate application of inorganic fertilizer or pesticides.

Trees are an important component of CATIE's livestock farm. Photo: CATIE

8. Conclusions and recommendations

Agriculture all over the world continues to transform forests, valleys, prairies and plains. In using – and frequently misusing – natural resources, agriculture can create either positive or negative environmental outcomes. Managing the connections between agriculture, health, natural resource conservation, and the environment must be an integral part of using agriculture for development. As climate change increases the pressure on agricultural lands, trade-offs among different land uses will intensify, as will competition for arable land, water, and minerals and natural resources.

The member organizations of AIRCA believe that the necessary trade-offs can best be identified and optimized through landscape approaches – including integrated strategies for management of crops, soil fertility, pests and diseases – together with land use planning that incorporates social, environmental and economic concerns. These approaches balance the imperative to increase yields and outputs against the need to secure the long-term sustainability of the environment within which that production takes place. By reducing smallholder risks and increasing the sustainability of their farming practices, the creation of healthy landscapes can deliver improved livelihoods and increased food security, thereby helping to make farming an attractive alternative to migration into the cities.

Effective strategies must be based on collective action involving researchers, development practitioners, grassroots organizations, decision-makers and the private sector. The proper management of agricultural activity in light of climate change is critical to creating, maintaining and restoring the healthy landscapes that are fundamental not only for feeding and nourishing the people of the world, but also for ensuring that the planet remains a thriving home to the complex web of microbial, plant and animal life it supports.

Farmers threshing quinoa near Puno, Peru. Photo: CFF

Water being transported in arid Wadi Rum, Jordan. Photo: Dorte Verner

In order to promote wider understanding and adoption of landscape approaches, AIRCA recommends that international development organizations, donors, investors and governments support the following three priority areas:

1. Scaling out

- Re-balance resources to support integrated approaches to plant health and nutrition as well as the development of new varieties. That is, we need to lose less as well as growing more.
- Develop and implement technologies to improve the use and efficiency of water and nutrients, reduce unwanted environmental impacts and increase the use of waste streams.
- Adopt and leverage the potential of modern communication technologies, as well as embracing public-private partnerships, so as to increase the reach, impact and long-term sustainability of their interventions.

2. Capacity strengthening

- Promote inclusive approaches, integrating traditional and indigenous knowledge, while also seeking to increase the involvement of women, young people and marginalized social groups.
- Support rural communities in creating value from resources and activities in addition to, or as alternatives to, agriculture, and enable them to transition from subsistence to business approaches.
- Develop the tools necessary to assess and capture the economic value of ecosystem services and healthy landscapes, alongside approaches to assess the effectiveness and long-term impact of interventions at the landscape scale.

3. Policy development

- Education authorities and ministries should put the concepts of healthy landscapes and sustainable agriculture at the heart of appropriate higher education courses in forestry, agriculture and environmental sciences.
- National governments and international organizations should implement agricultural policies that favour health and nutrition – preserving and utilizing crop diversity, promoting horticulture, enhancing traditional production skills and improving food preparation techniques to stimulate greater nutrient variety, availability and intake.
- Governments must develop policies to support institutions and structures at local, national and regional levels which will deliver strategies for the long-term protection of the goods and services provided by healthy landscapes.
- International and regional bodies should encourage scientific and economic dialogue between countries to resolve transboundary issues and put in place frameworks for knowledge sharing which will support the development of healthy landscapes spanning country borders.

International development donors should create funding mechanisms that stimulate the formation of broad partnerships that bring together the range of capabilities needed to address challenges at the landscape scale. To enable change to take place, conditions need to favour economic as well as biological sustainability. A sustainable farming community is one in which farming is a respected rural profession and where farmers make a living that will motivate them to stay in the landscape to farm, rather than seeking higher income in the cities. Thus, any landscape strategy must also have a vision of how to help communities to make businesses out of their activities. Financial mechanisms, incentives and training are needed to connect them to markets and obtain a fair share of the value they create.

To quote Gro Harlem Brundtland, former Prime Minister of Norway and Director General of the World Health Organization:

"You cannot tackle hunger, disease and poverty unless you can also provide people with a healthy ecosystem in which their economies can grow."

– Gro Harlem Brundtland

Farmers at a bamboo stand in Madagascar. Photo: INBAR

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Alleviates poverty and malnutrition in the developing world through the increased production and consumption of nutritious and health-promoting vegetables.

CAB International (CABI)
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Contributes to sustainable agriculture and food systems by enabling greater use of underutilised crops through research, capacity development and policy advocacy.

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