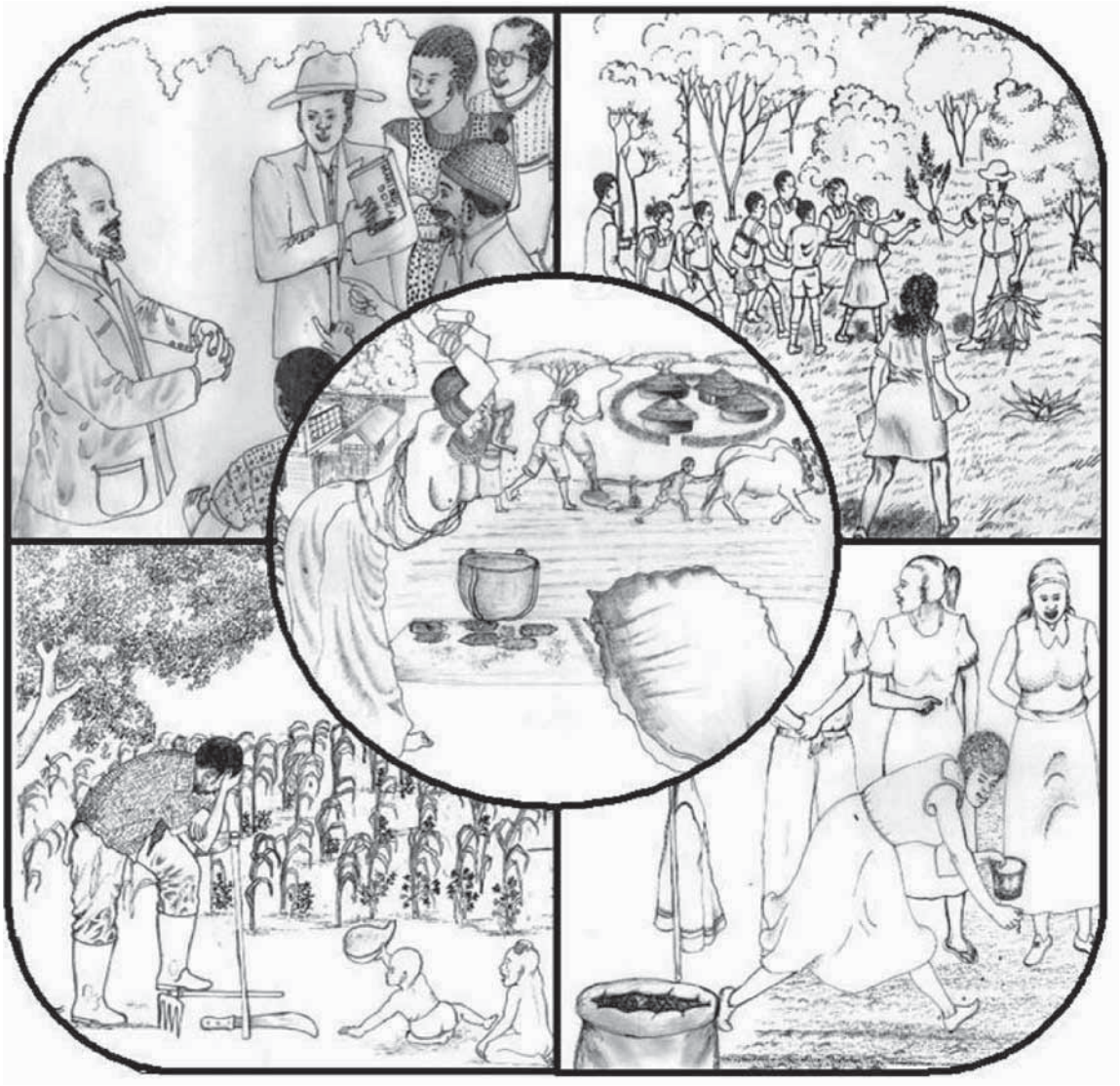
Part IV

The Social Dimensions of ISFM



Chapter 16. The role of ISFM in gender empowerment

ISFM practice by small-scale farmers in Africa necessarily involves all members of the household. Soil management is an essential farming task that should not further contribute to the drudgery of subsistence agriculture but rather reduce work burdens through efficiency and the substitution of skills and technologies for unnecessary labor operations. Small-scale farming households are subject to human resource traps where exhausting labor produces too little and illness and poor nutrition further reduce labor availability. Many farming practices are necessarily energy intensive, particularly land preparation that can test the endurance of family members. Small-scale farmers locked into high energy-low return farming are not well positioned to increase their workload but ISFM practices often allow for tasks to become more diversified as it involves new skills, technologies and investment, offering higher returns to labor. These benefits are readily passed to family members, including the elderly, women and children, through reduced workloads, improved farm ergonomics and occupational safety (Jafry 2000).

Decades of studies have described how African women conduct a large proportion of agricultural tasks while being disadvantaged in terms of access to information, land, cash and credit (Gladwin *et al.* 1997). Women are not only hindered by unequal opportunities within their families and communities, but many development programs tend to be male-oriented and consequently fail to recognize the special roles and potentials of women farmers (Burton and White 1984; Staudt 1975). Despite women providing 46% of farm labor and producing up to 80% of the household food supply, social scientists during the 1970s and 1980s too seldom collected gender-specific information, contributing to the failure of rural development specialists to build effective assistance programs around them.

Approaches to link farmers to markets that do not account gender in terms of access and outcomes are likely to compound existing inequalities. Women in Africa face several constraints as they endeavor to engage with market systems. Social and cultural customs that assign home and reproductive roles to women limit their commercial potential (OECD 2006). Women's agricultural activities in Africa are frequently oriented towards subsistence production and local markets producing reduced value crops on smaller tracks of land and have lower access to capital and inputs (Quisumbing 1996). Gender related barriers to markets create income disparities with men receiving higher income from market linkages. Women face mobility constraints that restrict their ability to travel or sell in more distant markets offering higher prices. Women receive lower prices for their produce because they sell in smaller volumes to powerful intermediaries who set the price (OECD 2006).

Women as land managers

Studies that cast women as less likely to adopt farm technologies are misdirected when they do not consider the inherent disadvantages faced by them. Africa and its women farmers were by-passed by the first Green Revolution in part because of the misconception that they were reluctant to adopt new crop varieties and use mineral fertilizers (Okigbo 1990), when in fact later studies demonstrated that such adoption is the result of economic advantage not gender difference (Gladwin *et al.* 1997). Both traditional value systems and their modern distortions force women to become household providers rather than income earners, in large part because men retain control over cash crops despite women's help in their production (Fortmann 1981). Some misconceptions are based upon women's wiser decision making as when they readily substitute organic inputs for fertilizers or they demonstrate reluctance to accept credit when they fear that needed household food reserves will be sold in order to service loans.

Unequal income and credit opportunities affect the abilities of women to adopt technologies and enter into new farm enterprises. Ironically, this constraint includes the adoption of labor-saving technologies such as inter-row cultivators, wheelbarrows, even donkey carts because men

resist paying for equipment that ease tasks that women otherwise provide at no cost (Ashby *et al.* 2008). In some cases, women and men derive income from very different sources (Table 16.1). Other than the sale of farm produce, which is common to both sexes, Ibo women in Nigeria rely more upon gifts, funds from rotating women's groups and paid labor for income, whereas men have greater access to non-farm income and credit (Ezumah and Di Domenico 1995). Consequently, the majority of Ibo women have no understanding of fertilizer while only 25% of men lack this knowledge. Other common constraints to farm productivity faced by African women include reduced availability to land in predominantly patrilineal societies, skewed division of labor as women are responsible for more tedious and time-consuming tasks and less access to farm inputs and extension information, all of which largely result from their cultural obligations toward men and gender norms imposed upon them over many generations. Because of these sorts of disadvantages, women farmers are less able to respond to commodity price and new enterprise opportunities (Evers and Walters 2000).

Table 16.1. Sources of income used for farming among male and female farmers in Iboland, Nigeria (Ezumah and Di Domenico 1995)

Income source	Female farmers	Male farmers
	%	
Sale of produce	49	40
Gifts from family	33	10
Rotating funds	20	11
Paid farm labor	11	6
Non-farm income	4	24
Borrowing and credit	3	20

On the other hand, agriculture in Africa is undergoing a rapid transformation from traditional, subsistence farming to market-oriented agriculture, and this dynamic has a marked effect upon gender roles within rural households. Fewer distinctions may be drawn between women and men's crops in Ghana and female-headed households readily enter into production of men's cash crops such as cotton, rice and sugarcane (Doss 2002). Women practicing agriculture in migrant areas face fewer gender constraints and find greater opportunities in Nigeria (Ezumah and Di Domenico 1995). The same is true for urban agriculture where women control not only the production of traditional vegetables but also their trading (Kessler *et al.* 2004). New market opportunities that emerge from changing agricultural value chains have indeed improved the standing of women in African agriculture but for them to fully capitalize on

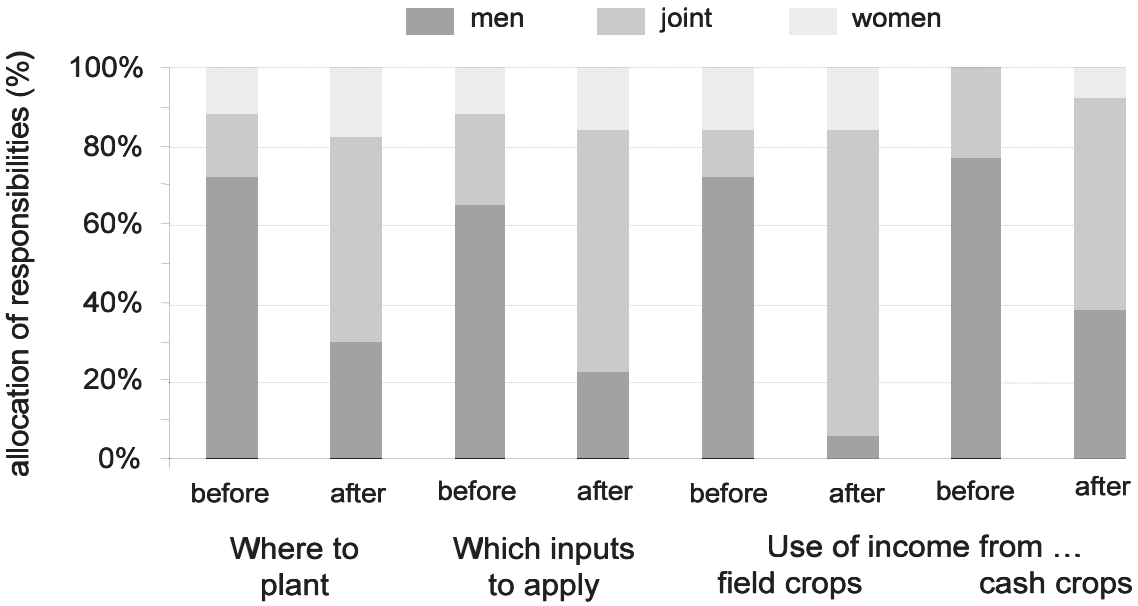


Figure 16.1. The effect of rural enterprise development on household decision making over three years (after Kaaria *et al.* 2008).

Table 16.2. Ranking of nutrient sources used by women and men farmers and reasons for their preference (after Mapfumo *et al.* 2001).

Nutrient Resource	Ranking by ... women	men	Factors (restrictions)
Inorganic fertilizer	1	2	Results in immediate and reliable benefits (cost prohibitive)
Animal manure	2	1	Affordable and longer-lasting in soil (requires ownership of substantial livestock)
Compost	3	4	Available from processing local materials (labor intensive to produce)
Termite mounds	4	3	Readily available in fields and long lasting (labor intensive to recover and spread)
Agricultural lime	5	6	Markedly improves groundnut yield (not widely available)
Leaf litter transfer	6	5	(increasingly less available)

these opportunities they require business development services (Ashby *et al.* 2008).

Several gender-responsive actions are available to improve women's control over resources and access to markets including the promotion of women's collective action and voice within farm associations, cultivating women's profit orientation, protecting women's control over their economic gains and involving them more in the design of rural development projects (Ashby *et al.* 2008). At the same time, gender mainstreaming necessarily involves men. Divisive views that consider men and women in farming households to be operating in separate spheres with coercive interdependency are losing relevance as farms become increasingly oriented toward markets (Evers and Walters 2000). Joint decision making on which crops to grow, which inputs to apply and how to allocate revenues was greatly increased over a relatively short market development program for beans in Malawi (Figure 16.1). Co-responsibility was also strengthened through improved marketing of potatoes in SW Uganda (Kaaria *et al.* 2008). Joint decision making realizes full comparative advantage of the sexual division of labor without leading to exploitive gender roles (Quisinbing 1996).

Differences in women's and men's attitudes toward technologies and their adoption, however, are to be expected. Women's perspectives place greater emphasis upon risk and household vulnerability, time requirements rather than force of labor, and more immediate contribution to household well being. These considerations are also reflected in soil fertility management. In the communal farming areas of Zimbabwe, farmers have a variety of nutrient resources available to them and preference for these resources varies somewhat between men and women (Table 16.2). Women prefer the use of inorganic fertilizer compared to animal manure, in large part because they have little control over livestock (Mapfumo *et al.* 2001). Women prefer composting whereas men prefer to mine and spread termite mounds. Women better recognize the importance of liming groundnut because pegging has an external Ca requirement and women generally control this crop. Note that leaf litter transfer from the dry woodlands is now less practiced as the resource become increasingly less available to households compared to alternative material. Nonetheless, options for soil fertility management are relatively finite within the context of efficient, market-oriented agriculture, and fewer differences in

Table 16.3. Adoption of soil fertility management practices by household heads in Vihiga, Kenya (after Marenya and Barrett 2007).

Soil fertility practice	Adopters Women	Men
	------ % -------	
Manure	59	64
Fertilizer	44	57
Trash lines	44	47
Agroforestry	24	22

technical preference may be attributed to gender than other farm characteristics. For example, in a densely populated highland in west Kenya, female- and male-headed household show little difference in the adoption of proven ISFM practices (Table 16.3), compared to other farm characteristics including farm size, value of livestock, family labor supply or education level (Marenya and Barrett 2007). This sort of similarity between women's and men's ISFM practice could readily be ascribed to joint decision making within families responding to the innovations required to address emerging agricultural markets (Evers and Walters 2000; Sanginga *et al.* 2004; Ashby *et al.* 2008). Development specialists now recognize that large impacts are achieved when assistance programs specifically address women's abilities and this opportunity extends into ISFM as well as illustrated through the following examples.

Distribute inputs samples. Women are worthwhile recipients of sample fertilizers that are being distributed to promote ISFM practices. Small amounts of fertilizer (e.g. 1 to 2 kg) can have a large beneficial effect on nutrient-deficient home gardens and small fields managed by women. These fertilizers are effectively distributed through women's and youth groups as a way of familiarizing these parties with new technologies and improving their household status. Free fertilizers are not a standalone option, rather they should lead to increased fertilizer demand by poorer households and improved fertilizer marketing by local merchants and farm associations (Gladwin *et al.* 1997; Blackie and Albright 2005).

Package fertilizer into smaller quantities. Fertilizers that are packaged in smaller quantities are more useful to women. Normally fertilizers are imported and distributed as 50 kg bags and suppliers must make special provisions to repackage and label them in compliance with quality assurance regulations. Once compliance is secured, local distributors that offer fertilizers in quantities of 2 to 20 kg are providing a valuable service to women who otherwise find it difficult to afford and transport larger quantities. (Omamo 1998, Ashby *et al.* 2008) Women's individual gardening enterprises tend to be sufficiently small that a 10 kg bag of a concentrated fertilizer (e.g. DAP or Triple 16) is sufficient to fertilize between 800 to 1000 m^2. This strategy logically follows the distribution of free fertilizer samples to women as a means to promote understanding in ISFM and generating demand for fertilizers. (Gladwin *et al.* 1997)

Expand women's intercrops. One means to provide greater access to land by women in traditional settings is through intercropping. Often cash and staple crops grown in the larger fields belong to men while vegetables and pulses are allocated to women (Doss 2002). This separation does not refer to the division of labor, as women are expected to toil in men's fields as well, but rather to which family member receives payment for the crop. As ISFM involves greater reliance upon nitrogen-fixing legumes, and as many legumes are considered to be traditional women's crop, then intercropping with legumes is one means to provide greater equity within the farm. (Gladwin *et al.* 1997)

Promote small animal enterprise. Just as there are men's and women's crops, so too is there gender division of farm animals. Men control livestock, particularly cattle, while women are generally responsible for poultry and other small, domesticated animals. The manure from livestock may be similarly allocated with smaller animals producing higher quality by-products (Lekasi *et al.* 1998). One means to channel more organic nutrients to women's farm enterprises is through the promotion of small animals, particularly chickens. Efficient recovery of these manures requires that animals be raised in confinement and provided with higher quality feed. In this way, entering or expanding small animal enterprise requires both initial and regular investment, but it can also offer some of the greatest returns, both in farm profits and the availability of organic fertilizers.

Introduce organic fertilizer production. Women are engaged in many household activities that involve the processing of available organic resources, particularly handicrafts. Opportunity exists to channel these efforts toward the improvement of under-utilized organic materials through the production of organic fertilizers. Unlike livestock and green manures, most crop residues are low in nutrients (Palm *et al.* 2001) and require special handling to become transformed into high quality organic fertilizers. One such process is fortified composting, where nutrient-poor crop residues are ameliorated with small amounts of fertilizers or agro-minerals and the mixture protected against nutrient loss in order to produce a valuable organic fertilizer within only four months (Ndungu *et al.* 2003). Another approach involves the use of epigeic earthworms to process farm by-products, crop residues and domestic wastes into rich humus while producing a protein-rich feed for poultry and fish (Edwards 1988; Savala *et al.* 2003). Other lower technology approaches such as pit and layered heap composting are available as well. These organic fertilizers may be produced on individual farms or as a grassroot's collective activity (Kibwage and Momanyi 2003). Resulting composts are best used in seedling potting mixtures or as soil amendments to higher value crops, strengthening the position of women within new agricultural enterprises.

Offer special incentives through women's groups. Women's groups serve as an excellent platform to advance many ISFM technologies. Women's groups have several forms, from the 20-or-so member grassroots neighborhood association to the women's chapter of large farmer organizations consisting of hundreds or thousands of members. All such groups exist to provide services to their members including better access to information and technologies, bulk purchase of key farm inputs and collective marketing of produce (see Chapter 18). ISFM technologies may be channeled to farmers through these groups in a number of ways. Extension information and sample products may be distributed at meetings. The groups may be commissioned to install field demonstrations and host farmer field days, or to initiate collective composting or seedling nurseries. Soil fertility management products may be extended on credit to women farmers through their associations and repayment used to initiate revolving funds for following seasons. Similarly, vouchers for the purchase of farm inputs through local stockists may be distributed through these groups. Women may collectively produce needed seed, particularly new varieties of legumes and vegetables for sale to their neighbors, farm organizations or contracting seed companies.

These groups should be registered with local authorities, but not dependent upon them and have regular meetings, elected officials, bank accounts and established contacts via post, telephone and email (Woomer *et al.* 2003). In many cases, these groups not only serve to support vocational agriculture, but also as the center of local social activities, further strengthening members' commitment. One great advantage in working within women's groups, rather than with individuals, is the peer support that strengthens members' commitment and performance. Another benefit is that successful groups tend to stimulate the formation of similar groups in adjacent areas.

Despite new opportunities to advance ISFM by women, numerous asymmetric power relationships continue within small-scale farming households. Women may be ordered by their husbands to hand over farm inputs and credit vouchers or instructed by them to conduct field operations in a time-bound manner. Women in societies that practice child marriage and polygamy are especially vulnerable as they are viewed as laborers supervised by their husbands. In some cases, male household members may simply expropriate successful farm enterprises initiated by women (Ashby *et al.* 2008). Nonetheless, change is underway as more women join grassroots groups catering to their needs. Microfinance associations and community banks specifically target women because they are more responsible borrowers. Furthermore, women are increasingly becoming heads of household as male family members' age, pass away or migrate

to urban areas in search of employment, placing these women in a better position as innovators, including the adoption and refinement of ISFM technologies. (Ezumah and Di Domenico 1995)

Introduce labour saving technologies and transport policies. Many labor saving and productivity increasing technologies prove to be particularly problematic owing to women's more limited ability to afford and operate them. Consulting women in the actual design of a new technology can effectively make its development more demand driven and dramatically improve the chances of adoption (Ashby *et al.* 2008.) Transport policies are particularly important for ensuring that higher prices actually reach women farmers at the farm gate. Strengthening marketing structures to ease women's access and to improve their terms of participation is critical for sustaining the supply of crops controlled by women (SIDA 1996; UWONET 1995).

Train and recruit more women as service providers. Women farmers operate under greater constraints than do men and require specialized assistance. Women generally have poorer access to information, technology, land, inputs and credit (Saito and Weidemann 1990). They also have less available time and mobility because of their responsibilies within the home. Too often, women in rural Africa are less illiterate. Male extension agents lack expertise and interest in rural home economics and efforts directed toward improving household nutrition and stimulating cottage industries are most effective when conducted by women to women (Saito & Weidemann 1990).

The importance of gender of the extension agent in transmitting information to women farmers varies enormously depending on the local cultural context. In Muslim areas, it is not permitted that a male extension agent work directly with women farmers, even where they are eager for advice (Saito and Weidemann 1990). Evidence from a wide range of other African countries demonstrates that communication with women farmers is generally enhanced when female extension agents are used (Evan 1989). This situation is true even in countries with relatively few social barriers to male-female interaction. In Zimbabwe women are legally equal in status to men but more women participate in extension when female agents are involved (Skapa 1998). To avoid domestic tension, however, it is best to enlist the support of husbands and male leaders before embarking on women's agricultural programs of any sort. A study of Igbo women in Nigeria noted that effective extension requires that female extension agents undertake training and visitations so that the cultural barriers are reduced (Ezumah and Di Domenico 1995). In addition, women agents tend to be more sensitive to different abilities and capacities in farm labor among household members.

Gender targeting is particularly useful in bringing extension services to new women farmers. It is consistent with the focus group approach of extension that considers the limited number of female extension agents. Women agents are first assigned to work with women's groups and then gradually introduce the group to another agent working in the area, often a male. The women agent then moves on to another women's group (Walker 1989). This approach requires that male agents also be retrained to work more effectively with women clients. The same conditions apply among women researchers, where new agricultural technologies that are pioneered without the women's perspective become difficult to adopt because they were designed by and for men but ultimately targeted toward women farmers (Ashby *et al.* 2008).

Increasing the employment of women as frontline staff in the delivery of extension, business development, veterinary and environmental conservation services is one of the most effective ways to improve the gender balance in service delivery. Gender policy that establishes and trains both women and men to work in teams as frontline staff supporting women producers has proven effective in India's ATMA program and Venezuela's CIARA foundation (Ashby *et al.* 2008). Replicating the success of such initiatives requires redressing the gender imbalance in all fields and types of agricultural education and training in tandem with targeted recruitment and

affirmative action aiming to increase the number of female students, instructors, extension agents, researchers and project managers.

Farm ergonomics

ISFM substitutes exhaustive and repetitive labor with new skills and greater investment in farm activities. This change is an important component in the transition from subsistence farming to mixed enterprise, market agriculture (Table 16.1) essential for improved standards of living in rural areas. Hand tillage is an example of relievable drudgery. Hand digging cultivates between 50 to 200 m^2 per day. Farmers can improve their efficiency of land preparation 20-fold by investment in oxen or by hiring an oxen team or tractor. Furthermore, the culture of animal traction may be stimulated by developing plowing, pulling contests, and livestock awards around it. However, moving from human to animal and machine powered tillage involves not only investment and skills, but also new understandings in smallholder occupational safety. For example, there are situations in Africa where development programmes could usefully promote donkey power for poorer farmers, and especially for use by poorer women. Animal traction or transport packages could be made available to women's groups on credit, where women are engaged in collective cultivation of cash crops, and prove particularly valuable for inter-row hoeing. A majority of poorer women in African countries believe that donkey-traction and transport would suit their needs and they are anxious for related credit and training (IFAD 1998). Planting and weeding are two other field operations that are rendered less labor intensive by investment in simple equipment and tools. (Kaaria and Ashby 2000)

Where fertilizers are in use, additional labor is required to spread and incorporate them, but this work is far less exhaustive than traditional land preparation and the returns to labor and

Table 16.4. Household impacts as farm innovations are adopted by small-scale farmers.

Current practice	Likely innovation	Impact upon household
Subsistence intercropping	Mixed enterprise farming	New skills, greater investment, improved marketing skills
Hand tillage	Oxen plowing	Less exhaustive labor, investment in livestock & tools
	Tractor hire	Payment for service or cooperative investment
Little or no fertilizer used	More reliance on BNF	Improved nutrition, investment in seed & inoculants
	Use of Agro-minerals	Increased investment and labor
	Manure management	Increased labor, substitution for fertilizer purchase, strengthened livestock enterprise
	Nitrogen top-dressing	Increased investment and labor, new skills
Hole planting	Open furrow planting	Less repetitive labor, greater reliance upon livestock & tillage implements
	Mechanical line planter	Less repetitive labor, investment in small equipment
Hand weeding	Lighter "cutting" hoe	Less exhaustive labor, wider gender participation
	Herbicide wick or sprayer	Less exhaustive labor, investment in technology
Field storage	Crib storage	Higher grain quality, some additional family labor, rodent prevention
Hand shelling	Rotary shelling	Less repetitive labor, investment in small equipment
	Machine shelling	More broken grain, cooperative investment

investment are large. The management of fertilizer nitrogen in particular requires new sets of skills to position the fertilizers and prevent their gaseous loss through combined top-dressing and weeding operations (Table 16.4). Improving crop harvest and processing operations also requires investment that substitutes for repetitive labor and is often necessary before crop quality can meet the industry standards of top-end buyers. One exception to this is the increased reliance upon mechanical grain shellers that do not differentiate off-grade grains and result in increased broken grains. New skill sets are necessary to operate this equipment in an effective and safe manner.

A key to improving human capital and reducing drudgery is through the new roles open to women and children. Musculoskeletal disorders are common among agricultural workers and may yet increase as labour intensive agriculture expands (Villarelo and Baron 1999). Women's physiology makes them especially vulnerable to farm-related ill-health and risk reduction in this area has large beneficial impacts upon the household as a whole. While men frequently shoulder the heaviest jobs, women and children are too often expected to perform lengthy and repetitive tasks with little regard to ergonomics. For example, weeding operations with heavy digging hoes is unfair to weaker members of the family considering that lightweight cutting hoes are known, if not readily available. The same may be said for planting and shelling where popular innovations can greatly reduce necessary labor. One impact upon market-oriented farming is its need and respect for knowledge and this raises regard for education, both by children and adults. Poorer households are more willing to send children to school when their educations are seen as essential to escape from poverty. Similarly, participation in youth and women's groups are also viewed as avenues of important information. In addition, when labor requirements are reduced, more time is available to assist the disadvantaged, particularly widows and the elderly, in completing their most arduous field operations. In this way, more efficient and profitable farming can also become more equitable and charitable.

Occupational safety and responsible treatment of hired labor

Human conditions may be improved through farm occupational safety. Smallhold farms are businesses that rely upon family labor backstopped to varying degrees by hired workers. In traditional farming systems, soil management practices are among the most difficult tasks, both in terms of drudgery and tedium. Particularly the poorer households lacking oxen or the funds to hire animal traction perform much land preparation by hand using crude hoes. Weeding is a tedious task that is usually performed by hand or with inappropriate tools, requiring workers to perform repetitious physical labor at rapid paces and in difficult postures. On average, men are better suited to perform these field tasks because of their greater musculature and cardiovascular capacities. Women and children expected to perform these same tasks often suffer ill effects to their muscles, skeletons and internal organs. In addition, women have a greater proportion of fat that absorbs more pesticides. Pregnant and breast-feeding women are affected most (Jafry 2000).

Smallholders' field operations are performed with little regard to farm occupational safety when the elderly, women and children are expected to perform tasks that exceed their physical stamina. Hired workers, recruited to fill needs that family labor cannot perform are often treated in the same manner. To be widely adopted, ISFM practices should not demand unrealistic tasks but rather develop in a manner that assures gender equity. The types and interactions among farm enterprises, soil conditions, investment opportunity in external farm inputs and tools, and the availability and stamina of family labor and hired workers determine specific ISFM practice. Some guidelines that promote farm occupational safety and gender equity follow.

1. Family farms will necessarily continue to engage household labor, including children but the tasks must be proportionate to members' strength and stamina. Despite household labor

needs, children must be permitted, indeed encouraged, to attend school. School schedules in rural areas should reflect the peak labor needs of surrounding farms.

2. School curricula should include vocational agriculture and ISFM practices. Schools should maintain demonstrational gardens and students encouraged to explain agricultural technologies to their families. Technology adoption campaigns must include schools.
3. Ergonomics within smallholder farms warrants further attention by agricultural researchers, tool producers, extension agents and rural development specialists. Most farm households make and affix their own wooden handles to metal farm tools and they should be advised concerning their better design. Heavy and repetitive work conducted in awkward positions must be minimized.
4. Occupational health not only involves risk avoidance but also treatment and therapy. Workers experiencing acute or chronic muscular, skeletal or internal pains require medical advice. At the same time everyone feels a hard day's work and care must be taken to relax following several hours of heavy labor so that small aches do not grow into medical conditions.
5. ISFM and its labor-saving facets must be advanced within rural development agendas. Incentives should be provided to farmers seeking to convert farm operations toward more mechanized agriculture. Other labor-saving technologies, such as minimum tillage, require new sets of skills and field equipment that are not presently available to many farming communities.
6. Pesticide applicators must receive training and use protective gear. Applicators must be particularly aware and careful when they are handling dangerous pesticides. Children must never apply pesticides nor be permitted to handle protective gear or sprayers until they have been cleaned. Pesticides must be stored and disposed in areas inaccessible to children.

Table 16.5. Contributions of ISFM toward the Millennium Development Goals.

Millennium Goal	ISFM contribution	Comments and implications
Eradicating extreme poverty & hunger	Increased household & national food supply and enjoy larger incomes from more profitable farming	Farm profits become recycled through the rural community (Cabral *et al*. 2006; Sanchez *et al*. 2007)
Achieving universal primary education	Less dependence upon child labor on the farm, greater appreciation of knowledge	ISFM practices must be explainable to those with a primary education
Promoting gender equity & empowering women	Less arduous and repetitive labor by women, greater occupational safety	As new tasks emerge, traditional division of labor must be abandoned
Reducing child mortality and improving maternal health	Improved diets as farm enterprises diversify and household income grows	Better crop nutrient management improves mother and child nutrition as well
Combating HIV/AIDS, malaria & other disease	Improved diets for the ill, labor and input donation to the disadvantaged	Illness diverts household income away from farm investment toward medical treatment
Ensuring environmental sustainability	Increased farm biodiversity, improved soil and water quality, reduced crop disease	Many ISFM practices result in net carbon offsets, reducing global warming
Developing global partnerships	ISM becomes prominent within rural development agendas	ISFM advances from a scientific discipline into a developmental strategy

Role of ISFM toward attainment of the Millennium Development Goals

One means to assess the role of ISFM toward gender equity is through its potential contributions to the Millennium Development Goals (MDGs). These goals were established at the Millennium Summit in 2000 in order to set an international standard in addressing improvements in the quality of life within developing countries (Juma 2006). The MDGs include eradicating extreme poverty and hunger, achieving universal primary education, empowering women, reducing child mortality and improving maternal health, combating HIV/AIDS, malaria and other disease and ensuring environmental sustainability with specific targets identified for the year 2015 (UN Statistics Division 2005). Where applied to farming communities, integrated approaches to soil fertility management make a positive contribution to many of these goals (Table 16.5).

The contributions of ISFM toward poverty eradication and environmental sustainability are described in detail elsewhere in this book. It is in the fulfillment of the other equally important MDGs where ISFM plays a more subtle and sometimes overlapping role. ISFM seeks to substitute skills and investment for arduous and repetitive labor, thus providing incentives for primary education and greater occupational safety for women and children. As farm enterprises diversify and household income grows, household diet improves in a manner which benefits expecting women, young children and the ill.

Some negative impacts may also occur, particularly in regard to combating HIV/AIDS, malaria and other disease. Sickness and death can result in labor shortages leading to reduced land under cultivation and declining yields. In many areas, children learn about farming by working alongside their parents. Because of gender division of labor and knowledge, the loss of even one parent can inhibit the transfer of skills. Farming households affected by HIV/AIDS and chronic illness are forced to divert limited incomes to medical treatment, precluding investment in needed farm improvements (Baylies 2002). In the worst affected households, farming may be abandoned altogether (Slater and Wiggens 2005). From these negative consequences, it is important that ISFM measures focus upon labor-saving technologies and be accompanied by strong educational campaigns if they are to fully contribute to gender equity within the Millennium Development Goals.

It is excessive to refer to ISFM as a livelihood strategy but indeed, it can be a key component to small-scale farming. Greater reliance upon legumes and mixed farming not only improves the soil, but also the protein, vitamin and micronutrient contents of household diets are upgraded (Manson *et al.* 2001). Soil conservation improves soil tilth, reducing the labor requirements of land preparation. Surface mulching and vegetative groundcovers not only protect soils but reduce crop maintenance, particularly weeding operations (Roose and Barthès 2001). ISFM offers a win-win situation in terms of land quality and labor requirements that are readily passed on to disadvantaged household members. Greater and more efficient crop production may increase the labor required for harvest and crop processing, but for farmers this is a labor enjoyed because it represents household security (Rahman *et al.* 1993). Furthermore, more profitable farming permits greater dependence upon hired labor during peak demands. These sorts of benefits are spread across household members in a manner that offers less drudgery and greater incomes, and in this way ISFM is gender-friendly.

Chapter 17. ISFM and household nutrition

While the immediate objective of ISFM is to provide nutrients to plants as a means of increasing crop yields, the ultimate goal is to improve the living conditions, food security and nutrition of farm households (Borlaugh 2003). The poor rural household consumes maize or other traditional grains daily but they eat beans, wheat and rice only once or twice per week and enjoy meat only on special occasions. Surprisingly, many maize producing households suffer shortfalls in their preferred staple because food needed over the next few months must be sold to meet demands that are more pressing. Ironically, many households may then spend most of their available cash to purchase the same commodities that they had months earlier produced and sold.

Not only food insecurity, but also the quality of diets in Africa requires urgent attention. Poor diets are defined as those that do not supply the essential, balanced nutritional constituents providing energy, protein, vitamins and minerals. Many diseases in poorer households are induced by incomplete diet and seasonal malnutrition. Many crops rich in starch are low in protein and other nutrients essential to human health (Johns 2003). Protein deficiency, also known as kwashiorkor, is all too prevalent in populations throughout rural Africa. This deficiency in foodstuffs results in part from insufficient nitrogen and sulfur for synthesis of amino acids by crops, which in turn relates to poor soil fertility management. Poor food quality in Africa is further complicated by the so-called hungry harvests. Crop harvests may be rich in starch but contain insufficient amounts of protein, vitamins and minerals that are required by the human body. To emphasize this point, Davis *et al.* (2004) reported a marked reduction in the nutritional quality in 12 common vegetables between 1950 and 1999 caused by changing agronomic practices. Another concern is seasonal malnutrition caused when poor households lack harvestable crops in their fields and have insufficient income to cover the food shortfall.

ISFM provides several entry points for increasing and diversifying human diets. Its reliance upon field legumes as sources of symbiotically fixed nitrogen allows cultivation of more intensive and more diverse food legumes that in turn improve the supply of vegetable protein. More closely integrating crop and livestock enterprises not only tightens nutrient cycles but also increases the supply of animal proteins available to the household. Improved soil fertility also enhances the nutritional balance of foods, including their mineral and vitamin contents. Diversifying crop enterprises also improves household diets, especially when new vegetables, tubers and fruits are produced in addition to staple grains. In some cases, raising food quality does not assure better diets without accompanying food processing technologies that protect nutritive value. For example, nutritive crops that require processing such as soybean may be grown for the market and bypass producing households unless training and incentives are offered for localized value-added processing. In other cases, non-food green manures may be grown for their soil benefits alone, and farmers must then take advantage to diversify their food production enterprises the following season. In this way, ISFM does not necessarily improve household nutrition, but rather it provides opportunity for informed homemakers, both farmers and consumers alike, to provide their families with more food and better diets.

Complex relationships between household diet and ISFM are revealed through interpretation of a household survey conducted in West Kenya during 2005 (Table 17.1). The overall purpose of the survey was to identify produce marketing opportunities among smallhold farmers but respondents were also queried concerning their soil fertility management practices, farm diversification and household wellbeing. Farms were grouped by resource endowment and household characteristics expressed (Shepherd and Soule 1998). All of these farms practice maize-bean intercropping as the main farm enterprise (Table 17.1). Resource poor households occupy smaller farms, practice fewer farm enterprises, own fewer domestic animals and use less mineral fertilizers. Poorer households also tend to better manage organic resources within their farms in a manner consistent with ISFM, particularly making better use of manure and legume intercrops, but their ability to combine these practices with top-dressed mineral fertilizer is

considerably reduced. It is important that very few of the least endowed households considered themselves food secure despite strong similarities in household diet. Note that better endowed households appear to have much better access to animal proteins and to have greater ability to respond to household needs. These sorts of findings present a challenge to proponents of ISFM because improved household nutrition is not necessarily reflected in better soil fertility management among the least endowed households, suggesting that ISFM promotional activities should include a component where farm diversification, especially expansion of legume cultivation and animal enterprise, bringing corresponding improvement in household diet.

Table 17.1. Household characteristics among 247 small scale farm in west Kenya (F.M. Mwaura, 2005, unpublished).

Parameter	Resource Endowment		
	Poor	Modest	High
Farm size (ha)	0.4	0.9	3.8
Household size (members)	7.1	7.6	9.4
Proportion of maize on farm (%)	67	67	49
Apply pre-plant fertilizer (%)	45	63	90
Apply top-dressed fertilizer (%)	7	27	49
Apply manure (%)	32	16	13
Practice innovative intercropping (%)	35	13	10
Number of cattle	0.5	1.9	5.5
Number of poultry	8.4	9.3	16.7
Produce potatoes or sweet potatoes (%)	13	19	35
Produce bananas (%)	5	12	45
Consider themselves food secure (%)	14	34	53
Meals served with maize (per week)	9	8	8
Meals served with beans (per week)	2	2	2
Meals served with milk (per week)	6	8	10
Funds spent for medicines ($ per week)	0.47	1.15	6.35
Belong to farmer associations (%)	49	63	68

Clearly, the best way for smallhold farmers to improve the quality of their diets is by growing and consuming a wider variety of foods, particularly those rich in protein and vitamins. The higher protein content and variety of vitamins contained in fruits, nuts and vegetables offer obvious solutions. These approaches to dietary improvement do not necessarily involve the integration of ISFM into farm operations when these crops are cultivated in small, isolated plots. ISFM interacts heavily with household nutrition in two major areas, however, through the intensification of cultivating symbiotic grain legumes and through the improved nutritional quality of harvests resulting from more balanced soil fertility management.

Benefits from legume intensification

A key to ISFM practices by many small-scale farmers is the combination of staple cereals and nitrogen-fixing legumes as intercrops or in rotation. This reciprocation is matched by nutritional complementarily of cereal and legume protein, a phenomenon that was discovered empirically throughout the tropics. Diets of rice and soybean in Southeast Asia, millet and pigeon pea in dryland India, sorghum and cowpea in Africa or maize and beans in Central America all illustrate this point (Hulse 1991). Ideally cereals and legumes should be consumed in a ratio of 70:30 in order to consume equal amounts of vegetable protein and to achieve a desired balance of amino acids. Unfortunately, this goal is not met with households producing and consuming a disproportionately greater measure of cereal and other starches. This trend is based not only upon the relative productivity of cereals, which is greater under low management regimes, but also due to market forces which generally process cereals into a wider range of products than legumes. Legumes are able to be processed into numerous products, however, and the development of new, and expansion of existing food technologies for legumes remains a major goal for developing countries (ICRISAT 1991). When placed into the needs of small-scale farming households, these market opportunities and a shortfall in legume protein offers an important signal for adoption of ISFM.

Table 17.2 Food composition of legumes important to ISFM[1]

food legume (*scientific name*)	edible part	Protein	fat	carbo-hydrate	Ca	P	K	Vit A	Thiamin	Vit C
		----- propotion dw-----			---------- mg per 100g ----------					
groundnut (*Arachis hypogeae*)	seed	0.25	0.48	0.25	52	438		16	0.84	1
pigeon pea (*Cajanus cajan*)	seed	0.22	0.01	0.73	179	316		61	0.8	
	green pod	0.24	0.02	0.69	202	489	1748	407	1.24	90
soybean (*Glycine max*)	seed	0.39	0.2	0.36	245	606	999	11	0.73	0
	sprout	0.42	0.1	0.43	251	580	467	11	0.74	0
hyacinth bean (*Lablab purpureus*)	seed	0.25	0.02	0.69	600	400	2232	1280	0.64	128
common bean (*Phaselus vulgaris*)	seed	0.25	0.02	0.69	137	368		11	0.42	2
	green pod	0.22	0.02	0.7	350	300				
	leaf	0.27	0.03	0.5	2076	568		24559	1.36	834
green gram (*Vigna radiata*)	seed	0.26	0.01	0.69	118	370	7	62	0.59	4
	sprout	0.42	0.02	0.5	152	717	2242	202	1.11	182
cowpea (*Vigna unguiculata*)	seed	0.26	0.02	0.69	124	432	777	11	0.67	1
	green pod	0.33	0.05	0.55	478	522	1947	4027	1.24	212
	leaf	0.36	0.03	0.5	664	964			3.18	327
bambara nut (*Vigna subterranea*)	seed	0.18	0.07	0.72	94	293		0	0.2	0

[1] Expressed on a dry weight (dw) basis. Based primarily upon Duke 1981.

Food legumes that are well suited to mixed and cereal-based farming systems of the tropics offer excellent sources of not only protein and starch, but also fat (oil), minerals and vitamins (Table 17.2). These nutritional benefits result from the versatility of legumes as sources of edible leaves, green pods, unripe seed, grain and sprouts. In addition to those essential nutrients presented in Table 17.2, legumes also contain significant amounts of fiber, sodium, iron and the vitamin B complex.

The potential for processing and consuming food legumes is great (Figure 17.1). Fresh or dried leaves of cowpea may be steamed or boiled (Maundu *et al.* 1999) and served alone or in combination with other ingredients. Leaves of *Crotolaria ochreleuca* may be prepared in the same way (Woomer 2002). Drying picked leaves greatly reduces their perishability as the leaves readily rehydrate. Slight wilting is not a problem, however, as leaves prepared in this state offer better consistency of the final product. The immature green pods of many legumes may be cooked and consumed including those of cowpea, pigeon, lablab and green bean. Pods are also processed by canning and freezing. The full sized but immature green seeds of several legumes may also be shelled and then cooked or processed, including those of groundnut, cowpea, pigeon pea and soybean. Dried grain can be either soaked and cooked, or ground into flour and grit. Legume flour is often combined with cereal flour to increase its protein content. Grain also serves as a source of seed for future planting. Note that legumes serve as important sources of animal feed as well. Not captured in Figure 17.1 is the pressing of oilseed, particularly groundnut and soybean (see Table 17.2). This process produces vegetable oil and press cake, the latter is an important component of animal feeds. In Asia soybean and other pulses are processed into several additional products including soy sauce, nato, tofu, tempeh and noodles. Some of these products require fermentation, a process also not captured in Figure 17.1.

Legume intensification is intended not only to increase crop productivity, but ultimately to improve farm livelihoods in terms of income, nutrition and health. Adoption of multi-purpose crops such as promiscuous soybeans will lead to better soil quality and increase of yields of subsequent crops. Farmers are also able to process some of the legume harvest for home

consumption thus improving the nutrition of household members, especially children who are more disposed to malnutrition.

Grain legume processing and utilization involves the training of trainers, farmers, support groups and community based organizations that results in a ripple effect whereby peoples' diets diversify and protein availability and quality improves. ISFM strategies, particularly cereal-soybean rotation, serve to supplement traditional staple cereals. Because of its pronounced effect on nutrition and health, poorer farmers readily adopt soybean utilization. With time, surplus production sold or processed into products that generate additional income. This adoption boosts economic wellbeing of participating households leading to diets that counteract HIV, hunger and malnutrition in sub-Saharan Africa (Friis and Michaelsen 1998).

Plant and human nutrition

Healthy plants are richer in micronutrients and vitamins required in the human diet including calcium, potassium, phosphorus, iron, beta carotine (Vitamine A), the Vitamine B complex (e.g. Thiamine, Niacin, Riboflavin) and ascorbic acid (Vitamin C). The effectiveness of various agricultural measures in increasing nutritional value depends on soil characteristics, crop cultivar, and other factors, thus necessitating development of a specific set of measures for individual agro-ecological zones. In this way, the potential to enhance micronutrient and vitamin concentrations of food through balanced crop fertilization features into ISFM design and decision-making.

Fertilizer application on a world scale is largely dominated by the need to provide crops with the macronutrients N, P and K. Better supply of these macronutrients increase crop biomass and in effect increase the assimilation of other non-limiting nutrients also required by crops and their consumers. In the same way, however, increased demand for secondary and micronutrients may lead to the expression of new deficiencies when their supply becomes limiting (Slingeland *et al.*

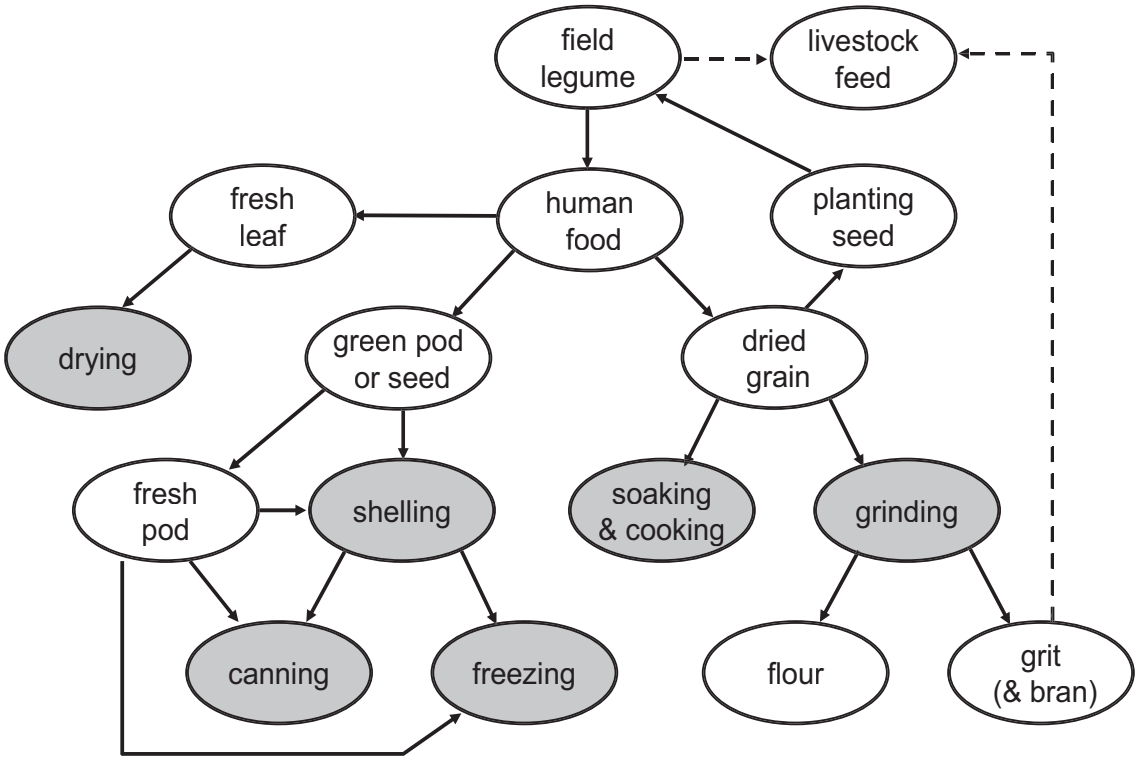


Figure 17.1. Products and processing options (shaded) of grain legumes useful in ISFM. Note that processing options do not consider pressing of groundnut or soybean as oilseed.

2006). Most human mineral needs can be supplied by eating a balanced, diverse diet and, should plant micronutrient deficiencies be expressed, it is important that land managers recognize and correct this condition (see Chapter 6). Studies across many countries in sub-Saharan Africa indicate that many soils are deficient in Zn and Fe once macronutrient status is corrected (Sillanpa 1990). Many fertilizers and agro-minerals contain secondary nutrients in carrier materials and micronutrients as containments (van Kauwenberg 2006; van Straaten 2002). Almost by definition, higher quality organic amendments such as green manures, livestock manures and composts contain required nutrients in the proportion they are required by plants (Palm *et al.* 1994, 2001). Acutely deficient soils can be fertilized with the required secondary and micronutrients to address specific plant and human nutritional demands (Boius *et al.* 1999; Manson *et al.* 2001).

In the case of N, S, P, and the major base cations Ca, Mg and K, there are well established relationships between use of mineral fertilizer, or measurement of available concentrations in the soil and plant uptake of these minerals as demonstrated by the QUEFTS model (Janssen *et al.* 1990). If cations added in fertilizers are not well-balanced, there can be negative interaction on uptake of the other. For example, excess K supply can result in decreased uptake of Mg (see Chapter 4). Relationships between plant uptake and translocation to the grain is less clear. The availability of Fe is not influenced directly by adding it to the soil or plant unless it is in a chelated form. This is because Fe is readily precipitated as oxides that are poorly soluble. Thus there is no sense in adding Fe as mid-season fertilizers to increase Fe uptake by crops (see Figure 17.2). Some nutrients (e.g. Ca, Zn, Fe) are transported through the plant by the xylem, but are relatively immobile in the phloem. This means that they are not readily loaded into accumulating storage organs. Selenium (Se) and iodine (I) are not classified as essential element for plant growth, but both are essential elements in human health. The Se concentration in plants varies considerably and provides a good indication of its availability in soil. Several countries in Africa have documented low Se areas. These include Zambia, Zimbabwe, and DR Congo.

The need for a package of health and nutrition services including micronutrient supplementation (vitamin A, iron and iodine) and nutrition education cannot be overemphasized whether in schools or community setting. Iron deficiency is the most common form of micronutrient deficiency in school-age children and caused by inadequate diet and infection. More than half the school-age children in low-income countries are estimated to suffer from iron deficiency anemia. Iron supplementation of children led to a reduction of anemia (Sifri *et al.* 2003), but the same goal may also be achieved by consuming greens rich in Fe.

Vitamin A deficiency causes impaired immune function, increases risk of mortality from infectious disease and is a leading cause of blindness. Recent studies suggest that this deficiency poses a major public health problem among school-age children in Africa. Vitamin A supplementation of school children and under five year olds in Suba, Kenya improved their general health (Kamau *et al.* 2008). Studies show that multiple-micronutrient supplements have improved cognitive function and short-term memory in school children and have reduced absenteeism caused by diarrhea and respiratory infections.

Further studies are required to examine the potential for addressing the nutritional quality of edible products by micronutrient fertilizer management. Better understanding the factors which influence the nutrient balance is important when selecting for accumulation of a specific nutrient. For example, application of Zn increased grain concentrations in various cereal crops by a factor of two to three, depending on species (Rashid and Fox 1992) and crop genotype (Graham *et al.* 1992). Soil type also influences the extent of increase in Zn concentration in grain as a consequence of soil Zn fertilization. It is important to note that regardless of the yield level or intensity of cultivation, not all the valuable components of a crop product can be increased simultaneously. Where the starch concentration of grain is increased, the protein concentration or another component may be lowered, or vice versa. An increase in the total amount of vitamins per plant may result in lower percentage concentrations owing to the dilution caused by relatively

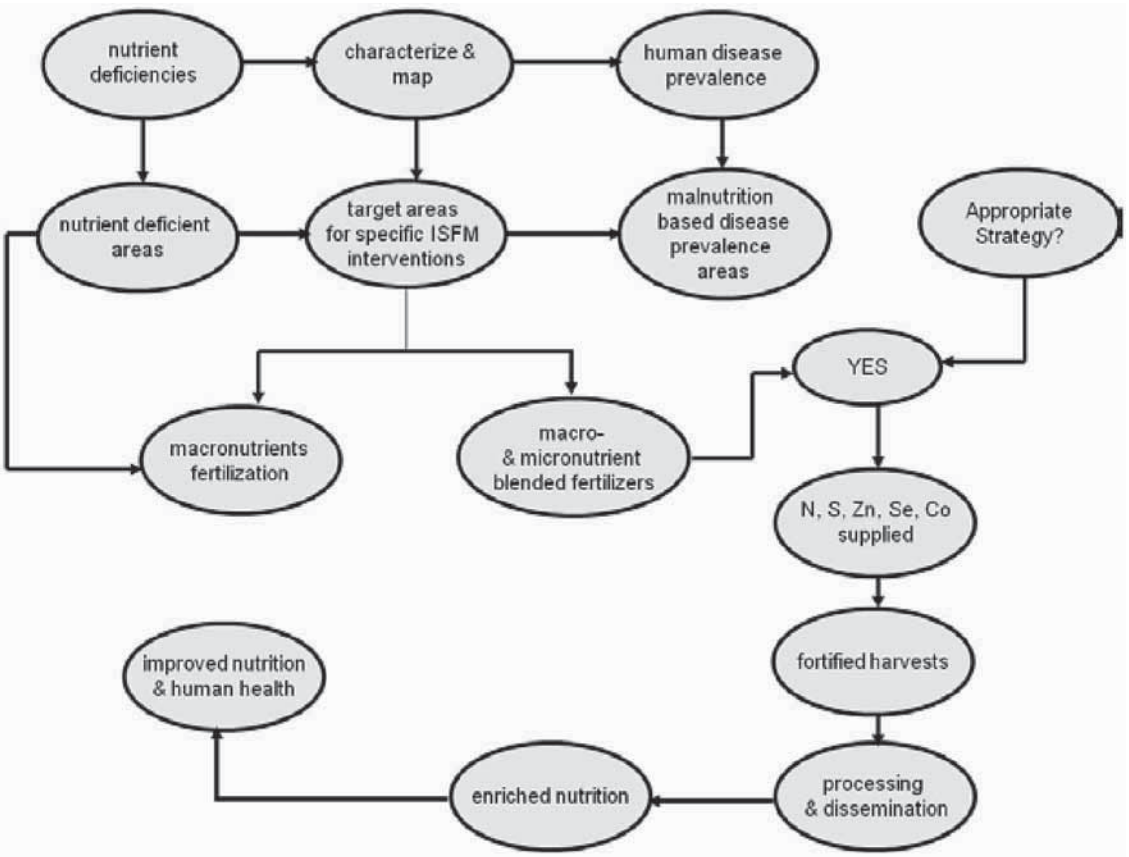


Figure 17.2. The conceptual pathway for impact oriented plant and human nutrition on food quality and health

higher starch and protein concentrations or biomass. The dilution effect is important in characterizing food quality.

Advancing ISFM and human nutrition

There are two potential scenarios that can occur in different areas; 1) nutrients essential for plant growth are both limiting and deficient in the human diet and 2) human mineral deficiencies are prevalent but the deficient minerals are either not essential for plant growth, or not limiting plant growth. The promotion of fertilizer-based approaches in addressing human mineral deficiencies is different for each of these cases. In the first situation, there is a clear need for new fertilizer blends and promotion of fertilizer-based approaches without involvement of the health industry. In the second situation, strong advocacy from all sectors and cooperation of the health sector are necessary to supplement the fertilizer-based approaches.

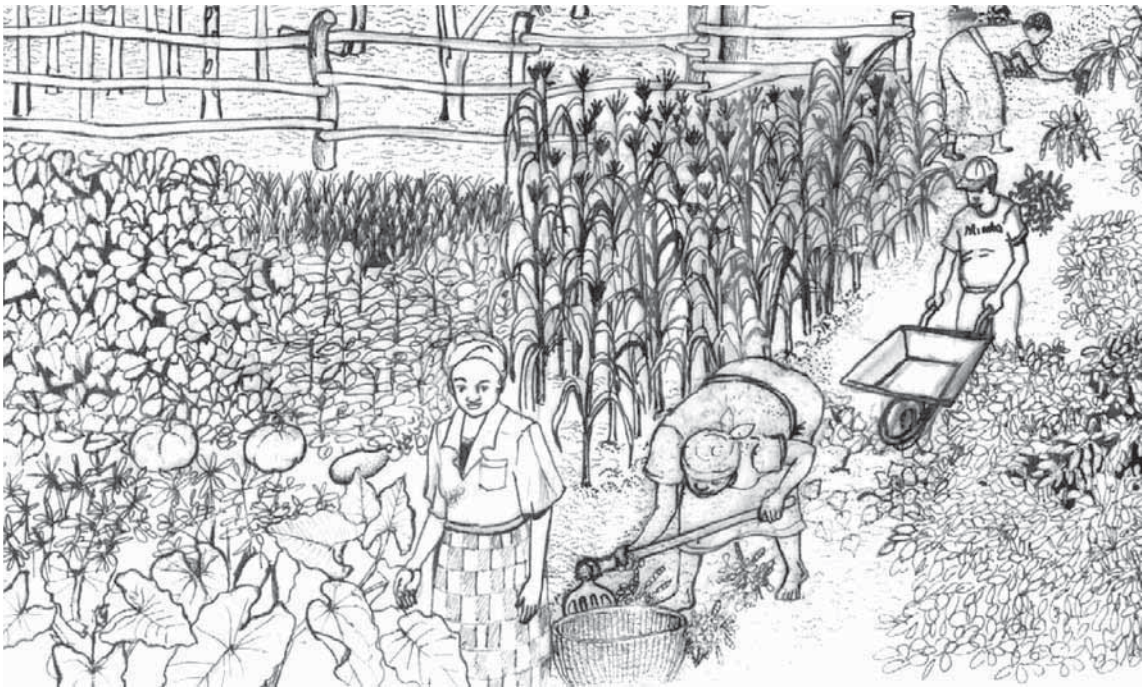
One means to simultaneously promote ISFM and human nutrition is through the strategic establishment of community resource and learning centers. The centers serve as technology dissemination points, information repositories and meeting venues. Information campaigns in print, electronic, audio, and visual media may be developed by the food industry, schools, health institutions, religious and social institutions, NGOs, and researchers. Qualified staff must be appointed to dedicate their time in awareness creation, database management and information exchange.

A key to the success of ISFM is the acceptance of new grain legumes by farm households. Bean stews are a major component of smallholder's diet and to a large extend ISFM requires that practitioners extend their consumption to include soybean, gram, lablab, pigeon pea and other pulses. One reason beans are popular is because they cook quickly after soaking and the stew

compliments cooked maize meal and other starches. Demonstrations may be conducted that exhibit the convenience and palatability of these other pulses and their processed products. These actions must be supported by the distribution of pamphlets that contain information on household recipes and held in conjunction with farmer field days and community resource centers.

Grain legume cooking contests may also be organized. Briefly, the contest is announced and recipes are solicited. Promising applicants are then selected, the contest scheduled and contestants provided similar cooking facilities. Prior to the contest, each contestant provides a list of ingredients and recipe that is compiled and published as a cookbook. After a specified period, a panel of judges assesses the taste, appearance and originality of the recipes. The contest winners receive a modest cash prize and cooking utensils. This type of contest is a crowd pleaser as observers are then invited to taste the final products. Detailed rules for similar cooking contests appear in Woomer (2002).

School meal programs support both child nutrition and education goals (McGuffin 2005). However, to provide safe and nutritious foods to children requires trained personnel in terms of food handling, sanitation and storage and optimal preparation. Successful programs in nutrition and health education carried out in Africa target specific needs with precise, accurate, relevant and compelling training materials (Probate *et al.* 2003). While ISFM may not have been designed as a vehicle to improve human nutrition and health, when placed into a proper developmental context it serves as a means to increase the diversity of household diets, particularly with regard to increased consumption of grain legumes, and to improve the nutritional quality of foods produced, consumed and sold by the farming household.



Chapter 18. Capacity building in ISFM

The need for capacity building in ISFM is great, but not overwhelming. On one hand, much knowledge is available on how to better manage soils at the farm and catchments levels (Gachene and Kimaru 2003; Kanyanjua *et al.* 2000) and what is required is the translation of these findings into straightforward farm guidelines and community action plans. On the other hand, capacities in soil science and resource management are deteriorating within national institutes, universities and agricultural extension systems remain poorly financed and hugely overburdened by the sheer number of smallhold farming clients (Swift and Shepherd 2007). An expedient means to mobilize existing knowledge is to identify which stakeholder groups require what sort of information and experience, to prioritize these stakeholder groups and to design and conduct cost effective training exercises that translate findings into information packages and field practices (Woomer 2004).

Vocational training in ISFM

The ultimate client of vocational training in ISFM is the farming household, although their large numbers and educational backgrounds do not permit them to be gathered and informed en masse. Important intermediate stakeholders that serve as more ready clients of existing practical technologies in ISFM include primary and secondary school students and teachers, officers of grassroot and farm organizations, frontline extension agents and their supervisors and private sector dealers in agricultural inputs. The needs of these stakeholders may be broadly grouped into the category of vocational training.

Primary and secondary school systems. School age children are receptive targets of vocational training in land management because they are literate and occupy a respected place within the rural household. Targeting technology demonstrations or community field days to schools allow for large numbers of farmers to be mobilized by their own and neighboring children and for teachers and school administrators to provide peer support and professional expertise to recommended farm practices. One particularly useful way to introduce extension recommendations is through school farming projects, where key inputs are distributed to school administrators, installed and managed by students, resulting produce used to improve school lunches and seed and information materials conveyed to parents (see Chapter 17). Prizes may be awarded to the best efforts during school functions. Furthermore, high school students are usually the most literate members of their family and often have computer skills. The internet revolution is now penetrating even the most remote farming communities, and making useful web addresses known to students is one means of spreading extension information to small-scale farmers. Indeed, disseminating agricultural extension messages via the internet has now become commonplace in developed countries and this cost-effective form of technology dissemination must not be overlooked in developing ones as well. On the downside, secondary education in rural areas is too often seen as a means to escape the drudgery and poverty of small-scale farming and vocational agriculture does not occupy an important position within curricula or student interest.

Farm association officials. The elected officials of farmer organizations and grassroot community groups serve as expedient conduits of recommended practices, in large part because they have been specifically elected by members to do so. The elected officials of these groups tend to be the more educated and ambitious group members, often retired civil servants or local school teachers, and understand the importance of accessing extension information, sample input products and new marketing and value-adding opportunities (Chirwa *et al.* 2005; Stringfellow *et al.* 1997). In most cases, these officials are early adopters of numerous promising technologies and

their farms serve as neighborhood models of mixed enterprise agriculture. An expedient means of dissemination is to contract farmer associations to install field demonstrations using technology packages accompanied by straightforward field protocols. Association members are required to install one or more core recommendations but also encouraged to modify them or include other practices as they see fit. The demonstrations should be monitored and the most successful of them upgraded to full farmer field days through additional and modest support. Distributing diverse information materials, inviting extension supervisors and agro-dealers, and arranging for local entertainment improves interest in the field days but care must be taken not to distract from the central messages. Focus may be preserved by halting all peripheral field day activities during the display and discussion of the main field demonstrations.

One risk of investing too heavily in technology dissemination through long-standing officials of farm organizations is the self-importance placed upon their positions. Some officials will take entrenching opportunity from collaboration with agents of rural change and even cause groups to fragment should they not be re-elected. For this reason, it is important for development networks to work with at least two officers from each organization and to establish liaison with some of the groups' regular members. Communication with officials and regular members alike is readily achieved via mobile telephones and electronic mail (Woomer *et al.* 2003). Another danger is that the poorest farming households are unable to afford membership dues to farm organizations and may be bypassed by efforts directed through farm organizations. This risk is lessened when working with more localized youth and women's' groups and increased when collaborating with farmers' produce and marketing associations.

Extension officer updates. Extension officers are obvious clients for capacity building in ISFM and, if they are better positioned to fulfill their designated roles in rural transformation as trainers, the role of other less accessible stakeholder groups would decrease. In fairness, ISFM technologies are complex and extension service providers, whether extension agents or farm liaison specialists placed with NGOs and the private sector, are too often unprepared to backstop developmental efforts in this area. Furthermore, ill-informed agents may extend inaccurate or conflicting messages to farmers and must therefore be empowered to understand and deliver key messages through cost-effective training exercises.

To better understand the failure of frontline extension, one must better appreciate the conditions under which its agents operate. Rigid organizational structure, poor access to recent information and useful extension materials, and adherence to outdated and unrealistic recommendations are three factors that greatly reduce the effectiveness of formal agricultural structure (Merrill-Sands and Kalmowitz 1990). Too often, extension content is fed to frontline extension agents through their supervisors in a top-down manner that discourages iterative, site-specific problem solving and precludes needed feedback. Most extension officers have no information materials to distribute to clients, holding on to the last copy of outdated brochures. They lack communication facilities or means of transportation. They have little or no budget and promised funds often arrive too late for planned field campaigns. Many extension agents pursue recent fads or are locked into jargon and frequently dismiss farmers for failing to adopt past ill-founded recommendations. Others insist that government officers must take the lead in all areas of collaboration and that other partners are only allowed to operate at their pleasure (Eicher 1999). Extension agents must be encouraged to integrate and reinterpret agricultural information rather than simply relay conventional knowledge (Mukhwana and Musioka 2003). But clearly, training extension agents in ISFM involves more than conveying new approaches to soil management, but also including them within a balanced, free-thinking collaborative framework where information flows, follow up actions are taken and outstanding performance is rewarded.

Many agricultural extension systems are well aware of their shortcomings and are taking important strides toward reform. Efforts directed toward re-training extension officers in the area of soil fertility should not only cover current techniques in nutrient management but also be

consistent with these reforms by providing participating frontline extension staff with the diagnostic tools necessary for independent agricultural problem-solving (see Chapter 11). It is important that both extension agents and their supervisors participate in discussions intended toward improving their impacts upon the farming community. Many of the topics covered within this book are suitable for use in the retraining of agricultural extension agents in ISFM.

Redirecting non-governmental organizations (NGOs). NGOs have emerged as a powerful force for development in Africa because of their practical agendas and flexible operations. NGOs range in size from massive international humanitarian organizations to very small community focused operations. As the importance of ISFM grows within rural development agendas, more, larger NGOs will incorporate its principles into their development activities and numerous, smaller NGOs will likely form around it. Many smaller NGOs are committed to rural transformation and simultaneously undertake the many services necessary to stimulate economic development although skeptics challenge their expertise and endurance (White and Eicher 1999). Farm input supply is one of these actions and farmers may be provided with the improved seeds, mineral fertilizers and other products required to raise their yields to a target level (Denning *et al.* 2009; Gordon 2000). Often conditions are placed upon these recipients and the principles of ISFM can direct these organizations into devising a suite of farm activities that improve the effectiveness of delivered farm inputs. Examples of these conditions are that participating farmers collect and apply a recommended amount of organic inputs that complement mineral fertilizer addition (see Chapter 4), that water harvesting or soil conservation measures be installed within their fields (see Chapter 7) or legume intercropping or rotation be conducted (see Chapter 8) and some fraction of harvest be returned to the sponsoring organization for use as seed by others during the next season. It is important that international NGOs recruit experts in ISFM to design these programs.

Another common role of NGOs, regardless of their size, is the training of trainers. In the case of ISFM, this often involves the development of master farmer programs designed to stimulate farmer-to-farmer exchange in nutrient management and soil conservation. This approach was included by Sasakawa 2000 that has its extension workers trained at MSc. level at the University of Cape Coast in Ghana. Similar expertise through practical M.Sc. training has resulted from the Forum on Agricultural Resource Husbandry, a collaborative effort of Faculties of Agriculture in East and Southern Africa (Patel and Woomer 2000). About 16% of the FORUM's M.Sc. graduates in agriculture found employment with national NGOs, more than those entering universities, private enterprise or seeking higher degrees. These recent graduates working with NGOs were instantly networked with national public universities and their colleagues entering employment in other areas of agricultural research and rural development, particularly Ministries of Agriculture (Woomer 2003).

The key to farmers' problem solving rests in their own ability to diagnose and correct new problems as they arise. Farmers interact with, and seek assistance from other farmers and this situation provides an entry point for rural development (Patel *et al.* 2004; Woomer *et al.* 2003). NGOs often launch these programs by providing candidate farmers with the information and tools necessary to instruct others in different farm activities and enterprises and then providing each trainee with a modest budget for their activities. Ideally, community members benefiting from these services will subsidize and then fully cover these operations. Again, the poorest members of the community risk being bypassed by this pay for service approach unless a charitable component is included within its design and operating principles.

Agro-dealer training. Local dealers in agricultural inputs are not only well positioned to market farm input products to farmers but also to make useful recommendations on which of their products is needed and how it is best applied. In order to make best use of this opportunity, training of agro-dealers should be an integral part of a progressive capacity building program in

ISFM. The suite of necessary skills includes not only product handling and marketing, but also cost-effectiveness of alternative products, agro-enterprise development, applicator safety, combining field operations, recordkeeping and budgeting, and analysis of returns to investments by farmers. It is simplistic to imagine networks of farm input suppliers behave as trainers first and business persons second, but strong arguments can be formed around building trust between agro-input dealers and their customers. What is critical is for these dealers to know that getting involved in spreading ISFM knowledge to farmers is also an effective means of helping their business grow.

Training workshops may be specifically designed for farm input dealers that permits them to better stock soil fertility management products and to better advise client farmers about the product use. These novel workshops may be attended by over 50 agro-dealers that include two-day instructional sessions on ISFM and visits to diverse representative field demonstrations. A third day may be devoted to striga, pests and disease management and their relationship to soil fertility management. The field demonstrations are best situated across strong soil fertility gradients, allowing the diagnostic skills of participants to be sharpened. Individual participants should be asked to score different land management practices. Such an exercise is likely to reveal the following practical information; maize responds to fertilizer in most sites and differences between DAP and more expensive complete fertilizer blends are slight except where potassium becomes limiting, top-dressing of nitrogen is most effective following more complete fertilizer application at planting, differences in performance between recommended maize varieties of different commercial seed producers are slight when those varieties are properly targeted to representative agro-ecologies, and strong effects are observed in cereals following a legume rotation. Following a well designed workshop, agro-dealers become keenly interested in applying this information to future product orders and can better recommend these products, particularly when they are accompanied by written information (TSBF 2009).

Professional and scientific training in ISFM

We note with great concern the general trend of declining capacity in soil science and the slow pace of technical breakthroughs in ISFM. Soil science curricula within national public universities are too often out-of-date. Many national soil laboratories are deteriorating and admissions to soil science courses have fallen dramatically, even in countries with extreme dependence upon agriculture and its products. It is clear that an aggressive strategy is needed to reverse these trends and equip Africa's research and education systems with the human and physical resources required to support development, and better understand and sustain the agricultural resource base (Miguel and Kremer 2004).

Essential elements for building human and institutional capacity in soil fertility input recommendations in Africa need to target human resources, their interaction, communication, and the rehabilitation of physical resources (Swift and Shepherd 2007). Building human resources will require the identification of capacity building needs of the various stakeholders, develop curricula for university students on modern approaches for targeting soil fertility recommendations suited to African conditions, and provide short courses to farmers, extension officers and other stakeholders on fertilizer recommendation and development of user friendly information dissemination materials. To strengthen interaction and communication, there is a need to create platforms that allow scientists to develop research proposals, compare research results, identify general lessons, improve joint implementation of programs and projects across borders, by using and strengthening existing interactive and mutual-learning networks, and promote regular interactions with policymakers. There is also need to improve the physical resources by building series of well-equipped sub-regional or national laboratories and by re-equipping laboratories for the new ISFM agenda.

Capacity building within universities and NARS. Priorities for curriculum development include the upgrading of Diploma, BSc and MSc courses intended to prepare better extension workers and field technicians within rural development projects. Much of these contributions will be based upon the establishment of key field demonstrations and other best practice mechanisms that disseminate needed technologies to large numbers of farmers. M.Sc. and Ph.D. courses must prepare senior agronomists and soil scientists using advanced modules on modern soil science and agronomy including spatial decision support tools GIS, remote sensing, digital soil mapping, crop modeling, soil and plant analytical tools and diagnostic surveillance concepts.

Professional capacity building not just provides people with the skills and expertise to better accomplish tasks and solve problems, but should also enhance the scientific working environment so that individuals can exercise and further improve their capabilities. Over-generalized approaches to soil fertility improvement previously employed by many researchers are not appropriate within the context of ISFM. New methods and ways of conducting research that are more efficient are evolving. Effective implementation of ISFM requires that scientists have in-depth knowledge of their specific research discipline, as well as to broaden their scientific scope in order to be able to integrate the scientific work in other research areas, in social contexts, and to function in non-scientific arenas especially in dealing with other stakeholders such as smallhold farmers. Hence, the need for *T-shaped* skills, a concept that requires a well rooted multidisciplinary horizontal approach based on mutual understanding among scientists from different backgrounds, and a strong vertical range of skills in the area of soil fertility diagnosis and problem-solving.

In an effort to build a critical mass of such expertise in Africa, research networks are strengthened by conducting a series of short-term training courses to enhance these *T-shaped* skills of multi-disciplinary research teams (TSBF 2005). Courses designed for scientists already accomplished in soil fertility management cover topics including, but not limited to, participatory research and scaling-up, gender analysis, decision support systems, grantsmanship, scientific writing and presentation skills, soil conservation, carbon dynamics and sequestration and nutrient monitoring in agro-ecosystems. Other areas worthy of coverage include agro-enterprise development, commodity marketing, data management and statistical analysis. Such courses should target both the young and advanced professionals and participants from both universities and national research institutes in order to foster balanced skills in ISFM and continuity of career development.

ISFM must be better covered within national public universities and put mechanisms in place to review, update and rationalize curricula. For this reason, outside parties are advised to press their agendas upon universities in a manner that is consistent with curricula reform processes and not viewed as obtrusive by academic peers. In most cases, ISFM skills may be reinforced through existing undergraduate courses in crop and soil science. Soil microbiology courses should emphasize decomposition and nutrient mineralization of different quality organic materials, and the role of soil biota in land quality (Chapter 5). Instruction in soil fertility should emphasize the combined benefits of mineral and organic inputs (Chapter 1). Soil chemistry should emphasize the ameliorative influences of inorganic inputs and soil organic matter upon persistent constraints to crop production (Chapter 4). Soil physics should cover practical approaches to water harvesting and their role in enhanced soil productivity (Chapter 7). Crop science must include strategies of rotation and intercropping, including innovations relating to nutrient cycling (Chapter 8). These course updates are largely left to individual instructors and we hope the contents of this book will prove useful to them.

The creation of new courses and degree programs is more complex, usually requiring approval of university administrators and Faculty Senates. The topic of ISFM is well suited as a graduate-level course in Soil and Crop Science Departments and could benefit students pursuing careers in agricultural extension, teaching and research. Faculties that seek to launch such a course should consider the contents of this book as a structure for instruction in ISFM. While

there is perhaps little need for special degree programs in Integrated Soil Fertility Management, clearly all Soil Science graduates should hold a developed understanding of the principles, practices and broader implications of ISFM and apply and advance this knowledge throughout their careers (Norman *et al.* 1994; Woomer and Patel 2000). One needed response by African universities is to establish an endowed chair on ISFM to ensure that this area of expertise is properly established within their institution's instruction, research and outreach activities.

Laboratory rehabilitation. The continent lacks adequate and well-equipped laboratories and staff that can offer precise and affordable soil and plant analysis services for the benefit of farmers. Conventional assessments of soil are somewhat expensive and there are frequently problems with quality control (Okalebo *et al.* 2002). It is important to upgrade at least one soil science laboratory in each country with modern equipment and methods. For example, all laboratories should have access to facilities for remote sensing and other GIS technologies, and new near infrared spectroscopic techniques that allow rapid, reliable and low-cost soil analysis. These laboratories should be inexpensive to equip and run, using mostly non-chemical approaches. Similarly, scientific and technical staff require on-the-job training in new approaches and methods.

The establishment of regional laboratories with more specialized equipment for advanced soil and plant analysis techniques, and resources for advanced GIS and database management could serve as reference laboratories and provide training and backstopping to the national laboratories. This centre is pivotal to upgrading both the physical and human capacity of African soil science. This center could consist of clusters of international and national research institutes and universities that promote integrated approaches. They would have state-of-the-art facilities including laboratories, equipment, databases, virtual libraries, training materials and distance learning built upon complimentary institutional advantages. Linking education and technical training with the research programmes of the centre of excellence will take advantage of the latter's physical facilities and expertise (Box 18.1). This problem-based approach to learning could build on existing networks of national and international research institutes. Internet communication among laboratories will become increasingly important for integrated data systems (Swift and Shepherd 2007). In general, the new soil science will increasingly demand strong skills in scientific method and quantification.

Finally, there is a need to build knowledge and skills in the area of linkages between soil science on one hand, and policy formulation and development strategies on the other. Capacity building efforts need to be targeted to both soil scientists and non-scientists in the wider development community. For example, soil scientists need training to communicate findings to different audiences, and to develop joint learning processes with policy makers, development partners and the private sector. These ideas are presented in greater detail in *An Investment Plan for Building Capacity in Soil Management in Africa* by Swift and Shepherd (2007) (Box 18.1).

Farm organizations as the focus of capacity building in ISFM

An important component of the development strategies of newly-independent African nations during the 1960s and 1970s was the establishment of agricultural cooperatives (Lynam and Blackie 1994). These organizations, designed to promote export of agricultural commodities such as coffee and tea, were directed through parastatal boards that were subject to political pressures and influences that did little to promote the welfare of small-scale farmers (Eicher 1999). The effect of this economic mismanagement was to breed strong distrust of government-controlled cooperatives among small-scale farmers. One condition imposed upon African nations during the 1980s and 1990s was that these monopolistic cooperatives be disbanded or privatized and that their input subsidy programs be discontinued (IFDC 2003; Smaling *et al.* 2006). The basis of these structural adjustments were often rooted in economic theory to

Box 18.1. Essential elements for invigorating educational and research capacities in African soil science (after Swift and Shepherd 2007)

Human Resources

- Identify core curricula for M.Sc. and M.Phil. courses and coordinate places of learning. These curricula should include topics such as knowledge management systems, encompassing a common monitoring and evaluation framework to synthesize results.
- Design Ph.D. fellowship programmes, sandwich programmes and research grant schemes.
- Build in multidisciplinary skills from B.Sc. level upwards.
- Promote post-doctoral fellowships and visiting scientist positions at the regional centres of excellence.
- Identify and support key universities for training in soil and land issues in each sub-region.
- Attach post-doctoral and other young scientists to centres of excellence.
- Provide scholarships with an emphasis on encouraging women soil scientists.
- Provide short courses and attachments to address specific needs, through local opportunities or training at advanced research institutions.

Interaction and communication

- Create platforms that allow scientists to develop research proposals, compare research results, identify general lessons and improve joint implementation of programmes and projects across borders, by using and strengthening existing interactive and mutual-learning networks.
- Include collaborative Ph.D.s with students from the north in project proposals
- Promote south–south and south–north collaboration of scientists through both short- and long-term exchanges.
- Promote regular interactions with policy makers.

Physical resources

- Build up a series of sub-regional laboratories by easing regulations on cross-border soil and plant movements.
- Re-equip laboratories in each sub-region for the new agenda (e.g. diagnosis, experimentation, soil molecular biology).

promote the role of the private sector and small-scale enterprise, but in reality, after the cooperatives were disbanded there was too few investors and entrepreneurs to fill the vacuum and agricultural services, including input supply and marketing. (Jayne *et al.* 2002; Omamo and Farrington 2004). Smallhold farmers felt abandoned by supporting institutions and justifiably so (Eicher 1999)!

Groups of neighboring farmers share common obstacles and opportunities and it is reasonable that they organize for collective action. The community-based organizations that arise commonly devote their efforts to accessing information, learning new technologies and pooling resources to acquire inputs or to market surpluses (Woomer *et al.* 2003). Most farmers, however, lack experience in forming self-help groups, particularly with the steps necessary to formalize and register their new organization. Part of the need for grassroots rural organizations throughout Africa is related to the weakness of formal extension services to the smallhold agricultural sector (Lynam and Blackie 1994). Many years previously, several programs were initiated in maize marketing, fertilizer supply and veterinary medicine but for a complex suite of causes, these services became scattered at best, and virtually non-existent for most (Eicher 1999). An abrupt introduction of market liberalization and structural adjustment imposed upon African nations by

international donors and lending institutions was partly responsible for the removal of subsidies, but equally responsible was the lack of a new approach to equitable service provision that followed these changes in national policies. Yet, even farmers receiving the best extension services often find it in their common interest to form local organizations aimed at improving their individual farms and communities (Terrent and Poerbo 1986). Good farming involves intuition and skill but seldom close-held secrets. Indeed, the willingness of farmers to assist one another is a comforting feature of rural life.

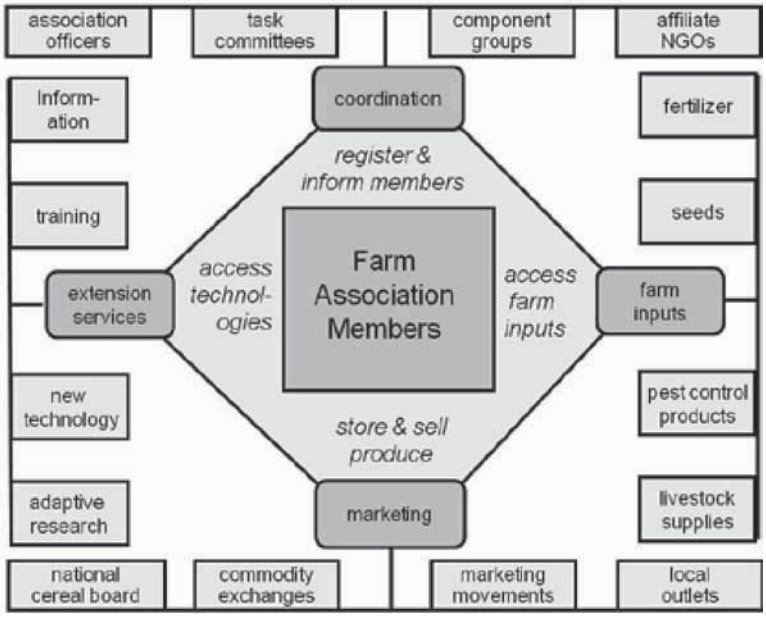


Figure 18.1. A conceptual model of empowering farmer association that offers information and extension services provides opportunity for bulk purchase of key farm inputs and is linked to top-end produce markets.

Organizing for collective action may be timely, but it also takes time. A large number of farmer self-help groups are emerging in Africa (Woomer *et al.* 2003), primarily to better access information and learn low-cost technologies. More recently, these grassroots organizations are consolidating into wider umbrella organizations in order to broaden the scope of their services. Stringfellow *et al.* (1997) recognize this kind of development as positive, but caution donors and development organizations from overburdening these newly-formed organizations with too complex or too many tasks. At the same time, the members of these new farmer associations are expecting services in return for the time and dues spent on them (Figure 18.1). Farmers that have joined these agricultural movements expect better access to and more reliable information, strengthened capacities for adaptive research, particularly in the areas of soil fertility management, pest and disease control, better access to, and lower costs for key agricultural inputs, particularly improved seed and fertilizers and improved access to higher-end buyers to market their crop surpluses. Furthermore, these four arms of empowering farmer associations (Figure 18.1) are not independent of one another, but rather represent an orderly progression in first, understanding and mobilizing land management technologies, and then using them to raise farm productivity beyond smallhold subsistence. Farmers and their organizations must not be viewed as passive targets for ISFM messages but rather as willing partners in their refinement. All capacity building actions must take into account the provision of broader services, particularly farmers' improved access to technologies, farm inputs and commodity markets, and their expectations of improved living standards as these are the reasons farm organizations are formed in the first place.

Integrating capacities in ISFM

Capacity building in ISFM involves more than educating or re-educating individual stakeholder groups but it also implies a re-orientation of conventional approaches to soil fertility management, the development of new sets of skills and the re-tooling of soil laboratories. In short, ISFM requires interdisciplinary thinking that encompasses a range of stakeholders. ISFM planners must consider development projects that cover multiple scales from fields through

farms, communities and watersheds to nations and regional bodies. In this way, capacity building begins with farm households and extends to rural development specialists and policymakers that are presumably working on behalf of the agricultural community. Policymakers require general knowledge and recent information on soil management as well, and this topic is considered in the Chapter 19.

New approaches to soil fertility management do not require that different actors become experts in all fields; rather, they must become better prepared to participate within interdisciplinary settings and to constructively interact with experts from other fields. This situation is particularly true for soil scientists that, despite skills in scientific and field approaches leading to important findings, too often find it difficult to explain their discoveries to others or translate knowledge into practical collective action. ISFM involves more than a suite of land management principles and their accompanying technologies, but also the knowledge of how to apply these and the larger environmental and social issues related to better land stewardship. Soil nutrient depletion resulting from continuous cultivation by smallholders presents a huge challenge to African agriculture and regional food security (Smaling *et al.* 1997) and capacity building in ISFM must reinforce the broader importance of responsible land management. The same may be said for watershed protection and greenhouse gas mitigation. Civic accountability and ethics also have an important role in capacity building. Leaders within the rural community must set positive examples for others by adopting and promoting needed technologies and new enterprises even though their livelihood may not be as at risk as less affluent households. Officials of farm organizations must be transparent in their relations with co-operators and members alike, and agro-dealers must not mislead customers in their pursuit of greater profits. ISFM empowers farming households to wiser decisions concerning crop enterprise and resource management on a daily basis and this more holistic view of ISFM must also be portrayed in capacity building as well.

Chapter 19. ISFM in the policy arena

A major factor that limits widespread adoption of ISFM is lack of innovative and bold policies addressing necessary facets for its promotion. Government policy should ensure that farm input manufacturers and suppliers, farmers, commodity buyers and processors, and development agents form strategic alliances and work together in mutually beneficial manner. The capacities of different actors must be strengthened for effective participation and contribution in public meetings geared at making informed input into ISFM policy formulation. All issues that constrain smallhold farmers' access to farm inputs and commodity markets such as unstable prices, high cost of transport, lack of standard measures, irregular quality control, and development of effective producer organizations for increased bargaining power must be addressed. Other issues that bear on adoption and retention of ISFM such as subsidies, credit and loans, and effective workable contract laws are also important to mainstreaming ISFM.

Very little progress has been made on elevating the importance of soil fertility issues. For instance, national soil fertility strategies have been developed in a few sub-Sahara African countries but with strong external influence and much focus on the role that mineral fertilizer could play. In fact, such strategies have been drafted in countries such as Burkina Faso. However, due to lack of public funds, the national assembly of most countries has not approved most of such strategies. High level lobbying of key stakeholders (including national governments and donors), championed by technocrats in the area of agricultural resource management and related disciplines, is necessary to move these drafts to the next level. Although it has taken long, policymakers are finally acknowledging the potential roles of organic resources and ISFM. New fertilizer strategies, where the science of ISFM plays a critical role, are being designed following the African Heads of State and Government Fertilizer Summit held in Abuja, Nigeria in June 2006 (Africa Fertilizer Summit 2006).

Reliance on traditional agricultural extension approaches and subsequent farmer-to-farmer diffusion is successful in dissemination and uptake of technologies when the technologies are less knowledge intensive and do not require overly complex adaptation to local farming conditions (Giller 2002; Vanlauwe *et al.* 2006; Woomer *et al.* 1999). Successful promotion and adoption of legume-cereal rotations required little more than new grain legume varieties becoming available and the distribution of accompanying agricultural extension messages (Mpepereki *et al.* 2000; Sanginga *et al.* 2003). Because of the complexity of ISFM technologies in other settings, however, there is need to support its wider understanding and adoption through specialized agricultural extension policies. Such specialized policy-led agricultural extension programs such as the Starter Pack and subsequent Targeted Input Program in Malawi resulted to a large payoff even in the face of a huge implementation cost (Blackie and Mann 2005; Denning *et al.* 2009). Insights gained with the Starter Pack program show that targeting inputs provides a vehicle for rapidly and widely disseminating technologies that permitted farmers to access fertilizer and other farm inputs (Levy and Barahona 2001). For simple farm technologies such as fertilizer and seeds, market-led extension approaches remain the most effective approach to agricultural development, especially in places where land managers are readily able to access and afford the required farm inputs, but for more complex technologies or difficult developmental settings, additional carefully formulated enabling policies are required.

ISFM policy realms

For effective and efficient ISFM policy formulation and implementation, it is important to structure the existing policies in terms of their target, compliance, enforcement and impact. Given the current level of knowledge, ISFM-related policies could be classified into five groups.

Beneficial policies or by-laws reinforcing ISFM that are not being followed or enforced. An example is the prohibition of the burning of crop residues in Kenya. This similarly applies to conservation polices or by-laws which are meant to enhance environmental protection. A review of policy and by-laws relating to land management and conservation in Africa indicate that many measures were potentially useful but were ineffectively implemented because responsible institutions were weak or poorly organized (Eicher 1999). In order to enjoy the benefits from sound ISFM such policies must be enforced.

Policies which are inimical to widespread adoption of ISFM technologies. This situation when policies create unnecessary obstacles between technology providers and their intended beneficiaries. Prohibition of fertilizer and seed repackaging as a means of protecting consumers exists in many countries but these regulations in effect prevent local input suppliers from marketing materials in the smaller quantities demanded by their clients. Such ISFM policies must be revised or repealed. Other examples include prohibition of intercropping in Rwanda that prevents farmers from deriving the numerous benefits of multiple cropping, and the prohibition of the selling of maize outside of specified administrative areas in Malawi which deprives farmers' access to higher prices elsewhere.

Policies that offer incentives to the intended beneficiaries. Such policies often favor input-output market linkages and increased returns to ISFM practices and must be retained, nurtured, and further promoted for widespread and increased impact. Examples include policies that secure property rights, enable farmers to hold service providers more accountable, enhance training and capacity building at all levels, and measures that strengthen farmers' bargaining power in otherwise one-sided farmer-industry relationships. Policies towards sustainable land use intensification and the necessary institutions and mechanisms to implement and evaluate its benefits also facilitate the uptake of ISFM. Other interventions include policies related to importation of fertilizer and agro-minerals, blending and packaging of fertilizer, or smart fertilizer subsidies needed to provide timely access to sufficient fertilizer at reasonable prices (Denning *et al.* 2009; Sanchez 2009). Specific policies addressing the rehabilitation of degraded, non-responsive soils may also be required since investments to achieve this may be too large to be supported by individual farm households alone (Buresh *et al.* 1997).

Policies with positive and negative impact on ISFM depending upon how they are interpreted or implemented. Policy change following the Structural Adjustment Programs of the 1980s and 1990s heavily and non-selectively reduced government agricultural support. Other examples include policies requiring excessive information on seed and fertilizer packages and measures that impede the right to form farmer associations. Although, prohibition of repacking of inputs helps check adulteration, it reduces widespread access to inputs, especially where farm input manufacturers and distributors are not keen on producing the smaller packages affordable to poorer farmers (Blackie and Albright 2005; Woomer *et al.* 1997). In addition, farmers' right to form grassroots and larger associations is necessary to achieving larger rural development goals (Chirwa *et al.* 2005; Stringfellow *et al.* 1997) but including any but token registration fees poses an unnecessary constraint to grassroots membership, especially among the poorest households that stand to benefit most from participation (Woomer *et al.* 2003). Policies that support the traditional rights to free grazing in situations where establishment of land tenure and increasing land use intensification support adoption of ISFM are also counterproductive.

Policy vacuums that impede ISFM. One example is the lack of tenure security in Ethiopia, Tanzania and many other sub-Saharan African countries, a situation that had strongly discouraged tree planting that in turn results in widespread use of livestock manure and even crop root residues as cooking fuel rather than soil inputs. Similarly, the lack of investment in

information and knowledge systems, particularly support for national agricultural extension service, inhibits the training in knowledge intensive ISFM technologies. Added to this is the fact that national soil fertility maintenance strategies exist in only few countries in sub-Saharan Africa. However, it is important to note that in many sub-Saharan African countries, property rights are not constraining. For instance, despite policies that are mixed in terms of property rights, farmers in Nigeria continue to make long-term investments in agroforestry technologies (Adesina and Chianu 2002). Another clear case of a policy vacuum is the continuing land fragmentation even to uneconomic levels due to inheritance and continuous land subdivision from generation to generation. The problem of this lack of policy for land consolidation is compounded by-laws that prevent landowners from selling or consolidating their land holding without permission from government authorities.

Economic incentives for ISFM

Economic incentives are important for widespread adoption of ISFM technologies and policies are critical for creating and backstopping those economic incentives. Conversely, inadequate agricultural policies and lack of economic incentives such as poor farm produce prices, lack of crop and livestock insurance, poor transportation and communication infrastructure and failure in promoting agricultural exports hamper investment in soil fertility maintenance that in turn reduces land productivity. In China, improved rural roads network was a stimulus for agricultural technologies. Too often, markets for mineral fertilizers are weak including credit mechanisms for timely purchase and application of farm inputs. Government investment in large-scale conservation or irrigation projects also reduce the social returns to ISFM.

Many smallhold farmers have limited ability to enter markets because they operate in remote areas. Effective policymaking for promoting ISFM technologies depends upon agricultural transformation that permits these farmers fuller access to farm input supply markets as customers and commodity markets as producers. Active farmer associations must become established and provide members with essential services (see Chapter 18). Policy-oriented market research and knowledge systems for ISFM involve identification of strategies that improve incentives to invest in emerging market enterprises by literally millions of poor farm households throughout sub-Saharan Africa. Policy and regulations are critical for viable farmer input-output market linkages and enhanced returns to ISFM. Market linkages support ISFM because it is practiced more where farmers have access to farm inputs, credit facilities, storage facilities, and fair produce markets.

Translating ISFM into impacts require effective policies and regulations concerning credit, subsidy and input-output market development, as well as establishing stakeholder dialogue, communications, and even lobbying. For instance, smart subsidies can greatly stimulate farmer investment in the use of mineral fertilizers and improved cereal seed, which in turn results in food surpluses where in the past food security was tenuous (Denning 2009). Although market-led agricultural extension is not yet widely practiced in Africa, it has the advantage of linking input supplies to financial markets and commodity buyers in a way that can provide smallhold farmers with incentives to further invest in ISFM.

Another area requiring attention is the regulation of farm input packaging and repackaging with strong penalties to ensure quality and prevent adulteration. Concerns over seed quality and type can inhibit its sales. Such problems require an infusion of trust into the market, which could be done through farmers' associations. For an association, there is initial need to help them get off the ground through marketing their services. At community scale, there can be need to train on how to collect, store, package and test.

Outgrower schemes are an important means of achieving linkages between farm inputs and guaranteed commodity markets. Many of the schemes supply fertilizer, seeds and other inputs to

farmers on credit in return for signed contracts agreeing to produce and deliver a certain commodity. These have been found to work very well in Africa for higher-value products, particularly export crops such as tea, coffee, vegetables, fruits and cotton. It has not been found, however, to perform well among producers of staple crops due in part to their lower values and also because of the large number of buyers and sellers involved. Credit schemes are very rare for smallholder agriculture outside of these outgrower schemes. Appropriate policy formulation, therefore, needs to be carried out to direct greater investment toward the producers of staple crops in Africa.

Support services and platforms for ISFM

In much of Africa, agricultural support services such as government agricultural extension systems are weak. Much of the innovation in agricultural extension has been performed by NGOs with small and less trained staff. Little progress has been made on technical support and grain legume seed systems. For instance, farmer field schools have been spreading slowly. Agricultural research institutions are poorly funded. One of the immediate results with direct relevance to ISFM is the systematic reduction of soil science capacity throughout Africa. Policies are critically required to reverse these ugly and agricultural productivity-threatening trends.

There are however opportunities to influence national-level and regional level policies in many SSA countries, taking advantage of current reforms and political engagement related to the Abuja Declaration and other agricultural development initiatives such as those of the World Bank, the International Fund for Agricultural Development (IFAD), and the African Development Bank (AfDB). Advantage should also be taken of the current reforms and political engagement to strengthen and promote policies that favor input-output linkages for enhanced returns to investment in ISFM. Examples of such good policies should include those that address the problems of access to appropriate farm inputs necessary for farmer adoption and retention of ISFM practices, enhance ISFM-related knowledge creation and information dissemination, and create tax incentives for increased and widespread adoption of ISFM practices. Further, policy support is required for agro-dealers, micro-finance agencies, and other actors in the private sector for ISFM-related input-output services, farmers' associations for effective ISFM input-output service provision to members and rural value adding enterprises that increase farmers' net returns and prolong the shelf-life of agricultural produce. Policies that ensure long-term adoption of the best practices of ISFM by smallhold farmers could counteract the massive negative nutrient balance that is commonly observed in SSA (Smaling *et al.* 1997). Platforms to facilitate related ISFM policy interactions at national and regional levels must be established. Need exist to harmonize relevant ISFM-enhancing sub-regional, regional, and continental policies and regulations. Some of these could involve the removal of cross boundary barriers. Alternative mechanisms for viable research-to-policy platforms must identified.

Key elements of ISFM policies

Important policy elements include accountability, implementation plans, institutional support and participatory community-based extension. Others considerations are involvement of agro-input dealers' network, integration of ISFM into development agendas and capacity building, seed and fertilizer strategies, and complementary investments. These should lead to the formulation of sustainable and effective ISFM policies.

Accountability entails the development of ISFM policies whose mechanisms build in answerability to target beneficiaries. The implementation plans for the stated ISFM policies must be clearly indicated. Some of the past soil fertility management initiatives failed due to lack of adequate policy and institutional support. The absence of policy support at national and regional

levels has been a critical missing element that forestalled the achievement of the impact of ISFM technologies at scale in the past. Lack of funds also contributed immensely to the problem.

Although policy support is critical for widespread and accelerated adoption of ISFM, most of the existing agricultural development policies in SSA were not fashioned with 'complete ISFM' promotion in mind (see Chapter 1). While some of the existing policies support and enable components of ISFM, others are completely inimical to widespread ISFM adoption. Basic up-scaling of good ISFM practices requires effective policy and institutional support, especially given the devastating effect of the structural adjustment program of the 1980s and early 1990s that dealt a blow to the formal agricultural extension programs of most Ministries of Agriculture in Africa. The associated job cuts and downsizing disproportionately affected the Ministry of Agriculture in most countries.

Innovative agricultural extension. There are examples of policy-led extension such as the Starter Pack and Targeted Input Program in Malawi. Although, massive funds were used in the dissemination of this intervention, the result was very encouraging. However, repeated failure of conventional approaches to technology dissemination elsewhere has led to experimentation with more participatory methods. There is now a large body of literature that indicates that farmer participatory research is vital for re-orienting smallholder farming systems (Johnson *et al.* 2003; Pound *et al.* 2003). One community-based agricultural extension program is the Farmer Field School (FFS) approach. While FFS appear to have reduced effect upon persistent transmission of knowledge among farmers (Tripp *et al.* 2005), however, FFS networks in Africa demonstrate a trend towards organizing for market engagement. There are contradictory findings on whether FFS is a cost-effective approach to technology dissemination and adoption (Feder *et al.* 2004). Many other approaches exist and are being tested by various research institutions, especially given the involvement of a diversity of NGOs (see Chapter 13). Generally, there are only slight differences in their approach to technology dissemination, awareness creation and target client training. Stronger aspects of FFS must be capitalized upon with new elements added to address their shortcomings.

Integrating ISFM into development agendas and capacity building. Strategies are required that effectively integrate ISFM into national and regional fertilizer promotion, agricultural development and poverty reduction efforts. This intervention option would establish mechanisms for capacity building, institutional learning, policy dialogue and advocacy at different levels to bring about policy and institutional reforms favoring all stakeholders, especially the rural poor. It is important to review national agricultural development strategies to identify gaps in policy that will favor the adoption of ISFM, then suggest alternative policies addressing above gaps and finally build capacity of all, including institutions, involved in policy making for informed agricultural development. The poverty reduction strategy of Rwanda incorporate soil fertility improvement issues. Most African other countries lack policy instrument. Increased efforts must be directed towards integrating ISFM into major agricultural development initiatives and sustainable land management programs in SSA (e.g., Comprehensive Africa Agriculture Development Programme of the New Partnership for African Development – CAADP-NEPAD,) and in the development agendas of international NGOs. Through the New Partnership for Africa's Development (NEPAD), CAADP addresses policy and capacity issues across the entire agricultural sector and African continent, is entirely African-led and represents its leaders' collective vision for agriculture in Africa. Overall, CAADP's goal is to eliminate hunger and reduce poverty through agriculture. To do this, African governments have agreed to increase public investment in agriculture by a minimum of 10 percent of their national budgets and to raise annual agricultural productivity by at least 6 percent by 2015.

Seed and fertilizer strategies for ISFM. Effective seed systems (especially for grain legumes) are critical for accelerated and widespread adoption of ISFM. Strategies must be developed for it, especially given the limited interest of the commercial seed sector in grain legumes. There is a strong need to pay due policy attention to all these components to incrementally attain the benefits of 'complete ISFM' (see Chapter 1). In particular, there is the need to facilitate and promote seed associations and community seed production.

Complementary investments. Strategies should be developed to effectively link and coordinate input-output markets related to ISFM. The lack of coordination in input-output markets means that programs focusing on either input or output marketing alone often fail as a result of the absence of complementary investments in related aspects of the supply chain. Coordination of the supply chain contributed to the success of the soybean-maize rotation ISFM in Nigeria, Zimbabwe, and Kenya, to mention a few African countries.

One of the key challenges that constrain the adoption of even proven technologies in SSA is the lack of platforms linking actors along the research-development-policy continuum. This poses challenge that faces both policymakers and private sector ISFM stakeholders. Also the links of improved soil fertility to environmental services need to properly permeate policy and development programs, and to reach out toward emerging issues such as developments in carbon markets intending to ameliorate global climate change.

Chapter 20. Marketing support for ISFM

The adoption, retention and sustainable impacts of ISFM depend upon the extent to which it is profitable and fits into farming systems. Strengthening and increasing market opportunities for small-scale farmers and linking input-output markets constitutes one of the potential routes out of poverty in SSA and provides great opportunities for smallhold farmers and other interests along the production-to-consumption chain. In this way, it has the potential to reduce the risk of leaving small-scale African farmers behind as occurred with the earlier Green Revolution (Okigbo 1990; Hazell 2005). Linkages that allow farmers to simultaneously and reliably access a range of resources, services, and commodity buyers are critical if they are to survive in an increasingly competitive agricultural food market (Poulton *et al.* 2005).

Much needs to be done to stimulate the profitable adoption of farm inputs, particularly among resource-poor farmers (Crawford *et al.* 2003) and calls for policy on linking input-output markets. Place *et al.* (2003) note that there is no direct evidence of the effect of the use of ISFM on markets for fertilizer and seed. Their analysis of indirect evidence, however, suggests that this link is potentially important. Although seeking to raise yields and outputs in small-farm agriculture is valid in contemporary poverty reduction strategies in SSA (Ellis 2005), this strategy is unlikely to be sustainable if input and output markets are not linked, creating difficulties for farmers who may not be able to sell their produce surpluses. This shows how raising yields and outputs cannot single-handedly provide the engine for poverty reduction in SSA (Ellis 2005). Improved supply of farm inputs and reliable produce marketing help create well functioning marketing services that stimulate production through better crop and soil management (Lerman 2001).

Access to market, technology adoption and poverty reduction

Success in transforming African agriculture must address the challenges faced by millions of smallhold farmers. This is particularly important if the strategy of introducing ISFM technologies is to lead to better farm income and improved wellbeing for rural households. Wider uptake of improved agricultural technologies is often inhibited by lack of the necessary pre-conditions for surplus production and sales.

Sustaining success in agricultural growth and adoption of ISFM technologies presented throughout this book critically depends on expansion of farm input, financial and produce markets (Reardon *et al.* 1997; Diao and Hazell 2004; Bingen *et al.* 2003). The level of farmers' market orientation underlies their willingness and ability to pay for farm services (Omore *et al.* 1997). Better access to profitable markets leads to crop intensification, investments in natural resources management, and adoption of improved agricultural technologies (Tiffen *et al.* 1994). However, it has been difficult to reach agreement on what should be done to improve the performance of agricultural markets in SSA (Poulton *et al.* 2006). Efforts must be made to increase the attractiveness of agricultural commercialization and make it beneficial to all involved, especially small-scale farmers. One major bottleneck in current marketing approaches is the compartmentalization and lack of coordination of input and output market promotion and the tendency to market farm inputs in quantities most farmers cannot readily afford. The types of coordination needed are vertical coordination to address problems of specific assets, risks, thin markets, product quality and timing, and missing credit markets; horizontal coordination that addresses problems of public goods such as research and extension, credit, grading, and staff development; and complementary coordination to address problems of service delivery and access in least developed settings (Figure 20.1).

Alternative marketing arrangements

Examples of alternative input-output marketing arrangements include contract farming, out-grower schemes, farmer cooperatives and associations, agro-dealer networks, and commodity exchange platforms. These mechanisms have a potential role to play in improving and driving market development in SSA and have done so in the past with varying degrees of success (Dorward *et al.* 1998). Under some contract farming arrangements, agribusiness firms provide farmers with inputs, extension advice, and commodity marketing services in exchange for commitment to supply their produce at an agreed upon price (Stockbridge *et al.* 2003). Limited market information systems and lack of effective linkage between input-output markets have attenuated the usefulness of the alternative marketing arrangements. For example, agribusinesses usually have better information and marketing strength compared to smallhold farmers and this advantage may carry over to contract negotiations.

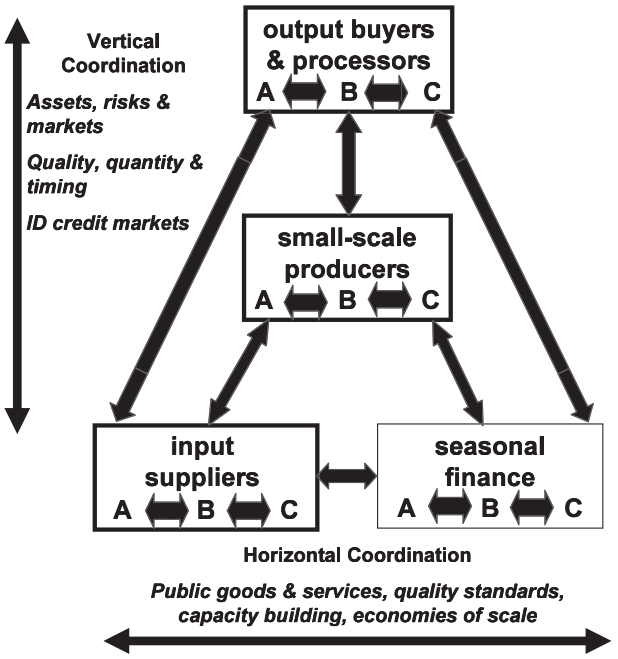


Figure 20.1. Vertical and horizontal coordination needed to address marketing bottlenecks.

More efficient commercialization and marketing of farm inputs are often emphasized within rural development initiatives in sub-Saharan Africa (TSBF 2009). Several development organizations and their donors now recognize that technical advances in soil fertility management are realized at the farm and community levels through the availability of products marketed by agro-dealers (CNFA 2002). Important questions concerning the accessibility of markets for surplus crop production resulting from greater use of farm inputs are now being considered within the context of farm technology dissemination strategies. Benefits of marketing initiatives must extend beyond the agro-dealers themselves and their resource-endowed clients, and specific activities designed to include poorer households. In some cases, the poorest rural communities face huge barriers to market participation that include lack of market information, inadequate transportation, insufficient bargaining power and credit facilities, and non-existent or weak farmer organizations. Thus, factors not directly related to land management practice still result in restricted dissemination of ISFM. However, the marketing interventions offered by these development agents may be seen as a transient phase during which expansion of rural trader capacity can lead to more competition among buyers and emergence of a more responsive service sector. The value of crop response to input use increases only when converted to cash income through marketing, and when such investment provides higher returns to farmers.

Bottlenecks to market development

Compartmentalization and lack of coordination between farm input and produce markets are among the major bottlenecks in SSA. In the past, programs focusing on either farm inputs or commodity marketing alone often failed due to lack of complementary investments in the other. Some programs designed to promote farm inputs but not commodity markets have proven successful from the standpoint of increasing farm production including the activities of CNFA (2002), IFDC (2002), Agricultural Market Development Trust (AGMARK), Sasakawa-Global

2000, and the Farm Inputs Promotion Services (Blackie and Albright 2005). At the same time, there are also examples of fertilizer and seed promotion that led to productivity growth but depressed local output prices (Crawford *et al.* 2003), demonstrating how market failures can counteract benefits of productivity growth and discourage investments. The experience of Sasakawa-Global 2000 in Ethiopia that promoted fertilizer use on maize production with little or no attention to output markets is one of the failures of compartmentalized approaches because input use resulted in depressed output prices (Crawford *et al.* 2003). There are indications that the current situation of good maize harvests resulting from fertilizer subsidies in Malawi described by Denning *et al.* (2009) may in fact lead to falling prices, leaving farmers stranded as government prohibits the sale of maize outside the country and is not prepared to purchase it or offer price guarantees. ISFM promotion must emphasize the need for both farm input supply and commodity markets as included in the approaches pioneered within the Millenium Villages (Sanchez *et al.* 2007). As a result of these experiences, several other initiatives across SSA are now seeking to simultaneously link farmers to both farm input technologies and produce markets.

Organizations focusing on output markets such as the Sustainable Agriculture Center for Research, Extension and Development in Africa (SACRED-Africa), Farmers' Own Trading Limited (FOTL) and Techno Serve did not address input markets, a situation that leads to low returns to land and labor and discouraging farmers from further production (Mukhwana 2000). Others explore both input and output markets as international consultants, however their terms of reference often lack the level of coordination required for comprehensive and well coordinated market development.

Compartmentalization leads to low access to inputs, limited access to output markets, market failures (Ellis 2005) and constitutes uneconomic and unsustainable approach to balanced market promotion in SSA. Under compartmentalized marketing, feedback on effects of ISFM by farmers and its effect on their livelihoods is not considered. Broader approaches identify cost-effective ways of increasing access to inputs, improve input delivery, and link farmers to output market to earn income to pay for inputs and attend to other household needs. Integrated rather than compartmentalized input-output marketing is needed to effectively deal with more demanding marketing chains. The advantage for smallholders to produce crop surpluses can only be realized once traders move into rural areas to purchase commodities from growing rural markets, yet this market linkage is slow to develop, in large part because of massive food importation. Nonetheless, optimism is growing towards potential African staple food markets (Hazell 2005).

It is also crucial to identify and remove factors that have perpetuated compartmentalization and reach a situation where farm input use and produce sales become parts of a chain, raising productivity and income, protecting the land, and distributing safer, more nutritious food. In few instances, this is presently happening at farmers' organization level where marketing services are provided to members (Stockbridge *et al.* 2003). Nonetheless, lack of empowerment of smallholders on how to effectively tackle output marketing in the face of limited infrastructure accounts for limited success in this direction. Too often, donors also place unbalanced emphasis on input market development. The production-oriented bias of Africa's Poverty Reduction Strategy Papers (Ellis 2005) seems to give credence to compartmentalization by paying more attention to farm inputs, rather than outputs.

Case Study: The rise and fall of Western Kenya's Maize Marketing Movement

The Maize Marketing Movement (MMM) was initiated in September 2002 to design and test a prototype system for storage, bulking and marketing of maize by poor farmers in western Kenya, thereby improving their market access and incomes (Woomer 2002). Its approach was modeled upon the experiences in West African cereal banking (Graham 1991; von Davidson and Loy 2001). The general approach undertaken by the lead NGO, SACRED-Africa, was to invite farmers surrounding five trading centers to participate in cereal banking and to assist interested

parties in formalizing these groups (Mukhwana 2000). Each local cereal bank was required to register its members, elect officials and establish a bank account. The lead NGO provided on-site training to 333 MMM members in post-harvest handling, storage pests and quality control. The NGO also provided specialized training to the 15 elected officials from the five branches in civics, bookkeeping, sales, and marketing. Each marketing branch next established a maize storage and market information center, installed maize processing equipment and received a loan enabling them to begin trading maize.

The lead NGO also established the MMM Central Cereal Bank near its headquarters in Bungoma town. This facility included a grain quality laboratory that provided services to the local marketing branches and a 250 t storage facility located along the railway to Nairobi. The larger grain borer (*Dinoderus truncbatus*) had recently invaded Western Kenya and protocols were established that allowed for its control through chemical dusting. Later, NGO staff became certified as phosphene fumigators to more-effectively control borer outbreaks within storage facilities. Project staff also developed guidelines and distributed tools that allow for maize to comply with national standards for moisture content (<13.5%), diseased (<3%), insect damaged (<3%) broken (2%) and off-color (1%) grains, and foreign matter (<1%). Once quality control standards among the MMM members were assured, the project started to bulk and trade maize within 10 months after initiation of the project.

Over the next 14 months (October 2003 to December 2004), the MMM sold over 560 t of top-grade maize for $108,000 and held an additional 67 tons of bagged maize in reserve. Unga Millers, Kenya's largest processor of maize meal, accounted for the majority of these sales, purchasing 393 t of maize in three shipments (Figure 20.2). This marketing strategy generated an additional $17,400 compared to marketing through the nearby National Cereal Producers Board, and an extra $41,400 than had these farmers sold at the farm gate to local assemblers. Maize was also directly marketed to members of the public during the hunger season and to local schools and other institutions (127 tons), greatly improving community food security. The MMM developed a reputation among buyers as suppliers of premium quality maize and demonstrated its credibility to its members and their neighbors. In many cases, the movement brought newfound vitality to its trading centers and collection points by providing marketing opportunities and part-

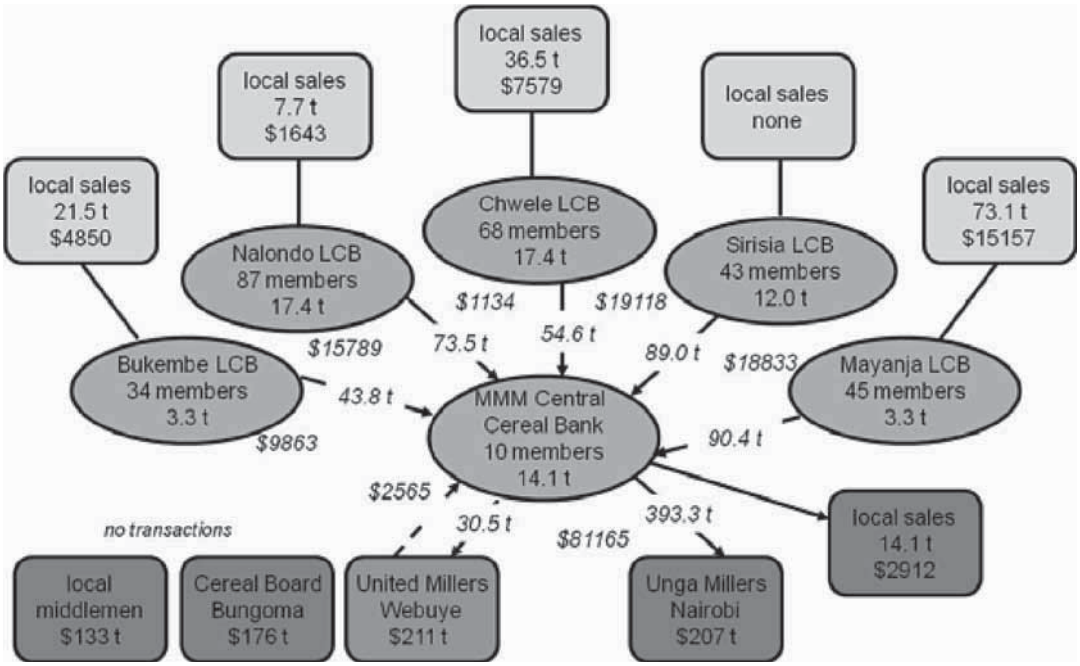


Figure 20.2. Maize trading by the Maize Marketing Movement and its component cereal banks between October 2003 and September 2004.

time employment to many households.

MMM suddenly became a donor's success story. Hosting delegations from several development organizations became almost a routine. Kenyan government officials recognized the project and sought to establish local cereal banks in their constituencies. Based upon these early successes, an expansion of the MMM was launched that brought operations to three nearby administrative districts creating 20 additional local cereal banks. Buoyed by their success, SACRED-Africa moved its headquarters 420 km away to Nairobi for greater donor exposure. Unfortunately, early signs that the MMM was being prematurely sensationalized were ignored including few follow up maize deposits by members, economic losses reported by local cereal banks due to inexperience and excessive costs, poor documentation of local sales, reduced quality monitoring, no further improvement in processing tools and a decline in cereal bank membership.

Project managers had become over-confident and distracted from their work plans, too involved with outside training and consultancies and locked into quasi-profitable maize trading ventures rather than exploring innovative marketing opportunities as originally intended. These distractions resulted in no large collective sales following the next season that in turn led to excessive ad hoc trading by local cereal banks and accompanying irregularities in financial control. Misdirected revenues by local bank officers resulted in net losses and inability to repay project loans. A FAO-World Bank team conducted an unscheduled visit in May 2005 that led to an unfavorable project evaluation. In response to declining project performance, skilled staff members grew demoralized and resigned without attempting to diagnose underlying causes of shortcomings, resulting in additional, uncompleted project milestones including needed improvement of grain processing tools and the production of a training video and booklet. Based upon these weaknesses, the donor withdrew its planned support for the expanded project.

The MMM was originally intended to serve as an exploratory pilot project yet it was later unfairly discredited as a non-viable business venture. Plans were made by members to continue the cereal banks without donor support, placing local banks under greater supervision, imposing additional service fees to cover expenses and halting trading in non-member grain. Unfortunately, premature withdrawal of donor support caused the faltering cereal banks to collapse over the next few growing seasons. Nonetheless, several valuable lessons emerged from this courageous collective marketing effort.

Smallholds were not too small to be economically viable as maize and legume producers. Indeed, participating smallholders were quickly organized for collective action after receiving basic training in cereal processing and being provided a convenient collection point to deposit their crop surpluses. In the moderate to higher potential agricultural zones of Kenya, household food security may be achieved by employing ISFM technologies on relatively small land areas that better position small-scale farmers to produce crop surpluses. Take for example, the adoption of staggered ISFM maize-legume intercropping (Woomer 2007). A family of eight requires approximately 1000 kg of grain per year. Given current maize-bean intercrop yields in absence of inputs, this yield is achieved by intercropping on 0.38 ha twice per year (Figure 20.3). Through ISFM in a bimodal precipitation regime, food security is achieved through double cropping 0.14 ha, requiring only $9.10 of additional investment in fertilizer and improved seeds. Viewed in another way, intercrop yields may be increased by 1500 kg ha^{-1}, worth $222 when improved intercropping is employed on the 0.38 ha previously required to meet household needs for an additional cost of only $26.

Smallholders produced grain that met the quality standards of top-end buyers (see table 14.1). Many smallholders are currently unaware of established quality control standards and how o avoid jeopardizing that quality during grain processing. This situation is another reflection upon poor market intelligence by farmers who, in the past relied upon government bodies to test and either accept or reject their maize through, what was to them, a rather cryptic process. The experience of the MMM indicates that grain quality immediately improves after farmers are

introduced to the concept of quality control protection through on-site training, and later provided with basic processing tools through their local cereal banks (Mukhwana 2000). Furthermore, the grain offered for sale by these cereal banks not only met industry standards, but was a recognizably superior product preferred by buyers. This is because smallholders who rely upon hand shelling and sorting are better able to differentiate grain quality during processing than when it is machine-harvested and shelled.

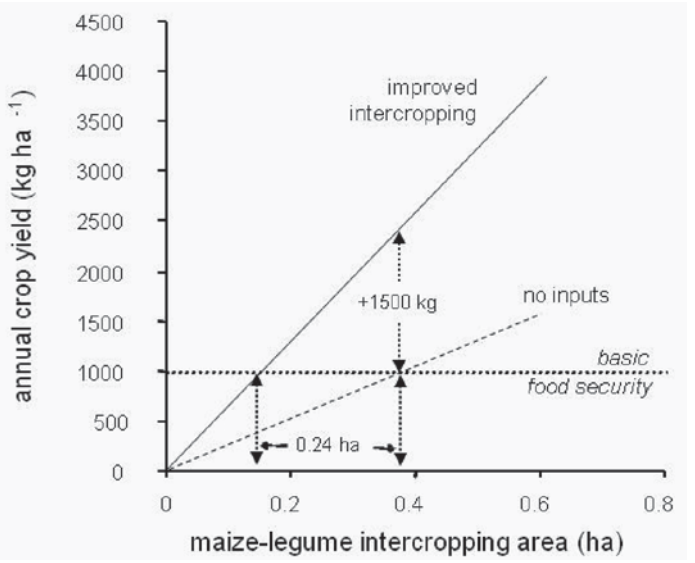


Figure 20.3. Household and economic advantages of adopting staggered maize-legume intercropping in west Kenya.

Given the nascent nature of farmer institutions, there is need to have intermediary institutions that can assist them in registration, negotiations, contract enforcement, quality improvement and local transportation. Such services cannot be provided through non-profit development agencies indefinitely, but rather these services should become privatized as income and employment generating activities. Ultimately, it is important that cereal bank coordination be recognized as a legitimate business opportunity by commercial lending institutions. Reliance on one profitable market, particularly millers in distant urban areas, is risky for farmers. To reduce these risks, cereal banks must also expand into other markets, particularly smaller-scale processors and local institutions such as schools and hospitals. Sound storage practices allow the local cereal banks to wait out the low prices following peak harvest in order to obtain a larger profit from their grain. Revolving credit and partial payment for deposited grain are important features within cereal banking because it provides access to capital at the farm level, allowing immediate payment to poorer farmers, thus providing additional incentive to participate. Conversely, members must be allowed to withdraw deposited grain whenever it is needed within their household. Looking ahead, this sort of collective marketing can also accelerate the uptake of improved production technologies among its members and offer modest, low-interest loans that allow them to purchase these inputs.

Marketing small fertilizer packages and creating awareness on input use

Repackaging farm inputs into smaller quantities is an important marketing mechanism worthy of a more detailed description. Within the strategy, farm inputs become more accessible and affordable to farmers, encouraging them to test new products without committing too much of their limited income toward farm experimentation. It is based on the principle that even the poorest households can afford simple necessities such as soap or salt, mainly because they are packaged and sold in small sizes by local shops. In late 1990s, the Sustainable Community Development Program (SCODP) in west Kenya adopted the strategy that fertilizers are one such commodity and combined the sales of small packages with widespread awareness creation and skill development in the use of mineral fertilizers and improved seed varieties. By repackaging farm inputs into smaller sizes (e.g. 100 g to 1 kg), they discovered the price at which even the poorest farmers were willing to invest in needed farm technologies. While SCODP purchased commercially available fertilizers in the standard 50 kg bags and repackaged and sold them for no

profit (Seward and Okello 1999), other stockists were inspired to do the same but for commercial gain (Blackie and Albright 2005).

Following the success of SCODP and its early stockist innovators, many other retailers joined in repackaging. A survey of 139 retailers in 74 markets in Kenya showed that 79% were repackaging fertilizer in smaller quantities (Mwaura and Woomer 1999). By 2004, SCODP had sold 480 tons of fertilizer and 75 tons of improved maize seed to 45,000 households. Under SCODP intervention, fertilizer demand by all categories of small-scale farmers rose sharply as they became more familiar with and confident in the returns from fertilizer use (Kelly *et al.* 2003). With time, many farmers became interested in larger packages of 2, 5, or 10 kg with sales of 5 and 10 kg bags representing a quarter of all sales in many SCODP outlets. Farmers purchasing farm inputs from the SCODP network produced an estimated 5700 tons of additional maize by the end of 2004.

Evaluation of SCODP impact shows that women purchased between 40 to 70% of the mini-packs at different locations (Blackie and Albright 2005). The SCODP example illustrates how an intervention may lead to increased fertilizer use in SSA, even without subsidy or establishing expensive credit operations. It also shows that fertilizer use and food security is stimulated even amongst very poor farmers and that effective demand for inputs applied to food crops can be developed when the knowledge, skill, availability, and affordability constraints are addressed (Kelly *et al.* 2003). Farm Inputs Promotion Service (FIPS) is currently involved in the marketing of mini-packs of *Mavuno* blended NPKS fertilizer and in awareness creation on input use in SSA (see Chapter 12). Its honest broker focus in delivering inputs to farmers is a service desperately needed by poor, disadvantaged farmers. In this way, FIPS has provided a valuable and trusted market-friendly model for refining and adapting ISFM technology to local circumstances (Blackie and Albright 2005).

A similar experience with the mini-pack fertilizer marketing is the fertilizer micro-dosing with relatively low quantities of fertilizer (<20 kg ha^{-1}) through point placement in millet or sorghum-based systems (see Chapter 7) or through agronomically appropriate fertilizer management in maize-based systems (see Chapter 6). In West African Sahel, micro-dosing is used to allocate fertilizer providing healthy economic usage. The Food and Agriculture Organization has linked the *warrantage* inventory credit system to micro-dosing as a means of scaling-up ISFM packages (Bationo 2008).

The SCODP, FIPS and micro-dosing examples are certainly a great success in many ways. However, SCODP sold an average of only 10 kg per household. More should have been expected, but probably not without farm credit or subsidy. Too many demands compete for cash available to rural household, reducing their capacity for reinvestment. The elegance of ISFM is attributable to its combination of modest but respectable increases in fertilizer use with better management of organic resources resulting in the critical mass of nutrients necessary to productivity breakthroughs by small-scale farmers.

Market linkage programs and increase in the use of ISFM

Yield, output prices, and input costs are key variables that affect net returns and the incentive to use inputs (Crawford *et al.* 2003). The extent to which input use increases per unit land area depends on the payoff to extra inputs, a function of input:output price ratio and the marginal product of each input (Smith *et al.* 1994) and shows how unlinked input and output markets could depress the incentives for the adoption of ISFM. A review of African smallholder experiences with ISFM practices shows that the patterns of use vary considerably across heterogeneous agro-ecological conditions, communities and households, but are stimulated by profitable agricultural opportunities (Place *et al.* 2003). Contract farming often functions best when focused on cash crops with multiple commercial products and profitable business turnover (Collion and Rondot 2001).

Studies in sub-Saharan Africa have shown how ISFM significantly increases yields and quality of products. In Malawi, farmers who applied fertilizer had 105% more yield and 21-42% more profits than non-adaptors (Snapp *et al.* 2003). Legume intensification was also found to increase subsequent cereal yields by approximately 40%, with a net benefit increase of US \$50 ha^{-1}. Sanchez *et al.* (1997) give evidence of profitability of soil replenishment, increasing net farm incomes by 80 to 160%. Diverse soil fertility technologies, particularly those combining mineral fertilizers, organic inputs and intercropped legumes, have also provided positive economic returns in Kenya (Woomer 2007), especially in combination with striga control measures (Woomer 2008). In all cases, higher rates of return were recorded where ISFM was practiced. Part of the reason why the above cases were successful might be their limited scale of operations, not yet affecting output supplies as did with the Sasakawa Global 2000 experience in Ethiopia where unmarketable surpluses resulted from too widespread crop production campaigns.

Examples of market linkage programs that led to increase in fertilizer use in SSA include the micro-dose fertilizer applications and the *warrantage* systems in West Africa, and dual-purpose soybean and cowpea-maize rotations in northern Nigeria (Eaglesham *et al.* 1982) and Zimbabwe. Dairy markets in Kenya provide opportunities for farmers to use manure and raise money to invest in fertilizer. Others are the case of cotton in semi-arid West Africa (Defoer *et al.* 1995) and fertilizer repackaging SCODP and FIPS-Africa in Kenya. In a market garden program in Togo, small-scale farmers apply several hundred kilograms of fertilizers and over 10 t ha^{-1} of manure to improve soil fertility for increased and sustainable production of vegetables (Debra 2003). Vegetable farmers in Cameroon directly phone D-O-U-A-L-A to ascertain ongoing prices to avoid exploitation by middlemen. This shows the potential role of ICT in input-output linkage for widespread adoption and impact of ISFM. The relationship between the activities of some of these programs and the use of ISFM has not been evaluated. However, there is ample evidence that in programs such as the *warrantage* system, input repackaging and the starter packs approaches have led to increases in the adoption of ISFM. Initial SCODP sales showed that the very small packs (1 kg and less) attracted most buyers. As confidence in the technology grew, farmers became more willingness to buy larger packs. In West Africa the combination of micro-dosing with complementary institutional and market linkage led to a significant breakthrough (A. Bationo, personal communication). In three years, about 5,000 farm households in 20 pilot sites started micro-dosing, producing 100% more food with 50% increase in farm income. Some NGOs (e.g., FIPS) are actively disseminating fertilizer sales in very small packets (100g) in East Africa. These programs provide evidence that demand for inputs can be developed among poor farmers if the availability, accessibility and affordability constraints are removed.

Most of the market linkage programs that lead to increased fertilizer use are also the ones where the returns to fertilizer use are high enough to warrant expansion in farmers' demand. Commercialization of smallholder agriculture, featuring high-value cash crops, can provide a strong stimulus to smallholder agriculture and have major indirect benefits for food crop productivity. This is not without problems. In southern Mali, although income from cotton made fertilizer investments possible, extreme soil degradation on other parts of the farm was reported because little fertilizer or manure was applied to adjacent food crops, lowering the soil organic matter below levels that protect soils from irreversible degradation (Van der Pol 1992).

Farmers need to be confident that investment in inputs will prove profitable, even when input use is small. One of the most important ways of maintaining interest in farming is to ensure that crop value remains considerably higher than the cost of production. For rain-fed food grain production, it is generally accepted that the value cost ratios (VCRs) must exceed 2 to motivate farmers to use mineral fertilizers given the risks involved. However, reported VCRs of fertilizer use on rain-fed food grain in West Africa rarely exceed 2, suggesting that returns to fertilizer use on food grain under rain-fed conditions without accompanying ISFM are too low to expand farmers' demand. Lack of well functioning input-output markets can reduce VCR, suppress agricultural productivity and exacerbate rural poverty in SSA.

Improved linkage between farm input and commodity markets will lead to more equity, especially if it is accompanied by improved market information systems. In Kenya, interlinked input-output marketing for cash crops has been shown to have the potential to promote food crop intensification (Jayne *et al.* 2004), demonstrating how institutional arrangement provides spillover benefits for overall farmer productivity. A review of studies across SSA indicates that fertilizer use could be as profitable in Africa as it is in Asia and Latin America (Yanggen *et al.* 1998).

Market-led extension approaches

For simple technologies such as fertilizer and seeds, market-led extension approaches are effective and have the advantage of linking input provision to output and financial markets, providing farmers with incentives to further invest in ISFM. In their article on expanding access to agricultural inputs in Africa, Kelly *et al.* (2003) argue for strengthening agro-dealers and rural stockists' networks. Given the large number of smallhold farmers using low rates of fertilizers, improvement in access has focused mainly on packaging fertilizers and seeds into smaller packets to increase their affordability, and networking of rural agro-dealers to provide better advice to farmers. Many more experiences across SSA give evidence of cases where market-led extension expands fertilizer use, however, a key problem with private extension is recovering their investments in services provided. The private sector is also generally considered weak for this role. It lacks organizational capacity, capital, human resources and the incentives to undertake large, risky and somewhat unattractive investments in rural areas (Doward *et al.* 2005). A number of problems need to be overcome prior to cost-effective commercial extension services to farmers. These problems include:

- Dysfunctional service delivery that occurs when farmers do not receive complementary extension services needed to practice ISFM. In many cases, inputs are not available on time.
- Rural markets tend to be thin, leading to high transaction costs of providing extension services to small-scale farmers and reducing the incentives for commercial service delivery to them.
- Market perversion that permits some private sector actors to exploit farmers through misinformation, product adulteration and dishonest measurements.
- Monopolistic opportunism that arises where limited commercial activity makes it possible for agro-dealers to exploit farmers through high cost of services.
- Strategic default or deliberate failure of farmers to adhere to terms of farm business contracts.
- Failure that arise when farmers demand for purchased inputs depends on unreliable access to finances, market access and complementary extension services.
- Limited farmers' voice making it difficult to hold the private and public sector service providers accountable for ineffective services.

Some market linkage programs are criticized because they lead to mining of the soil. Most of such programs lack ISFM, especially the need to optimally maintain soil fertility through a combination of organic and inorganic fertilizers (Defoer *et al.* 1995). This explains why some scholars caution against market-oriented farming saying that it requires financial commitments that many farmers do not have and may increase resource degradation (Van der Pol 1992; Snapp *et al.* 2003). Studies and observations in Uganda found that nutrient balances in banana and plantain production are negative, as up to 82% of nutrients in the bunches are exported to urban markets. Where produce markets are linked to well functioning input markets, like cotton farming in parts of West Africa, tobacco in southern Africa and cooperatives in the highlands of Kenya, it has been observed that farmers are able to reinvest their income into production and adoption of ISFM, leading to intensification and further increase in income.

Small-scale pro-poor initiatives

The choice of soil fertility management options is dependent upon the capacity of the farmer to afford related investment. In SSA, pro-poor initiatives have been conducted on a limited scale among farmers incompletely linked to markets (Omamo and Farrington 2004). Due to their limited potential for investment, some organic-based systems appear more attractive to a poor households that cannot access or afford inorganic fertilizers (Reardon *et al.* 1997; Place *et al.* 2003). The increasing value of groundnut and cowpea residues as marketable commodities in West Africa is generating income for poor farmers. At current adoption rates, the use of the legume residues has the potential to reach several million farmers with internal rate of returns of 50-103% (Kristjanson *et al.* 2002). Livestock manure is also marketed in northern Nigeria and Madagascar. These initiatives have the potential to create output markets in tandem with the promotion of input packages. If coupled with improvements in on-farm storage, such initiation can permit farmers to take advantage of inter-seasonal price variability (Howard *et al.* 2003).

Innovative production and marketing ventures. Production and marketing ventures are managed by empowered farmers' associations and supported by well equipped rural service providers. This approach permits producer associations to offer better access to farm inputs to their members during the cropping season and also guarantees access to produce markets at the end. Producer associations also broker information, test improved technologies, and help influence policy, creating incentives for greater adoption of ISFM.

Widespread integration of the activities farmers' organizations in innovative production and marketing ventures is an important means to avoid compartmentalization. Farmer organizations help members to overcome unfavorable economies of scale associated with individual operations attempting to acquire inputs and market their surplus produce (see Figure 18.1). They also have a major role to play in both accessing services (negotiation, coordination, delivery, etc.) and advocacy required to guarantee that the poor can benefit from ISFM investments. However, according to Poulton *et al.* (2005), despite the recent emergence of some promising farmer organizations, their track record is mixed. There is therefore, the need to investigate the conditions under which farmer organizations most effectively operate.

For competitiveness in the market, producers must continually look for ways to increase the efficiency and profitability of their production. Production ventures pay due attention to crops, livestock, and other enterprises where investment will benefit different categories of small-scale farmers and provide them with the needed resources. Investments must be on enterprises that expand market opportunities and involve identification of critical areas in the value chain where interventions can have wider impact and stimulate positive shifts (Sanginga *et al.* 2007). These investment options must address the needs of male and female farmers in marginal areas, and stimulate sustainable investments by all stakeholders to create impact at scale.

Strengthening market information systems. The aim of market information systems (MIS) is to diversify the sources of farm input supply and expand access to commodity buyers in a manner that directly benefits small-scale producers. Presently, market information is commonly conveyed through agro-dealers and commodity assemblers who are often selective in their messages provided. Lack of information, irregular access to it or one party having more information than another negatively affect market performance and development. Many a time, agro-input dealers are the sole sources of market information on farm inputs. Alternative channels and the use of modern information technologies (IT) are urgently needed. Effective MIS must be developed and made available to all stakeholders. The potential of MIS to increase market efficiency and strengthen the bargaining position and competitiveness of small-scale producers against traders and of smaller traders versus larger ones makes it an important mechanism. A number of innovative approaches for effective MIS provision are being piloted in

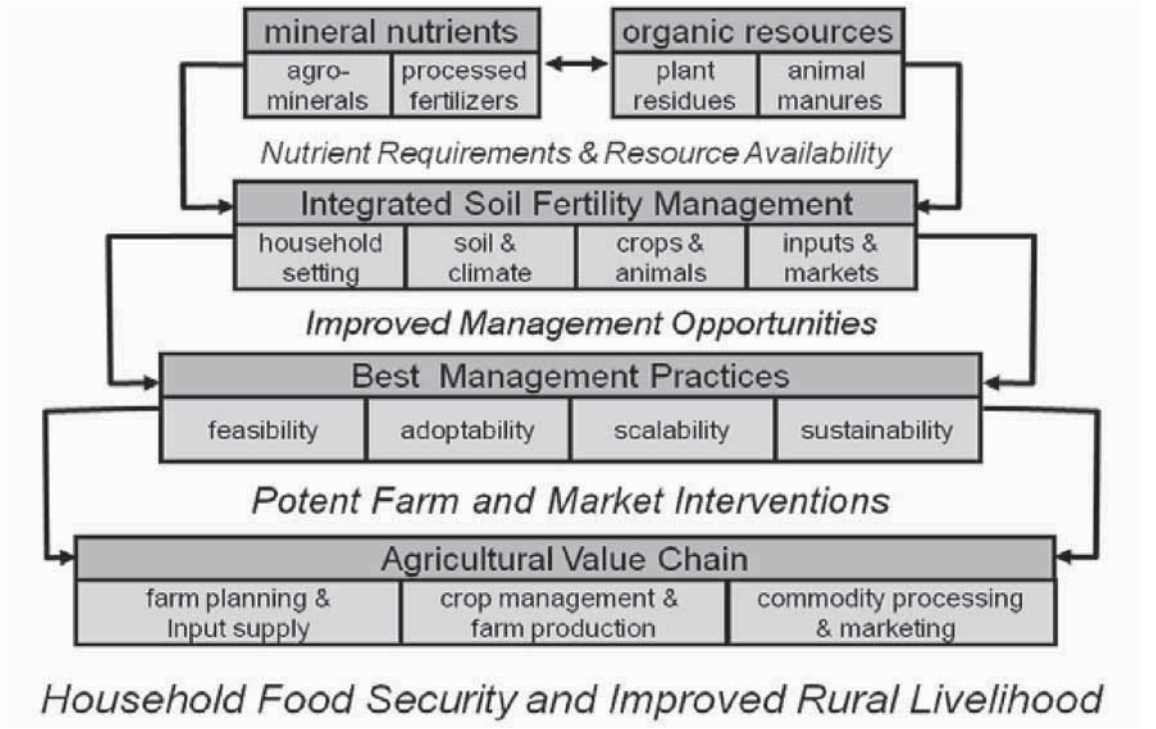


Figure 20.4. The hierarchical relations between resource requirements, management opportunities, market intervention and improved rural livelihood.

SSA, taking advantage of advances in IT, radios, cell phones, internet, and satellites to facilitate the spread of information.

Alternative credit and finance markets. Rural households require savings, credit, insurance, and money transmission to derive full benefit from improved marketing services. Successful financial service providers for poor rural areas in Africa include savings and credit co-operatives village banks, rotating savings and credit associations, and micro-finance institutions. Insurance provides incentives for the poor to assume greater risk. A challenge in developing incentives that accelerate widespread adoption of ISFM is that a great proportion of the target farmers are extremely poor. Seasonal credit and smart subsidies specific for ISFM are critical to accelerate widespread technology adoption and retention. Seasonal credit enables farmers to access and apply inputs that would otherwise be beyond their reach. Key components to this approach include providing loans to intermediary traders with inbuilt strategies to avoid default, establishing smart subsidies with clear exit strategies to relieve seasonal credit and cash constraints, arranging duty-free importation of fertilizers and agro-minerals and devising tax incentives to encourage needed farm inputs.

Strengthening the agricultural value chain

ISFM permits farmers to make the best use of gathered and purchased nutrients based upon their site-specific conditions and farming objectives (Chapter 1). These practices may be grouped into sets of best management practices (Chapter 12) and promoted within ISFM extension programs (Chapter 14) in order to take hold within rural communities. But the full benefits of ISFM, particularly household food security and improved rural livelihoods, can only become realized through their integration into agricultural value chains in terms of farm planning, input supply and commodity marketing (Figure 20.4).

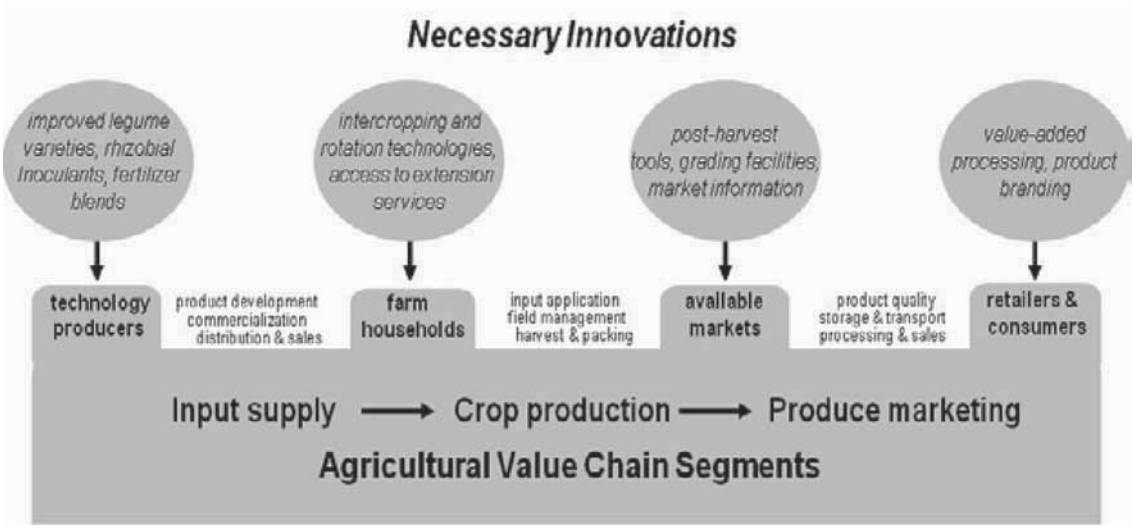


Figure 20.5. Promoting ISFM, grain legumes and their inoculants requires innovation along the entire agricultural value chain.

Expanding ISFM among African smallholders requires participation and innovation along the entire agricultural value chain. Needed product innovations include the development and release of improved crop varieties to seed producers, the identification of needed accompanying technologies such as seed coating and legume inoculants, blended special fertilizers and low cost agro-minerals (Figure 20.5). New products must also be accompanied with knowledge on handling and application. Extension messages on ISFM are required, and farm organizations will likely serve as an important means to deliver these new products and knowledge. Those organizations seeking to expand commodity processing and marketing services to their members must also provide tools and training to them as well. Opening new markets for produce and products requires that quality standards be met and transportation and storage difficulties be overcome. Indeed, the best way to expand ISFM practice and farm input use is to access fair markets with preferred products of reliable quality.

Chapter 21. Advancing ISFM in Africa

The promotion of Integrated Soil Fertility Management must be viewed within the larger context as contributing to rural development agendas. These actions necessarily occur at local, national and regional levels and investments in ISFM must be consistent with needs of rural communities, the national priorities established for balanced agricultural and economic development, and regional initiatives designed to achieve greater self-sufficiency through closer ties and fair interdependency between African countries. This lofty placement of ISFM is not unfounded given that soil fertility decline is the leading cause of declining per capita food production in sub-Saharan Africa (Sanchez *et al.* 1997) and that industrial development is near impossible without preceding agricultural intensification (Eicher 1999). African leaders recently reinforced this underlying importance of soil fertility through their resolution to increase the region's fertilizer use from the current 8 to 50 kg nutrients ha^{-1} by 2015 (Africa Fertilizer Summit 2006). The impact of achieving this target will, however, vary depending upon how efficiently increases in fertilizer use result in production and economic gains, and herein rests the importance of ISFM and the challenge to its proponents and practitioners.

ISFM does more than assist small-scale farmers to produce larger crop yields, but also improves household diets, recovers and manages soil health, reverses nutrient mining of soils, sequesters soil and biomass carbon to counter climate change, and offers a host of other economic, social and environmental services. These benefits are readily characterized by the variety of ISFM successes described throughout this book and summarized in Table 21.1. Despite geographic and logistic diversity, these successes share common features and the driving forces for achieving impacts at scale include technology sparks. These signals result from raised competence in land management leading to multiple benefits to practitioners, flexibility in dissemination approaches and parallel innovations in policy support and market development (Roose and Barthès 2001). Within this context, technology sparks result from simple to understand and acquire products and field practices that provide additional and obvious benefits to crop and farming system productivity. Market linkages support ISFM because it performs best where farmers have access to farm inputs, credit facilities, post-harvest storage and fair produce markets. While some of the existing policies support and enable ISFM, others are inimical to widespread ISFM adoption and must simply be removed.

Recognizing technology sparks

The major successes of some technologies and practices mentioned in the preceding chapters are classified on the basis of ISFM characteristics, adoption potential and expected benefits (Table 21.1). The following set of strategic interventions focus on ISFM practices that improve the agronomic efficiency of fertilizer and applied organic inputs that are relevant to specific cropping systems and agro-ecological zones.

Promote grain legumes in cereal- and cassava-based cropping systems. Strategies must be designed that optimize the role of legumes within a wide range of smallholder cropping systems and the availability of these legume seeds improved. We must devise recommendations to better integrate legumes into systems and to target phosphorus sources and improved rhizobial inoculant delivery system that result in additional BNF by legumes, increase the availability of improved legume germplasm through local and formal seed systems and better organize legume production and marketing chains to quickly respond to commodity surpluses and shortages.

Optimize and promote fertilizer micro-dosing and nitrogen top-dressing. Optimal micro-dosing and top-dressing strategies must be refined and campaigns launched that promote their use. Applying fertilizers in micro-dose amounts permits more precise and better timed fertilizer

Table 21.1. Lessons learned from the ISFM success stories.

Case studies	Role of fertilizers	Adoption prerequisites	Known and expected benefits
Fertilizer micro-dosing	Although quantities are small, the entry point is appropriate management of fertilizer	• Local availability of technology • Extension and training • Setting up *warrantage* system • Credit systems (fertilizer, seed) • Product storage infrastructure	• High return to fertilizer • Yield gains 43-120% compared to non-adopters; income increase 52-134 % • Increased food security • Less need for food aid
ISFM linked to soil and water conservation	Fertilizers only applied when other growing conditions are favorable	• Village-level soil and water conservation structure in place • Extension and training with NGOs • Corralling agreements in place	• Combination of high WUE and AE allows profitable intensification • Re-vegetation of rangelands due to intensification under ISFM • ISFM options can be turned into best fit technologies
Dual purpose legume-maize rotations	Targeted P fertilizers help soybean fix high amounts N, on which maize partly scavenges; very high AE under proper management	• Availability of improved maize and soybean germplasm • Access to input/output markets and credit facilities • Organize production chain to respond to increased soybean demands	• Maize yields up by 1.2-2.3 fold compared to monoculture • Net returns up by 50-70% compared to non-adopters • Partial substitution of mineral fertilizer; N-fixation in Nigeria is worth at \$44M yr^{-1}
Maize-legume inter-cropping systems	Targeted P fertilizers help legumes fix high amounts of N, on which maize partly scavenges; high AE likely under proper management	• Adjustments in row spacing and orientations • Commercial legume and maize seed production • Extension and training • Additional benefits include suppression of *Striga* • Rhizobial inoculants available	• Increased maize yield by 24% • Partial substitution of mineral fertilizer • Increased groundnut by 472 kg ha^{-1} compared to non-adopters • Potential benefits of \$88M when scaled up to 1M farmers
ISFM in conservation agriculture	Well-watered areas with undisturbed soils allow good returns to fertilizers applied as top-dressing	• Potential conservation tillage technology available that can be adapted to local conditions • Extension and training • Presence of inputs/output markets	• Doubling of maize yields realized • Existing nutrients, organic C maintained • High potential for scaling-up • High potential in empty lands
ISFM for cassava-based systems	High population density and new markets for cassava justify fertilizer use	• Demand for cassava increasing • Market integration needed • Participatory R&D should yield attractive ISFM applications	• Substantial yield and production increases • Increased market access for cassava growers • Sustainable production under ISFM includes legume intercropping
ISFM for rice-based systems	NERICA highly responsive to fertilizers adjusted to indigenous nutrient supply	• Demand for rice increases • Efficient access to consumer markets, extension and training	• Substantial yield and production increases • Increased self-sufficiency in rice for SSA • Increased urban food security
Large-scale use of phosphate rock	Rock phosphate can substitute for more costly imported soluble P fertilizers	• PR deposits within economic distance of the utilization areas • Processing needed for many deposits	• Substantial foreign exchange savings through substation for imported fertilizer • Substantial increases in yields through long-term soil P capital build-up

placement, particularly in semi-arid areas where moisture availability constrains production. Top-dressing cereals with N-bearing fertilizers is a near universal requirement for highly profitable cereal and green vegetable production that is too seldom practiced by smallholders. In many cases, the fertilizers well suited for top-dressing are available but not used for that purpose. Timing micro-dosing and top-dressing to the rains is a skill required by farmers because it improves fertilizer use efficiency and reduces the consequences of drought.

Improve P capital and use locally available phosphate rock deposits. Greater effort must be made to assess the economic benefits from the addition of phosphate rock and means found to better process and distribute these fertilizer products for use by smallhold farmers. These deposits occur throughout Africa and may be used to supplement and substitute for imported mineral fertilizers. Sedimentary and igneous deposits vary greatly in terms of their nutrient concentrations and solubility, but many are able to be used in raw or semi-processed form, particularly when combined with applied organic resources. In other cases, we must improve our capacities to increase the solubility of less-reactive rocks through co-granulation or partial acidulation. Plans must be developed for better distribution and marketing of phosphate rock in areas with widespread phosphorus deficiency.

Better mobilize other agro-minerals. Local deposits of other agro-minerals, particularly limestone, dolomite and gypsum effectively correct pH, calcium, magnesium and sulfur imbalances. These deposits occur throughout Africa, and are often being mined for industrial purposes not involving fertilizer production. Clearly, benefit will be obtained from assessing the agronomic potential of current industrial by-products containing plant nutrients and then informing land managers of their comparative advantages.

Fine-tuning soil management advice to farmers' local conditions

Land management recommendations in Africa have too often failed to take farmers' traditional practices and their limited capacity for investment into account because they were developed using top-down diagnostic approaches and formulated using inappropriate economic models. On the other hand, ISFM appreciates the intricacies within small-scale farming systems and recognizes opportunities for improved nutrient management in a localized and stepwise context.

Target nutrient additions per unit input. Many fertilizer recommendations made to farmers are regarded as excessive and rightfully so. Fertilizer recommendations are generally based upon sound field trials, but too often, they are formulated by optimizing returns per unit area rather than unit input (see Figure 2.3). Recommended fertilizer rates based upon the greatest returns per unit input are usually 30% to 50% of those based upon unit area. This implies, for example, that if a farmer can only afford to fertilize 1/3 of the farm at the unit area recommended rate, then she is usually better off by applying only 1/3 of that rate to the entire farm. ISFM achieves greater agronomic efficiency from reduced fertilizer application and its combination with organic inputs.

Reinforce traditional nutrient management practices with judicious addition of mineral fertilizers. For example, composts may be fortified with rock phosphates, resulting in greater nutrient solubility and retention. Manure piles may be protected against nutrient loss resulting in lower amounts of mineral fertilizers required to supplement them. Farmers least able to afford mineral fertilizers should be provided special guidelines on how to use limited amounts of them most effectively.

Accommodate additions of organic resources into recommendation domains. Farmers with sufficient manure can substitute them for pre-plant fertilizers and invest more in top-dressed fertilizers later in the season. Fertilizer recommendations may also respond to the amount and placement of nitrogen-poor organic residues intended to boost soil organic matter and improve physical properties. Fertilizer recommendations must not only provide suggested types and rates but also offer guidelines on how to make adjustments in conjunction with the use of commonly available organic resources.

Adjust recommendations to farmers' resource endowments. Different resource endowment categories exist within a given farming community and the capacity of each category to invest in mineral fertilizers differs. Fertilizer recommendations have so far had little impact on smallholder production systems beyond those in the higher resource endowment category. Similarly, households have different degrees of labor availability, especially during periods of peak demand, that influence the feasibility of more tedious and knowledge intensive tasks. Farmers producing cereals for market should be offered one set of recommendations, and those seeking food security for least cost could be offered another, lower one where fewer fertilizers are used more efficiently. Thus fertilizer recommendations may be formulated along two parallel paths, one for strictly commercial production that optimizes returns per unit area at prevalent market conditions and another intended for resource poor farmers that makes the best use of limited available inputs.

Recognize nutrient depletion as an ongoing and reversible process. Soil nutrients represent resource capital that can be assigned value and supplemented through investment and labor. In some cases, soil nutrient depletion has exceeded critical thresholds that require ameliorative treatment quite different from routine crop management. Furthermore, soil health can be described using readily diagnostic parameters that identify severely degraded lands and influence farmer decision making. A separate suite of recommendations that allows farmers to rehabilitate their least productive fields in a resource and time efficient manner is required.

Adjust management to spatial heterogeneity. Spatial heterogeneity within and across farms results from topography, nutrient depletion and specialized land use, and these differences necessarily influence soil fertility management. In many cases, heterogeneity is intensified from past management when more resources are devoted to nearer or more productive fields. It is near impossible to capture individual farm level heterogeneity within extension recommendations, but different advice can be forwarded for major topographic units, such as valley bottoms, hillsides and plateaus and the major land management units contained within them in a way that leads to complementarity within farming enterprises.

Involve farmers in formulating recommendations. Participatory research methods guarantee farmers' role in the formulation of land management technologies, farmers' adaptive response to recommendations and the resulting impacts. This approach is markedly different from top-down, prescriptive approaches to fertilizer use. Localized fertilizer recommendations are best developed, adjusted and validated through close collaboration between researchers, extension agents, farmer associations and their members. Extension efforts should seek to assist farmers to undertake adaptive adjustments to those local recommendations by providing necessary information and field diagnostic tools.

Carefully evaluate, validate and apply decision support tools. Greater use must be made of available decision support tools, particularly plant and soil simulation models and geographic information systems (GIS). Models may be used to screen candidate recommendations and test their agro-ecological ranges. GIS allows for finer definition of recommendation domains.

Models and GIS may be interfaced to generate spatially-explicit model outputs describing responses to different land management strategies. Familiarly with plant and soil simulation models inspires system's thinking that may then be applied to specific production constraints. Improved fertilizer targeting may be achieved through the use of models and GIS, but time and resources spent initializing these tools must be balanced with and closely linked to localized, on-farm testing of ISFM practices.

Building stakeholders' capacities in ISFM

Training at several levels, from policymakers to farmers and particularly re-training of extension agents and national scientists is an essential component of widely-adopted ISFM. Furthermore, investments within individual countries must be coordinated and provided with up-to-date information on ISFM principles and practices. Lessons learned through failure or over many years of trial and error in one country need not be repeated in the same manner elsewhere. Managing individual investments in ISFM on a regional scale and as a network suggest the need for a Center of Excellence in ISFM.

Balance public sector extension, community-based approaches and market-led promotion of ISFM. There is ample evidence that reliance on more traditional extension approaches and farmer-to-farmer diffusion is successful in dissemination and uptake of ISFM technologies. This is particularly true when the technologies are less knowledge intensive, and do not require extensive adjustment of farming practices. While past extension efforts focused upon crop response to mineral fertilizer, the widening angle of extension and dissemination approaches based on better understanding of land management technologies views ISFM as more complex and challenging than just mobilizing seed and fertilizer packages.

Repeated failures of conventional extension approaches to dissemination led to the development of more participatory methods. Community-based organizations offer viable alternatives to government bodies by virtue of their intensive and client-focused working styles. Farmer participatory research is vital for re-orienting technology development, accelerating adoption and creating wider impacts of agricultural technologies in small-scale farming. Participatory extension methodologies have been widely employed as means to improve dissemination and adoption of ISFM technologies by building local capacity to conduct adaptive research, and for farmer-to-farmer dissemination. However, CBOs must not be backstopped by NGOs that express ideological biases against manufactured fertilizers and pesticides.

For simple, product-based technologies such as fertilizer and seeds, market-led extension approaches are very effective. These have the advantage of linking input provision to output and financial markets in a way that provide farmers with incentives to further invest in ISFM. Given the large number of small-scale farmers who use fertilizers at low rates, improved accessibility of fertilizers and seeds should focus upon repackaging of inputs into smaller quantities to increase affordability, and the development of agro-dealers networks able to provide accurate product information to farmers.

Strengthen the capacities of African countries to implement ISFM as a component of their rural development agendas. The capacity to implement ISFM must be strengthened at the level of international networks, NARS and extensions services, vocational schools and universities, non-governmental and community-based organizations and within the private sector. The research agenda for saving Africa's soils implies a re-orientation from conventional soil science approaches, the development of new skills, and a re-tooling of soil science laboratories.

Working with existing NGOs and farmer associations and their umbrella networks is important to promote ISFM. These groups represent a ready-formed audience for technical

messages, will collectively undertake independent technology evaluation and provide necessary feedback and peer support on ISFM technologies. Furthermore, these groups can participate in innovative pilot efforts at ISFM technology dissemination such as voucher systems, revolving funds, and planned production and marketing ventures. Market-led technology adoption implies that improved profitability and access to market will motivate farmers to invest in new technology. Ideally, when farmers purchase fertilizers they should also be provided with accurate information on how best to use them.

Key developments to advance capacities in ISFM include the establishment and expansion of international networks with a critical mass of expertise to provide a key foundation for upgrading both physical and human capacity of African soil science. National scientists must be encouraged and supported to design ISFM practices and develop strategies for their dissemination. Extension staff must be retained for effective delivery of ISFM at the farm level. Educators must understand ISFM in theory and present it within school and university curricula. Finally, agro-dealers require training in distributing products and information that advance ISFM.

Establish a Center of Excellence for ISFM. A Center of Excellence for ISFM will backstop all capacity building activities and drive the generation of new knowledge and approaches to disseminate ISFM practices in a cost-effective manner. ISFM is an interdisciplinary pursuit with tremendous potential but scattered expertise. Need exists to concentrate some of this expertise in a manner that accelerates technical breakthroughs and provides training materials describing ISFM in a practical context. These experts will not be desk scientists, rather, members of this center would serve as a mobile cadre of ISFM practitioners prepared to assist in the design and implementation of country-level projects and be held responsible for trouble-shooting ISFM interventions.

Such a center would provide several services. It would synthesize ISFM principles into flexible field practices presented in ways best understood by farmers and rural development specialists. It would also design, field-test, and commercialize diagnostic soil test kits and fertilizer test strip packages suitable for Africa's highly weathered soils for use by extension agents, rural development specialists, and farmer associations. Finally, need exists to better harness new advances in spatial decision support systems, including GIS, remote sensing and diagnostic surveillance approaches, to improve regional planning of ISFM and targeting of appropriate advice and inputs to farmers.

Identifying and enacting policies supporting ISFM

Policy interventions facilitate the availability of specific ISFM products including agro-minerals, fertilizer and improved crop germplasm, and the integration of ISFM into national and regional development initiatives.

Integrate ISFM into poverty reduction strategies. Strategies should be developed to effectively integrate ISFM into informed national and regional fertilizer promotion, agricultural development and poverty reduction efforts. This intervention option would establish mechanisms for capacity building, institutional learning, policy dialogue and advocacy at different levels to bring about reforms favoring all stakeholders, especially the rural poor. Achieving this goal requires a review of national agricultural development strategies to identify gaps relating to soil management, and then developing alternative policies addressing those gaps.

Facilitate enabling policies for seeds and fertilizer. Effective seed systems are critical for accelerated and widespread adoption of ISFM and strategies must be developed to overcome the limited interest of commercial seed sector in self-pollinating legumes. Along the same lines, there is the need to facilitate and promote seed associations and community-based seed production.

There is also the need to reformulate regulations on repackaging farm inputs that provide quantities affordable to farmers while assuring product quality. Instituting strong penalties for product adulteration are preferable to banning the repackaging of farm inputs.

Improving agricultural market linkages

Better coordinate input-output markets related to ISFM. The lack of coordination in input-output markets often means that programs focusing on either input supply or produce marketing alone often fail because of the absence of complementary investments in the other aspects of the supply chain. Coordination of the supply chain involves the development of an effective system to support investments and services by different players. Better linkages to credit and fair commodity markets increase productivity and returns to investments in ISFM because farmers better benefit from crop surpluses. Means must be found to support agro-dealers, micro-finance agencies, and farmer associations to provide services advancing ISFM and to promote higher value crops, prolonged shelf life and value added products.

Provide seasonal credit, loans, and other incentives. Several incentives relating to ISFM are critical to accelerate widespread adoption and retention of new land management technologies. Key components in these areas include providing loans to intermediary traders with inbuilt strategies to avoid default, devising smart subsidies with clear exit strategies to relieve seasonal credit and cash constraints, allowing duty-free importation of fertilizers and agro-minerals, and offering tax incentives to encourage legume seed production and access to rhizobial inoculants.

Conclusions

The Integrated Soil Fertility Management paradigm, as defined and elaborated throughout this book offers an alternative to the so-called Second Paradigm that identified fertilizer as the key entry point for improving productivity of cropping systems in developing nations (Sanchez 1994). The ISFM paradigm recognizes that applying organic resources in conjunction with fertilizers offers immediate and longer-term economic and environmental advantages and a positive interactive effect upon farm enterprise development. ISFM places importance upon an enabling environment that permits farmer investment in soil fertility management, and the critical importance of farm input suppliers and fair produce markets. In this way, ISFM is a holistic approach that not only requires land managers to invest in external farm inputs, better recycle available organic resources and foster beneficial soil biological processes (Uphoff *et al.* 2006), but also provides additional incentives and strengthened understanding for them to do so.

The key components to supporting ISFM development and adoption involve actions by international, national and local bodies. International networks are required to establish the critical mass of expertise needed for upgrading both physical and human capacities of soil science in Africa. National scientists must be encouraged to adopt ISFM philosophies, design innovative soil fertility management practices, and develop strategies for their dissemination. Extension staff must be retrained for effective delivery of ISFM technologies at the farm level. ISFM theory and practice must feature within vocational school and university curricula and community-based organizations must be mobilized to promote ISFM. Agro-dealers must be trained in accessing, managing, and distributing products advancing ISFM and their accompanying information. Formal and indigenous knowledge systems must become better integrated to allow farmer associations to recognize, adapt, and implement ISFM practices. It is hoped that this book not only raises awareness and understanding of Integrated Soil Fertility Management, but will prompt action by the research and development community to include its approaches into their agendas for African food security, poverty alleviation and rural transformation.