3  Maize mixed farming system
An engine for rural growth and poverty reduction

Malcolm Blackie, John Dixon, Maxwell Mudhara,
Joseph Rusike, Sieglinde Snapp and Mulugetta Mekuria

Key messages
• The maize mixed farming system in eastern, central and southern Africa is the food basket of the region, with good natural resources and an agricultural population of over 100 million with an average holding of 2.1 ha. This system integrates trees, livestock, and cash and food crops. Off-farm income is significant.
• The system is rapidly changing, driven by increases in population and urbanisation, gender roles, markets, information availability and climate change. Long-term agricultural growth prospects for transformational development are promising, with opportunities for diversification to horticulture and dairy, for crop-livestock integration and for agricultural intensification based around enhanced legume systems.
• Pathways to better food and nutrition security and broad-based inclusive sustainable development can be accelerated by greater investment in improved varieties and services, improved farm and value chain management, rural innovation and entrepreneurship, effective local institutions and enhanced enabling policies.

Summary
The maize mixed farming system is found largely in the sub-humid agroecological zone of eastern, central and southern Africa, with a crop growing season of around six months. It has a greater agricultural population, around 107 million in 2015, and more extreme poverty than other farming systems in Africa. It is the food basket as well as the driver of rural economic growth in the region. Many smallholders supplement dietary energy from maize with cassava and other root crops. Farm households are characterized by ageing farmers and an increasing role of women. Dietary protein derives from animal and fish products, and a variety of legumes grown as intercrops or in rotation with maize. Market access is reasonable for many areas. Cash crops include coffee, tobacco, cotton, groundnuts, vegetables and livestock products. Large and small ruminants are integral to the system, often grazed communally. Livestock and poultry augment household cash income and nutrition. Most smallholders earn substantial off-farm income and are net purchasers of food grains, often selling staples at harvest time to meet immediate household cash needs.
Cultivation is typically with hand hoes or animal draught, but with increasing use of machinery. The productivity of crops and livestock are limited by poor management as well as biotic and abiotic constraints. There are signs of serious fertility decline and evidence of increasing soil acidity where there has been prolonged use of inorganic fertilizers without manures or crop residues. Farmers are struggling to adapt to increased climatic variability. Over the medium to long term, the projected increase in temperatures and decline in precipitation associated with climate change are expected to reduce the potential yields of maize and other crops substantially, especially in southern Africa.

Widespread adoption of sustainable intensification and diversification requires improvement to input and output value chains, including better access to finance, knowledge, seed, fertilizers and pesticides, and produce marketing. Producer incentives for adopting new technologies and increasing productivity can control food prices and improve access to staple food for poor consumers, both urban and rural. Improved natural resource management is essential to ensure environmental sustainability and productivity in the future. Increased investments in agricultural research and rural infrastructure are critical. Interest is growing in targeting support programs to specific aspects of the maize mixed farming system, such as improved soil fertility, diversification, resilience or human nutrition. Public policies can create incentives for business investments in transport, storage and processing.

Overall, the potential for long-term improvement in food and nutrition security and reduced poverty is promising. The relative abundance of natural resources in the region provides the basis for pro-poor sustainable agricultural development if appropriate incentives are created through supportive national policies, reorientation of institutions, investment in innovation systems and provision of infrastructure, information and agricultural services. Broad-based inclusive agricultural growth with reliable access to services and inputs in poorer sections of the farming system will accelerate increases in small farm income.

Introduction

Maize was introduced into southern and eastern Africa from Latin America by the early Portuguese explorers in the 16th century (as were other important components of this system such as *Phaseolus* beans and groundnuts). Maize gradually spread north from the Cape and replaced the more labour-intensive small food grains (pearl millet and sorghum) and, initially, cassava. Maize became the main food staple for eastern and southern Africa early in the 20th century. In the southern parts of the region, maize-based farming was encouraged by the demand for food by the expanding mining industry.

The population density in eastern and southern Africa was low until the mid-20th century, in no small part as an outcome of the slave trade which devastated large areas. In this relatively land abundant era, labour was a major constraint; the seasonality of rainfed production means labour constraints persist today. Land preparation by hand hoe has a long tradition, due to limited draught power in some areas. Cattle, the main source of animal draught, are susceptible to severe diseases such as trypanosomiasis. Theft and scarcity of grazing also limit access to animal draught. There is evidence of farmers turning to mechanization. Most farm households engage in small-scale business activities, notably trading.

In the system, there are significant areas of sorghum, and food grains are complemented by root crops, especially cassava, legumes, notably beans, and horticulture. Cash crops include coffee, tobacco, cotton, groundnuts and sunflower. Cattle, sheep and goats are
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common through the system, but per capita ownership of cattle is falling. Off-farm work (many young men work in mines and other industries) is prevalent across the system. The expansion of market-based institutions has stimulated diversification towards higher value crop and livestock activities – although national policies which focus on increased maize production are a core strategy for achieving food security and reducing poverty in the region (Homann-Kee Tui et al. 2012).

Overview of the farming system and subsystems

The maize mixed farming system and its nine subsystems extend over about 361 million ha of eastern and southern Africa (Figure 3.1), of which some 40 million ha are cultivated and only 1.9 million are irrigated (Table 3.1). Of the total population of 180 million in 2015, including cities and towns, some 107 million are agricultural (expanding at 2.7 per cent annually) – more than any of the other farming systems in Africa. At an average of 5.5 persons across all types of farm households, this system has about 19.5 million farm households. An estimated 56 per cent of the farm population lives in extreme poverty (using the standard definition of daily consumption of less than US$ 1.90 per capita) – greater number than any other African farming system. Despite the prevalence of poverty and the increasing average age of farmers, the farming system serves as the food basket as well as the driver of agricultural growth in eastern and southern Africa.

Geographically, the system extends across plateau and highland areas at altitudes of approximately 800 to 1500 metres, from Ethiopia, Kenya and Tanzania to Zambia,

Figure 3.1 The maize mixed farming system and subsystems.
Source: GAEZ FAO/IIASA, FAOSTAT, Harvest Choice and expert opinion.
Malawi, Zimbabwe, South Africa, Swaziland and Lesotho with low altitude extensions into central Africa (including the Democratic Republic of Congo (DRC)) and Madagascar. Originally most of the area was heavily forested, but increased population pressure led farmers to push the agricultural margin into the forests, and indigenous forests have also been thinned or clear cut for timber or to create commercial forests.

The maize mixed farming system has two key characteristics: a medium to high potential agroecological potential and, second, a medium level of access to markets. The farming system is found largely in the tropical warm sub-humid climatic zone with an average growing season length of 196 days (between six and seven months), termed length of growing period (LGP). The core of the system falls in the zone within 150–240 LGP, with climate varying from dry sub-humid to moist sub-humid. The length of growing season, and hence the potential yield of crops, varies substantially across the system and between years, largely as a consequence of the El Nino weather patterns. Within the season, crop growth is particularly sensitive to drought at establishment, flowering and grain-filling stages. The most typical areas of the system have monomodal rainfall, but some areas close to the equator (Kenya, Uganda, and some of Tanzania) have a bimodal rainy season with two growing seasons.

Although dominated by the staple maize crop, the system is typically a diversified mixed system incorporating significant numbers of livestock (36 million tropical livestock units (TLU) in total) and areas of root crops, pulses, oil seeds and sorghum (total crop area is 40 million ha). Beans, other legumes and cassava are often planted as intercrops. Cassava is particularly common in three different contexts: areas with frequent droughts such as in southern Africa; areas where cassava has been commercialized such as Mozambique; and areas where cassava was traditional but farmers are adopting maize, such as in central Africa. Both local and improved maize varieties are grown, although the taste and processing characteristics of the local varieties are sometimes preferred. Sorghum is more drought tolerant than even the recent drought and stress tolerant maize varieties but is grown on less than 10 per cent of the cropped area in the farming system, increasingly for home-brewed beer or sale to commercial breweries. Groundnuts, beans and cowpeas,

### Table 3.1 Basic system data (2015): maize mixed farming system

<table>
<thead>
<tr>
<th>Item</th>
<th>Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total human population (million)</td>
<td>181</td>
</tr>
<tr>
<td>Agricultural population (million)</td>
<td>107</td>
</tr>
<tr>
<td>Total system area (million ha)</td>
<td>361</td>
</tr>
<tr>
<td>Cultivated area (million ha; % of total area)</td>
<td>40; 11</td>
</tr>
<tr>
<td>Irrigated area (million ha; % of cultivated area)</td>
<td>1.9; 5</td>
</tr>
<tr>
<td>Total livestock population (million TLU)</td>
<td>36</td>
</tr>
<tr>
<td>Main agroecological zone</td>
<td>Tropical subhumid</td>
</tr>
<tr>
<td>Length of growing season (average, days; core range, days)</td>
<td>196; 150–240</td>
</tr>
<tr>
<td>Access to services (low/medium/high)</td>
<td>Medium</td>
</tr>
<tr>
<td>Time to market (average, hours; core range, hours)</td>
<td>8.3; 2–10+</td>
</tr>
<tr>
<td>Agric population density (persons/total area; persons/cultivated area)</td>
<td>0.3; 2.7</td>
</tr>
<tr>
<td>Livestock density (TLU/total area; TLU/cultivated area)</td>
<td>0.1; 0.9</td>
</tr>
<tr>
<td>Standard farm and herd size (cultivated area/household; TLU/household)</td>
<td>2.1; 1.9</td>
</tr>
<tr>
<td>Extreme poverty (% of rural population)</td>
<td>56</td>
</tr>
</tbody>
</table>

Source: Refer to Table 2.4.
Maize mixed farming system

with expanding areas of pigeon pea, chickpeas and soybeans, are important legumes in the system (Figure 3.2) and are planted on more than 15 per cent of the cropped area. Legumes are an important source of dietary protein and contribute to soil health and livestock fodder, as well as an expanding role as a source of cash. Traditional cash crops include coffee, tobacco and cotton. As in other parts of Africa, livestock and many food crops are increasingly marketed by smallholders.

The maize mixed farming system contains only 1.9 million ha of irrigation, mostly scattered and small scale with the notable exception of Madagascar, which has a significant area of irrigated rice. Substantial numbers of smallholders have access to small areas of potentially irrigable land in the shallow valley bottoms, sometimes known as dambos or vleis in southern Africa. Farmers establish gardens on these dambos for high value crops, grown on residual moisture or supplemental irrigation, often pumped from shallow wells or surface sources. Crops include green leafy and other vegetable crops such as tomatoes, as well as winter maize (an important market crop as ‘green maize’) for both the market and home consumption. These wide valley bottom areas are also of considerable importance for grazing, particularly during the dry season.

Livestock production, supported in most areas by functioning local grazing institutions, is a major income-generating activity and, in some areas, has the potential for more consistent returns on investment than crops (Ryan and Spencer 2001). Per capita ownership has been dwindling since the turn of the century. Small ruminant and poultry numbers are steadily increasing in most countries (Homann-Kee Tui et al. 2012).

Figure 3.2 A field day in Kandeu, Central Malawi, with a farmer evaluating agronomic benefits of rotation of soybean with maize.

Source: Sieg Snapp.
One of the striking aspects of the system is the growing access to labour markets. Thus, off-farm income is a critical source of livelihoods, especially for households with smaller farms – and in drought years. As young males migrate in search of farm work, farm women play expanding roles in farm management and marketing. Sometimes women do undertake local off-farm work, which unfortunately compromises the productivity of their own fields. The expansion of rural road networks during the past few decades has given most farm households moderate or good access to farm input and produce markets, thereby opening up new income earning opportunities. Smallholder household income is significantly augmented by off-farm employment, trading and small businesses. Off-farm employment includes work (often for food) on nearby farms, as well as seasonal migration to nearby towns and cities, or other countries.

Population density is 0.3 persons per ha, equivalent to 2.7 persons per cultivated ha. An average farm household cultivates 2.1 ha and manages 1.7 TLU of mixed livestock. The variation is substantial across the system and within communities. Overall, the system has medium level access to services, with an average time of 8.3 hours to large market towns with populations of 50,000 or more. The core hunger season typically occurs in the late dry season and early wet season after stored food grain runs short and before the next harvest. Because cassava roots can remain in the ground, they are often harvested during this period. Some crops provide food from early in the growing season, for instance green maize (immature maize cobs). Nutrition is supplemented cassava leaves in the dry season and legume leaves in the wet season, as well as forest products, milk products and poultry. Naturally, the bimodal rainfall systems in the eastern African part of the system tend to generate more stable household food and nutrition security.

Smallholders occupy more than 90 per cent of cultivated land. Larger and wealthier smallholders often cultivate more cash crops and manage more livestock (Table 3.2). Of the typical cultivated area of a smallholding (2.1 ha), half is planted to cereals and 0.35 ha to cassava, sweet potatoes and other roots. Legumes and groundnuts account for 0.37 ha, and cash crops only 0.14 ha. The profile of typical maize mixed system smallholders is outlined in Box 3.1 (but there is considerable variation).

As only 11 per cent of the farming system land is cultivated, most farm households access significant common grazing land. Livestock holdings average 2.3 cattle, including

<table>
<thead>
<tr>
<th>Percent land in crops (%)</th>
<th>Selected farm household characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>35</td>
</tr>
<tr>
<td>Sorghum, millet</td>
<td>8</td>
</tr>
<tr>
<td>Rice</td>
<td>5</td>
</tr>
<tr>
<td>Wheat, barley, other cereals</td>
<td>3</td>
</tr>
<tr>
<td>Cassava, sweet potato, other roots</td>
<td>19</td>
</tr>
<tr>
<td>Bananas</td>
<td>2</td>
</tr>
<tr>
<td>Pulses</td>
<td>14</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>6</td>
</tr>
<tr>
<td>Cotton</td>
<td>3</td>
</tr>
<tr>
<td>Vegetables</td>
<td>2</td>
</tr>
<tr>
<td>Coffee, tea</td>
<td>3</td>
</tr>
</tbody>
</table>

Source: FAOSTAT.
dairy cows, 2.6 small ruminants and around a dozen poultry. Most large and small ruminants use the common grazing and water points, although in the dairy sector numbers of staff fed animals are growing.

Box 3.1 Typical smallholder farm household profile

A typical smallholder five-six person family farm would have a cropped area of 2 ha of which 0.5–1.0 ha would be planted to maize. The equivalent of about half the maize area will be devoted to other cereals such as sorghum, millet, rice or wheat. Maize and other cereals account for 80 per cent of total food production – further plantings include pulses, roots and tubers, oilseeds and vegetables. Where market access is reasonable, small areas may be allocated to cash crops such as cotton, tobacco and coffee. The family owns two or three small ruminants or cattle, generally communally grazed, and uses its oxen to plough the land (in some areas, where cattle are scarce, cows are used, but they lack the strength and their fertility is compromised). Typical yields are low – around 1.2 t/ha for maize and 500 kg/ha for beans or other pulses. The household would be food self-sufficient in average to good years and deficient during extreme weather years (poor rainfall, illness or other external events). One son works in the capital and sends occasional remittances which are used to pay for school and medical fees and clothes. Home-grown maize is the main source of subsistence. Cash is obtained either from off-farm activities, local trading, or from the sale of agricultural products such as maize, cotton, coffee and milk. Although household income would be above the poverty line in average seasons, often sales are made at harvest when returns are lowest, and cash is a major constraint on the purchase of improved inputs.

In this system about 56 per cent of the agricultural population is extremely poor with a daily per capita consumption of less than US$1.90; about half manage small- to medium-sized farms with modest farm incomes, and only a few could be termed large or rich farmers.

Changes in the socioecological economic environments in Africa since the turn of the century have led to changes in the extent and characteristics of the maize mixed system. For example, compared with Dixon et al. (2001), increasing commercialization has led to some areas of the maize system being transferred to the market-oriented highland perennial farming system. With the continued adoption of maize in previously extensive systems, a large swathe of central Africa has been reclassified from mixed cereal and root crops to the maize mixed system. There has been a substantial increase in diversification since 2000, especially into dairy and horticulture. These changes are driven by an increase in the availability of agricultural production, market and policy information and wider choices in production and marketing management.

Subsystems

For ease of use by policy makers, the maize mixed farming system can be subdivided into nine distinct subsystems grouped by countries with recognizably different production and livelihood patterns and institutional and policy environments. Both agroecology (altitude, rainfall, length of growing season) and market access determine the subsystems, as shown in Table 3.3.
<table>
<thead>
<tr>
<th>Subsystem name</th>
<th>Market access (hours from city)</th>
<th>LGP (days); Altitude (m)</th>
<th>Total area; Cultivated area; Agricultural population; Cattle population</th>
<th>Principal subsystem features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopian maize-livestock</td>
<td>Low (11.4 h)</td>
<td>Medium (198 d); Medium-high altitude (1244 m)</td>
<td>17.9 mha; 2.8 mha; 11.5 m; 8.5 m</td>
<td>Medium intensity crop-livestock system, small farm size (1.3 ha), monomodal (single crop season), about four cattle per household, livelihoods from maize, cattle, teff, oil seeds and legumes including haricot beans and sesame as cash crops, some sorghum, off-farm income.</td>
</tr>
<tr>
<td>Kenyan-Ugandan hoe-tractor maize</td>
<td>Medium (7.0 h)</td>
<td>Long (253 d); Medium altitude (961 m)</td>
<td>34.6 mha; 6.5 mha; 29.1 m; 12.3 m</td>
<td>Medium intensity, bimodal (two crop seasons), small farm size (1.2 ha), hoe/tractor power, some external inputs, relatively good access to seed, livelihoods from hybrid maize, banana, cotton, vegetables, off-farm income (note: includes some districts of northern Tanzania).</td>
</tr>
<tr>
<td>Tanzanian semi-mechanized maize</td>
<td>Medium (7.3 h)</td>
<td>Medium-long (211 d); Low-medium altitude (745 m)</td>
<td>37.9 mha; 5.6 mha; 11.3 m; 3.9 m</td>
<td>Central and southern parts medium intensity, monomodal (single crop season), medium farm size (2.7 ha), partially mechanized, livelihoods from hybrid maize, diversified (beans, pigeon pea, sorghum, cotton, vegetables), off-farm income.</td>
</tr>
<tr>
<td>Malawian market-linked maize</td>
<td>High (5.0 h)</td>
<td>Medium (183 d); Medium altitude (974 m)</td>
<td>8.8 mha; 3.8 mha; 11.1 m; .04 m</td>
<td>Monomodal (single crop season), densely populated, small farm size (1.9 ha), few cattle, livelihoods from maize, legumes, oil crops, cash crops, significant seed and fertilizer use, off-farm income.</td>
</tr>
<tr>
<td>Region</td>
<td>Subsystem</td>
<td>Rating</td>
<td>Duration</td>
<td>Altitude</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------</td>
<td>--------</td>
<td>----------</td>
<td>----------</td>
</tr>
<tr>
<td>Central African</td>
<td>Scattered maize-root</td>
<td>Low</td>
<td>(11.7 h)</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Crop</td>
<td>Medium</td>
<td>(199 d)</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1110 m)</td>
<td>Medium altitude</td>
</tr>
<tr>
<td>Mozambiquan</td>
<td>Extensive maize</td>
<td>Medium-high</td>
<td>(6.6 h)</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium</td>
<td>(201 d)</td>
<td>Low altitude (431 m)</td>
</tr>
<tr>
<td>Southern African</td>
<td>Dualistic maize</td>
<td>High</td>
<td>(3.5 h)</td>
<td>Short</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(129 d)</td>
<td>Medium-high altitude (1227 m)</td>
</tr>
<tr>
<td>Zambian</td>
<td>Medium-low population</td>
<td>Medium-low</td>
<td>(10.5 h)</td>
<td>Medium-short</td>
</tr>
<tr>
<td></td>
<td>Maize</td>
<td></td>
<td>(178 d)</td>
<td>Medium-high altitude (1147 m)</td>
</tr>
<tr>
<td>Madagascan</td>
<td>Maize-rice</td>
<td>High</td>
<td>(5.0 h)</td>
<td>Long</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(310 d)</td>
<td>Medium altitude (999 m)</td>
</tr>
</tbody>
</table>

Note: the ratings of low, medium and high for subsystems are relative to the average for the whole maize mixed farming system.
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The northern maize-livestock subsystem in Ethiopia is a mixed system with a medium length crop growing season and a monomodal rainfall pattern. Cattle and trees play important roles in power, energy provision, resilience and diversification of livelihoods. Population density is high and farm size is small. There is a significant area of teff (*Eragrostis abyssinica*), the unique national small-grained traditional cereal, along with cash commodities: haricot beans, sesame and livestock. Animals provide draught power as well as manure. Off-farm income is a major source of livelihoods. Although market access is poor, significantly constrained by poor secondary roads, the extension service is one of the best in Africa, and technical information, improved seeds and fertilizer are available to many farmers. The area of maize has been expanding at about 1 per cent annually since 2000, whereas maize yields have been increasing at around 5 per cent per year. Yields of groundnuts, cassava and other crops are trending up.

The hoe/tractor subsystem of Kenya, Uganda and northern Tanzania is the most populous subsystem. With an average altitude but a bimodal rainfall pattern which underlies a long crop growing season, the subsystem has medium access to markets but fewer cattle than the Ethiopian subsystem. Smallholder dairy is emerging as a remunerative activity in selected areas. Maize dominates the cropping pattern which has better-than-average diversity with significant areas of cash crops, notably coffee, tea, fruit and vegetables. There has been a relatively long tradition of access to improved seed, particularly OPV and hybrid maize, and fertilizer, which has led to recent increases in productivity. Markets strongly influence cropping patterns, particularly for tea and coffee.

The moist bimodal intensive subsystem with high population density is found in the hilly environments of Rwanda and Burundi. Farm sizes are small and land use intensity is higher. Services and market access are generally weak with poor development of rural businesses. Cropping systems are diversified, but livestock numbers are relatively low.

The central African scattered maize-root crop extensive subsystem, typified by DRC, is a marked contrast to the above subsystems. Land and water resources are plentiful but infrastructure, services and access to markets are weak and crop yields are low. Notwithstanding the recent expansion of commercial cassava production, maize production has grown rapidly and forest products play an important role. Other cash crops and livestock play modest roles.

The semi-mechanized subsystem in the central and southern parts of Tanzania are diversifying with medium market access, notably cotton, tobacco and the expanding market chains for pigeon pea exports. Farms are medium sized with livelihoods derived from hybrid maize, beans, pigeon pea, sorghum, cotton, vegetables and off-farm income.

The medium intensity subsystem of Malawi has far fewer livestock than other subsystems, which has implications for livelihood portfolios, risk management and the management of biomass and nutrient flows at the farm and landscape levels. The monomodal rainfall of Malawi limits the diversification options available compared with comparable bimodal areas. Legumes, especially groundnuts, and cash crops are important.

The medium population density subsystem in Zambia has monomodal rainfall, farm size is medium-large and external input use is low. Cultivation depends on hoe, animal draught and tractor power. Livelihoods are mixed, from maize, root crops, pulses, livestock and off-farm income.

Madagascar (upland rice and irrigated subsystem) has a major secondary cereal, upland rice, to complement the maize crop, partly because of major areas of irrigation. Farm sizes are small yet farmers can take advantage of employment opportunities arising in neighbouring farming systems and cities.
Mozambique has a relatively extensive system, with medium farm sizes and several other food grain crops including sorghum with medium-high market access, illustrated by the significant commercialization of cassava and sorghum. Nevertheless, off-farm income from migration to South Africa is a major source of livelihoods.

South Africa and Zimbabwe show dualistic land tenure arrangements: a mix of smallholder and large commercial farms. Smallholders have notable off-farm income, both in agriculture and industry. Land tenure changes mean large farms may decline in coming years.

Broad development needs vary across the subsystems. For policy makers, it is worth noting the differences in the crop-cattle ratios across the overall system. Livestock availability (and access to draught power) varies widely. Market development is very poor in some subsystems.

**Trends and drivers of change across the system**

There are seven major drivers of change of the system: population, natural resources, energy, knowledge, technology, markets and policies. In broad terms, the cultivated area will increase from 40 mha to approximately 49 mha by 2030 (authors) with higher rates of expansion in several medium-low population density subsystems, notably the subsystems of central Africa, Zambia and Mozambique. Land use and livelihood patterns will evolve substantially by 2030. As a past example using the period 1961–1999 in Kyamtware division, Bukoba district, Tanzania, the area of grassland declined by 40 per cent while cultivated fields increased in area by 225 per cent. The cultivation of maize and root crops in pure stands became more prevalent. Farmers reduced the cultivation of the traditional small food grains, sorghum and finger millet. Indigenous cattle numbers halved while dairy expanded (but concentrated in fewer households). Cattle-owning households decreased by 85 per cent. Increasing population density, changing land tenure, distribution and economic policies, and poor crop markets were the major drivers of the changes (Baijukya et al. 2005).

Maize cropping will displace lower yielding and more labour-intensive traditional food crops. The proportion of smallholder farm households who are net purchasers of staple crops, typically selling produce at harvest time to bring in needed cash, will grow (Jayne et al. 2004). New market opportunities will emerge for smallholders with access to technologies and resources. The prevailing increases in rural populations will drive significant intensification and diversification.

**Population, hunger and poverty**

Increasing population density will continue to shape the system in the future. The traditional maize mixed system developed to optimize the use of family labour over the medium length growing season, originally by using shifting agriculture. Where family members find off-farm employment, labour shortages may occur. In recent times the land frontier has nearly closed in some subsystems, for example Rwanda or Malawi. Where there is little new employment outside agriculture, this accelerates the ongoing reduction of farm size (see discussion in the next subsection) and increases land fragmentation – constraining farm growth, intensification and diversification options for the next generation.

Except in a few densely populated areas with reliable access to irrigation (such as on the slopes of Mount Kilimanjaro or Madagascar), the farm size of smallholder hoe agriculture
was determined by the capacity of the household to cultivate and weed the cropland. With animal draught power, households can cultivate up to about two ha (Figure 3.3). Mechanical power, either small two wheel or larger tractors, enables farms to cultivate larger areas where land is available or consolidation possible. Mechanized land preparation is becoming an option for smallholders who can afford it, and mechanized land preparation is expected to become more widespread during the 2020s.

The rural population in east and southern Africa (which includes towns and service centres) has grown rapidly since 2000 – faster than in other regions of the world, even as the region is urbanizing rapidly. The farm population of 107 million in the maize mixed farming system confronts a massive challenge: their own food security as well as that of another 74 million living in cities within the area of the system. This excludes exports to other countries and to nearby lower potential areas. Urbanization is increasing the total demand on local food production and serves to encourage farms into higher value products.

The farming population is getting older, which may impede investment in farm resources and adoption of new technologies. As an increasing proportion of households are female-headed, new constraints related to land tenure and access to credit and other services emerge.

Human health and farm productivity are closely related. Even before the devastating effects of the AIDS pandemic, labour was often seriously short at critical periods of the
crop cycle such as planting and weeding. The start of the rains often brings diarrhoea and malaria. For women-headed households for whom family labour is particularly scarce, illness of a family member often results in late planting or weeding and low yields of food crops. To feed her family, she will need to work for nearby farmers, typically planting or weeding — a downward spiral creating much of the poverty in the system.

Hunger and poverty trends are causing widening socioeconomic differentiation. Poverty limits purchasing power and ability to acquire external inputs even where input markets are functioning, as well as access to credit. Hunger reduces labour productivity and limits the effectiveness of government educational and development programs. In some areas of high population density with limited external employment opportunities, the farming system is trending rapidly towards crisis, often exacerbated by the inaccessibility of productivity-enhancing modern inputs such as improved seed, fertilizer and agro-chemicals. Farm households move, most often to peri-urban slums (see Chapter 16 for an analysis of the urban and peri-urban farming system). Retrenchment of off-farm workers, coupled with policy reforms removing subsidies for food crop inputs and food grain prices, is a double blow to many of the poorest in the system.

Where off farm employment opportunities exist, population growth can augment the supply of labour in secondary and tertiary industries, and boost the demand for food. The increased demand, whether rural or urban, strengthens food grain and other markets and expands farmer opportunities. With rising incomes and shifting food preferences of consumers to include non-staples, smallholders can benefit from diversification to high value crops, livestock (including dairy) and fish.

Natural resources and climate

Both climate change and availability of natural resources are major determinants of farming and food systems. As an outcome of population pressure in the system, typical cultivated areas of smaller farms have fallen in some places to less than 0.5 ha (compared with the average farm size of 2.1 ha across the farming system). Such small farms operated under rainfed conditions with only moderate market access do not produce enough food or other livelihoods for households. Their livelihoods are commonly supplemented by off-farm earnings. Encroachment of cultivation into scarce grazing land will mean a reduction in cattle numbers in some high population density areas such as Malawi where cattle for draught power are almost totally absent.

Trends in farm size distribution indicate that population growth, urbanization and the changing composition of the economy will push towards smaller farm sizes1 (Figure 3.4), and greater fragmentation of farms (Mallawaarachchi et al. 2014). In some areas informal arrangements to increase the managed farm area exist so that even without firm legal title to land the existence of conservation and investment incentives is possible (Bezabih et al. 2016).2

There are signs of serious fertility decline over much of the system. Key issues for farmers include the high cost of mineral fertilizer relative to the price of maize and other crops (at existing productivity levels), the difficulty of maintaining soil fertility, shortage of livestock to produce manure due to feed shortage, and the lack of oxen for farm power. Importantly, soil nutrient deficiencies mean that the crop can make effective use of only 10 to 15 per cent of total rainfall.

Climate change and the associated progressive increase in temperatures and decline in precipitation are expected to reduce maize and other crop yields substantially, especially
in southern Africa (Thornton et al. 2010). The end date of the rainy season is more reliable than the start; there is evidence of onset of the rain becoming later thus reducing the growing season. Farmers struggle to manage their systems as climatic variability and extreme climatic events (droughts, for example) increase. They are forced into low-risk and sometimes lower yielding production patterns.

**Energy**

Energy is a critical input to agricultural intensification and also to value chain function essential for transformation of the system. Some traditional energy inputs, biomass, labour and animal power, are available in some parts of the system. A transition from biomass to modern renewables and fossil fuel-based traction and transport is expected. Fossil fuels and electricity availability is growing in the more accessible parts of the system. There are ambitious plans for expansion of grids in the 2020s. Solar, wind and other renewable are attracting increasing investments for the 2020s, which will facilitate intensified water pumping, production, processing and transport. There are likely to be major farming system changes as value chains develop for more extensive subsystems such as in central Africa.

Many maize mixed farms typically use slow, inefficient and physically demanding manual cultivation techniques (complemented with animal draught where available). These are particularly challenging for the elderly and women who remain on the farm, when the more able-bodied seek better paid employment elsewhere. Weeding is labour and energy intensive; labour can be reduced by technology (such as herbicides and animal draught – where accessible). Weeds and the pay-off to better weeding, increase with intensification, and with much diversification. Draught availability has been compromised in the southern parts of the system where the droughts of the 1990s, followed by Corridor...
disease, decimated draught animal populations. The record of government-sponsored tractor schemes is poor. In the wealthier parts of the system, there is some growth in four- and two-wheel tractors for production, local transportation and water pumping.

While mechanization is progressively saving labour and human energy inputs to annual crop production, the gradual uptake of reduced tillage is beginning to reduce the labour requirements for crop production. Reduced tillage is generally associated with some additional energy inputs including fertilizer. Such improvements in production practices generally lead to increased energy use efficiency. Such promising technologies require further testing under local conditions (Andersson and Giller 2012; Giller et al. 2009) if they are to expand in future decades.

The intensification of livestock production is also increasing energy requirements. Dairy, small ruminant fattening operations, and semi-commercial poultry production will increase energy requirements in farming – for example, milk cooling, refrigeration and transport – especially in the subsystems with better market access in Kenya and South Africa.

Biomass is the principal source of domestic energy but is becoming increasingly scarce with the loss of forests. Tree production on the larger and better endowed farms is becoming more widespread, in part to enhance family fuelwood supplies.

**Human and social capital**

One of the most important drivers for development of the system will be widespread knowledge of innovations, markets and policies. The traditional separation of roles for food and cash crops between women and men has been breaking down in many areas as men have sought work outside the community. Women have been empowered by universal (male and female) education, market access, new technologies (mobile phone money transfers) and farming system innovations (crop-livestock integration, stall-fed dairy production). In Zambia, the growing roles of women in farm household decision making has been documented (van Koppen 2001).

Countries are planning for major increases in agricultural productivity, employment and profitability of the maize mixed farming system. But consideration of the human resources necessary to implement these plans is typically based on unrealistic and highly optimistic assumptions and generally overlooks aspects related to gender. Investment in human capital development overall has been constrained by weak support for universities. Public sector hiring freezes have eliminated an important avenue through which young graduates gain experience.

A deficit is emerging of young agriculturalists, especially women, gaining professional experience in agricultural services – a major challenge when the current generation of experienced African agriculturalists reaches retirement (Cabral and Scoones 2006). Transformation of the system needs better-informed and supported decision making by producers and value chain operators – service providers, aggregators, traders and processors – supported by service providers with interdisciplinary and systems competencies.

There is change. Not only are younger farmers better educated, but most farm households are better informed about labour, input and produce markets and available technologies. The improvement of rural communications, including radio, TV, sometimes internet and especially mobile phone connectivity will underpin a revolution in knowledge sharing to boost productivity and resilience of the system. Growth in the availability of innovation and market knowledge will be a major driver of change,
most especially in the low population density subsystems in Central Africa, Zambia and Mozambique. Along with ICT-based communications will come a variety of decision support tools which will improve management decisions of farm women and men and value chain operators.

**Science and technology**

Since 2000 the investment in market, agricultural services and policy research has expanded considerably, in line with the growing awareness of the complementarity between technology, market access and enabling policies. Smallholder choice among improved varieties and breeds and complementary production, processing and storage technologies has grown. However, despite the availability of yield-enhancing technologies in most countries of the system, food crop productivity increases have been modest and gaps between farm yields and attainable yields remain large.

The situation is improving. About 160 drought tolerant maize varieties have been released since 2006, and provided coverage of the total system by 2015. African seed companies are actively producing and marketing seed of these varieties to smallholders, and the commercial provision of seed will expand over coming decades. The new drought tolerant varieties have at least 30 to 40 per cent yield advantage over existing materials under severe stress, and similar yield advantage under optimal conditions (Shiferaw et al. 2011). Many new productive and abiotic/biotic stress resistant varieties are expected to be released during the 2020s, including nitrogen-efficient maize varieties. There has also been substantial progress in improved cassava, bean and pigeon pea varieties.

Despite the development of improved varieties for the maize mixed system, many food crop producers use farm-saved seed due to access issues. In one survey about 82 per cent of rural households identified maize seed supply as a major agricultural constraint (Langyintuo et al. 2010). Farmer and other civil society groups are now organizing farmer-based seed multiplication systems linked to farmer-based knowledge sharing of technical information. There are widespread exchanges of seeds among farmers in neighbouring areas and even countries. Donors and NGOs also distribute free kits, especially to the poorest farmers.

Researchers have also made great strides since 2000 in improved crop management to complement the genetic gains. Good crop management has underpinned the expansion of pigeon pea and the noteworthy development of the export industry. Substantial progress has been made across the maize mixed farming system on adapting conservation agriculture to the maize legume cropping system in a majority of the subsystems, from Ethiopia to Mozambique. Recent results from SIMLESA agronomic studies in Malawi and Mozambique confirmed the added benefits of conservation agriculture-based sustainable intensification practices evaluated on farmers’ fields resulting in 30 to 60 per cent yield advantage, 40 per cent labour cost reduction and improved soil fertility (Nyagumbo et al. 2015).

Sustainable resource management research will target widespread land degradation and declining soil fertility with a view to landscape restoration, soil recapitalization and improved productivity. Farmer-managed natural regeneration of indigenous trees on maize croplands is being adopted in Malawi as a practical and low-cost response to these constraints. Lack of moisture can be alleviated by small-scale irrigation and water harvesting—fostered by participatory, applied research focused on integrated technologies blending indigenous and scientists’ knowledge.
The combination of adapted technologies and market demand will increase diversification to incorporate dairy or other livestock into the maize mixed system. The development of small-scale dairy management systems in the Kenyan and Tanzanian subsystems has been impressive, and further adaptation can be expected as these systems expand into new areas. Such diversification generally creates a demand for research on forage species and management practices, as well as other crop-livestock integration technologies such as improved feeding systems for cross-bred dairy cattle and small ruminants.

The integration of perennials into the maize mixed farming system is expected to increase. Based on over two decades of intensive research, the incorporation of fertilizer/fodder trees into the maize mixed system is now being promoted as a means to enhance both fodder production and soil fertility under either full or reduced tillage (e.g. FAO 2010, 2011). These practices are currently being extended to hundreds of thousands of farmers in Malawi and Zambia (Akinnifesi et al. 2010; Garrity et al. 2010). Integrated soil, plant and landscape computer modelling has expanded massively and broadened to include livestock and trees, and ultimately household consumption and management decision making. While public sector investment in research declined in the years leading up to 2015, and there was little growth in private investment. As the system becomes more commercial and diversified, private sector investment will grow, and industry and farmer groups will invest in adaptive research on production and processing methods.

Trade and markets

While market access for most agricultural commodities has developed rapidly since 2000, albeit somewhat unevenly, scaling out technological innovations requires reliable and competitive input supply chains (including seed, fertilizers and pesticides) and knowledge dissemination accompanied by produce marketing. But developing an efficient input-output value chain is costly when demand for inputs is erratic and marketed output highly variable. Although the business environment for small- and medium-sized enterprises is improving in eastern and southern Africa, there are still significant constraints to effective rural value chain operation. These include private sector access to public technologies and know-how including germplasm, limited availability of experienced and qualified staff, lack of awareness/demand among farmers and lack of access to credit (for both agribusiness and farmers). Weak rural institutions for delivery of services and inadequate farmer organization contribute to poor capacity for remedying market imperfections in the supply of key inputs and marketing surplus produce. This affects seed companies, input suppliers and equipment distributors alike.

Technical change requires improved market access – both to stable output markets offering remunerative prices, and to input and finance markets to support the purchase of inputs, machinery or labour hire, or investment in equipment or infrastructure (Ebanyat et al. 2010).

Since 2000 the input/output price ratio for maize steadily deteriorated following trade reform and price liberalization. Following the removal of input subsidies, the dismantling of price supports, withdrawal of the state from grain purchasing and abolition of pan-territorial pricing, most smallholders struggled to adjust to rising input prices and declining maize grain prices. Alongside this, smallholder input supply, credit and marketing services collapsed and the private sector response was less than anticipated. As
governments withdrew from seed production, the private companies focused on hybrid maize. Smallholder access to good quality open-pollinated seed (OPVs) (not only of maize but of vegetables and other minor crops) has been a problem until small domestic seed companies in Uganda, Zimbabwe, Mozambique and Tanzania then began to produce and market OPVs.

In some countries, there is now a significant private sector seed industry. Langyintuo et al. (2010) estimate that around two-thirds of all seed sold through the formal sector is maize. In the late 2000s, there were nineteen registered maize seed companies in Angola, Ethiopia, Kenya, Malawi, Mozambique, Tanzania, Uganda, Zambia and Zimbabwe. Today, a total of about eighty companies in the same nine countries produce and market 103,600 tons of seed, sufficient to cover 35 per cent of the maize area (Langyintuo et al. 2010). Given that the number of seed companies increased four-fold between 1997 and 2007, but the quantity of seed marketed barely doubled, this suggests that the seed production and deployment environment is less than favourable.

Langyintuo et al. (2010) exhaustively analysed the maize seed value chain and noted several critical bottlenecks which apply, in the main, to the seed systems of other improved crops. Establishing a seed production facility is expensive and capital is difficult to access. Thus the seed sector is largely monopolized by the large regional and multinational seed companies. The transfer of genetic materials between public and private sectors is inefficient. Rapid regional spillovers of varieties released in one country to similar agroecologies in different countries are compromised by a failure to implement harmonized regional seed laws and regulations. Over a third of seed companies surveyed considered production bottlenecks as the dominant constraints, followed by policy and company establishment constraints equally in second place.

Policies and institutions

Although national policy development receives considerable attention, the key role of institutions at local level is frequently overlooked, even though they are instrumental in shaping the incentives and behaviour of farmers and value chain actors. There is considerable variation across the system in the dependence on free market development. Despite improvements in business-friendly policies, agribusiness has grown less rapidly than expected since the late 2000s. Input supply and produce marketing issues persist and are unlikely to be resolved without focused national leadership.

In Ethiopia, cereals form a consistent one-third of agricultural Gross Domestic Product. Mellor and Dorosh (2010) emphasize that to expand and sustain cereal productivity, major policy changes to both seed and fertilizer markets will be required. Current policy is for fertilizer distribution to be undertaken through the cooperative movement, but expansion of access to fertilizer will require greater participation by the private sector (Spielman et al. 2010). Access to maize seed is a major problem, with little growth in the production and marketing of certified seed. There are major bottlenecks in the production of breeder, foundation and certified seed, and greater participation by the private sector in seed production is needed. Furthermore, the research sector needs to increase the amount of breeder seed produced (Mellor and Dorosh 2010).

Tripp and Rohrbach (2001) document earlier constraints in the commercial seed sector. These included a seed regulatory framework that favoured parastatal enterprises, together
with government and donor projects that provided seed to farmers for free or at subsidized prices. There has been significant deregulation of the seed sector in many countries in the maize mixed cropping zone and a consequent proliferation of private seed companies (Langyintuo 2004). However, seed producers remain heavily focused on hybrid maize seed production; few seed companies are actively involved in open pollinated maize or in improved legume seed production – with the arguable exception of groundnut seed for export. Important constraints include difficulty in raising the substantial capital required to establish a new seed business, problems associated with gaining access to improved germplasm, and government policies which prevent or discourage seed trade within the region. Where these difficulties have been overcome, the price effects can be remarkable. In Uganda, the entry of small seed companies into the industry lowered the average price of hybrid maize seed by about 40 per cent to about US$1.20 per kg in 2008, and in Zimbabwe, reduced the price of hybrid maize seed by some 15 to 20 per cent.

Dorward et al. (2008) describe the challenge of the ‘price/productivity tightrope’, which creates an important policy dilemma in encouraging staple food intensification. The elements of the tightrope are: producers need high returns from investment in new technologies in order to provide them with incentives to invest in productivity-increasing technologies; and poor consumers need low prices for food security and welfare, and to raise real incomes to drive and support growth. Policy needs to tread a fine line between providing attractive incentives to producers to adopt new technologies and keeping cereal prices low (and preferably declining in real terms over time) so poor consumers can afford to purchase them. One of the major agricultural policies implemented across the maize mixed cropping area has been a series of structural adjustment programmes (SAPs) intended to reduce the dominance of government in the economy. The private sector players consequent on SAP implementation were unable to provide the services needed by smallholder farmers (Gabre-Madhin 2007). SAP implementation failed to address the price/productivity tightrope problem.

Short run attempts to deal with the food price tightrope problem include policies which focus on various combinations of input subsidies, output price subsidies for farmers and for consumers, and social protection to raise the incomes of the poor. The potential impacts of subsidized input costs have gained considerable attention following recent actions by the Malawi Government (Box 3.2). Subsidies can come at a major cost to other sectors of the economy (plus other inefficiencies), although the contributions to food security, poverty reduction and economic growth can be considerable (see, for example, Minde et al. 2008). An effective programme requires that the basic input technology is reliable and potentially profitable, and that the design of the input subsidy takes into account the effects on the overall rural economy. A prior and complementary investment in public goods and services (roads, agricultural research and extension, market development infrastructure) is critical. In the absence of such investment, generalized subsidies of this type have a negligible impact on poverty as the principle beneficiaries are those who already purchase inputs. Furthermore, the costs to government can quickly spiral out of control since the government does not control the international price of inputs, the exchange rate and input demand. Subsidized inputs create major incentives for cross-border trade, and uncertainty regarding government intentions seriously disrupts trade as importers and farmers wait to see the magnitude of the subsidy before placing orders (Conroy et al. 2006).
Box 3.2  The law of unintended consequences in policy

Well-intentioned government actions can exacerbate food insecurity. For six months in 2001/02, Malawi experienced a food crisis. Drought and the sell-off of the Strategic Grain Reserve were factors in the crisis, but the major cause was a sudden spike in consumer maize prices in late 2001. This problem was attributable to the adverse impact of government policy on maize supplies from the private sector. ADMARC (the public sector marketing board) had tried to stabilize maize prices by subsidizing them below prevailing market prices. As a result, private sector traders saw no opportunity to sell at a profitable price in Malawi and made few plans to import maize into Malawi. Instead there were incentives to export cheap Malawian maize to neighbouring countries where prices were higher. As the ‘hungry season’ progressed, ADMARC depots ran out of maize and consumers turned to private markets – which had little maize. Prices skyrocketed (Conroy et al. 2006).

Interest is growing in programs to link input subsidies with more sustainable ways of enhancing soil fertility. For example, fertilizer subsidies in Malawi are accompanied by the distribution of seeds of legume crops such as pigeon peas, and trials are underway to link the provision of fertilizers with the establishment of leguminous fertilizer trees at appropriate densities in maize fields (Garrity, D. 2014, pers. comm.).

However, in eastern and southern Africa the incentives for large firms are inadequate to address the problems of dispersed, risky and low value staple food crops markets (Barrett, 2008; Dorward and Kydd, 2004). Contract farming and interlocking transactions can be effective where there are limited numbers of produce buyers and/or there are long-term stable incentives for farmers to work in groups to access finance, advisory, input and output market services – typically involving cash crops (cotton, tea, tobacco), although there are examples where these are extended to staple food crop production (Chirwa and Kydd 2005; Chirwa et al. 2007; Jayne et al. 2004).

System performance

System performance is considered from the perspectives of productivity, resilience and sustainable development including human development outcomes. Where possible, sustainability and resilience are considered through an ecological, social and economic lens. It should be noted that about half (56 per cent) of the farm population can be rated as extremely poor (daily consumption of less than US$1.90 in 2015) with low welfare and food security. Although many household surveys offer point estimates of system performance and national statistics report agricultural sector performance, aggregate data with which to assess farming system performance are limited.

Despite several decades of sound agricultural research, food crop productivity is low and yield gaps are large. The productivities of selected major crops in the maize mixed farming system are summarized in Table 3.4. Average yields are, in 2015, relatively low for all the crops, well below achievable yields for these crops in this farming system environment. Investments in enhancing agricultural production are generally low. Stagnant or declining agricultural productivity and limited biomass availability are important issues within the system.
Biotic, abiotic and socioeconomic constraints limit the productivity of maize and legumes in particular. Despite improved market access, institutional and socioeconomic constraints weaken price signals for market production. Figure 3.5 illustrates how maize yield gaps can be disaggregated by major constraints in the maize mixed system (Waddington et al. 2010). The importance of abiotic constraints – soil fertility, nitrogen and drought – is striking. At low yields the influence of biotic factors are relatively modest although crop pests and diseases are often reported as significant. Post-harvest pests are also important due to poor on-farm storage on smallholder farms. Gibbon et al. (2007) estimated that the main abiotic constraints accounted for about 1.4 t/ha maize yield loss and biotic constraints accounted for around 0.75 t/ha yield loss. Weed competition, often as a result of late planting into exhausted soils and delayed manual

Table 3.4 Productivities and yield gaps of major crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Average yield (t/ha)</th>
<th>Proportion of farm (%)</th>
<th>Yield gap (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>2.1</td>
<td>35</td>
<td>79</td>
</tr>
<tr>
<td>Paddy rice</td>
<td>2.7</td>
<td>5</td>
<td>67</td>
</tr>
<tr>
<td>Cassava</td>
<td>10.9</td>
<td>19</td>
<td>59</td>
</tr>
<tr>
<td>Beans</td>
<td>0.9</td>
<td>14</td>
<td>54</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>1.1</td>
<td>6</td>
<td>81</td>
</tr>
</tbody>
</table>

Sources: FAOSTAT for yield; authors for proportion of system cultivated land; and van Velthuizen (2015, unpublished) for yield gaps.

Notes: Other root crops are grouped with cassava; and other pulses are grouped with beans.

![Constraints to maize yield](image)

Figure 3.5 Relative importance of constraints to maize yield in the maize mixed system.

Source: Waddington unpublished data.
weeding, severely limits crop yields. Increasing from a single weeding to two weedings can double yields even on low fertility soils.

Waddington et al. (2010) estimated larger yield gaps for cassava, comprising approximately 2.5 t/ha from abiotic constraints, 3 t/ha from biotic constraints and a substantial 6.5 t/ha from socioeconomic and management constraints. Wairegi et al. (2008) indicate a similar picture for banana in Uganda. Yield gaps are much smaller for sorghum and cowpeas: for sorghum Waddington et al. (2010) estimate 0.4, 0.25 and 0.6 t/ha respectively for abiotic, biotic and socioeconomic/management constraints; and for cowpea 0.2, 0.25 and 0.45 t/ha respectively. Notwithstanding differentials in market access and product prices, there is a *prima facie* case for investing more in yield gap reductions for maize and cassava rather than sorghum and cowpea. No equivalent analyses of livestock performance gaps were found in the literature.

The proportion of area under improved maize germplasm varies in the maize mixed system from 18–19 per cent in Tanzania and Ethiopia, to 72–73 per cent in Kenya and Zambia (La Rovere et al. 2013). The area under improved varieties is increasing, and the same authors forecast that proportions of improved maize will approximately double in the ‘low-adopting countries’ and increase by about one-fifth in the high-adopting countries. Nearly all the improved maize seed is distributed through small and medium seed companies (Langyintuo et al. 2010).

With the right combination of innovations (including improved germplasm and fertiliser), institutions and policies, impact is evident (Figure 3.6). Ethiopia has doubled its maize productivity since the late 1990s. Maize yields grew at an annual rate of

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**Figure 3.6** Maize fertilizer response was from Nsipe, Ntcheu district, in Central Malawi, with Dr Regis Chikowo illustrating the difference between recommended fertilizer (69 kg N/ha + 23 kg phosphate fertilizer) vs no fertilizer.

Source: Sieg Snapp.
Figure 3.7. a Relative suitability of main crops to the maize mixed system (low inputs); b Relative suitability of main crops to the maize mixed system (high inputs).

Source: van Velthuizen et al. (2013).
68 kg/ha between 1990 and 2013 (Abate et al. 2015). The use of improved maize varieties approximately tripled between 2004 and 2013, and inorganic fertilizer use in maize approximately doubled.

A second system performance characteristic is resilience, especially in the context of increasing pressure from climate change and variability, notably droughts. Fortunately, the diversity of farm household enterprises, both crop and livestock, in the maize mixed farming system may be greater than any other African farming system, and foster ecological resilience in the face of increasing climatic stresses, shocks and biotic stresses. The presence of perennials in the system adds to ecological resilience.

The crop diversity of the maize mixed system is supported by the suitability of the major crops of the system to the soils and climatic environment (Figures 3.7a and 3.7b). About 80 per cent of this zone consists of prime land for high input farming, but only about 10 per cent of the maize mixed system is currently cultivated. Under prevailing low input management, at least a dozen crops are well adapted to this farming system (Figure 3.7a). The relative suitability of these crops increases with high inputs with good crop management (Figure 3.7b). The differences between high input and low input suitability profiles are explained by pest, disease and workability constraints in the wetter part of the farming system and, overall, due to natural soil fertility constraints.

Many species of perennials and several species of livestock, poultry and fish are very suitable for the farming system, which underscores the adaptability of the farming system to changing climate. Resilience also derives from the number and diversity of livelihood sources. The seasonal variability of livelihoods is often negatively correlated, and thus crop, livestock and off-farm income move in different cycles. Farmers and the local institutions are relatively adaptable and resilient, especially given increasing educational levels and growing access to knowledge. This is reinforced by decentralization. Thus the farming system contains a moderately high inherent level of resilience to uncertain climatic, market and policy environments.

In relation to overall system sustainability, productivity, social parameters and economic conditions (including food security) are slowly improving. While area expansion (extensification) used to underpin growth in food production, recently it has derived from a mix of area expansion and yield increase. Smallholders are responding to the increasing demand for food mainly by expanding or shifting crop fields or increasing herd sizes. In most countries fallow land has almost disappeared and continuous cropping is the norm (Twomlow et al. 2006). Marginal lands are being cultivated and remaining grazing areas and woodlands are overexploited, resulting in degradation of the resource base and lower yields per hectare. In Table 3.5 the yield gap is included for ease of reference. Of the five crops examined, annual area expansion varied from 0.5 to 4.2 per cent whereas annual yield growth rates fell in the narrower range of 1.5 to 2.2 per cent.

Another aspect of economic sustainability is the accumulation of assets. The differences in rural household wealth depend significantly on external factors such as off-farm earnings, their reinvestment in farming or commercial enterprises, and the health of working family members rather than the profitability of farm enterprises per se. The upper stratum of farm families has more and better farmland, more cross-bred dairy cattle and larger areas of cash crops. Irrigation is more likely to be found on medium and larger farms. They also use more fertilizer, agro-chemicals and hybrid seed, as well as taking more credit (all land-augmenting technologies). Poor households consist of landless or marginal farmers, often with no cattle (40 per cent of households), no regular off-farm earnings and no high value crops. They grow mostly local maize for home consumption and cannot afford to buy
fertilizer or hybrid seeds. A family can rapidly move from the upper stratum to poverty as a result of illness in the household (Conroy et al. 2006).

Institutional barriers constrain farm performance. With typical government policy to encourage the movement of labour out of agriculture into the modern industrial sectors (Lele et al. 2010), with remaining producers taking up adapted international knowledge and technology, this approach has meant that formal and informal links between the research and the extension services are poor, and scientists receive little feedback on farmer response to technology choices. Access to markets is constrained by high transaction costs due to the lack of infrastructure, particularly rural roads, and a constraining overall policy and regulatory environment governing market transactions (including tax regimes and licensing requirements and costs). Agribusiness is weak and development is hampered by poor service provision to smallholders and the absence of functional cooperatives and strong farmer organizations in the agricultural sector. The many landlocked countries have poor access to international markets both for imports and exports, made worse by trading, licensing, and quarantine rules, and transport restrictions (Conroy et al. 2006).

Where these constraints are addressed effectively, change is significant. Kenya, by a combination of liberalizing crop input and output markets and support to smallholder agriculture, increased smallholder fertilizer use by 34 per cent and maize yields by 18 per cent in the decade ending 2007 (Ariga and Jayne 2009). Kenya has an active and thriving indigenous seed sector. Marketing margins, of both crops and inputs, have declined

Food prices remain stubbornly high in the system. The region overall has a typical net food import of around 10 per cent or more (a proportion is emergency food aid). Drought is not the main cause of poverty; chronic poverty is strongly related to the availability of the two major resources: family labour (especially at the critical planting and weeding periods) and remittances (Conroy et al. 2006; Tiffen et al. 1994). While there is significant variation between households in access to resources, such as farm size, land quality and agricultural services and markets, a key determinant of poverty is labour availability (both human and animal traction). The poorer the household, the more the diet is dominated by cereals. In ultra-poor households, cereals represent 82 per cent of calories consumed. Urban diets are less dominated by cereals with sugar and oil products accounting for almost 20 per cent (Conroy et al. 2006; Mtimuni 2004). In significant areas of the system nearly half of rural children are stunted (measured as greater than two standard deviations from expected growth rates) compared with about a third of urban children (Conroy et al. 2006).

Table 3.5 Main crop expansion and productivity growth rates

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area expansion rate (% pa)</th>
<th>Average yield (t/ha)</th>
<th>Yield growth rate (% pa)</th>
<th>Ratio yield growth to area expansion</th>
<th>Yield gap (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>3.9</td>
<td>2.1</td>
<td>2.1</td>
<td>0.5</td>
<td>79</td>
</tr>
<tr>
<td>Rice</td>
<td>2</td>
<td>2.7</td>
<td>2.2</td>
<td>1.1</td>
<td>67</td>
</tr>
<tr>
<td>Cassava</td>
<td>0.5</td>
<td>10.9</td>
<td>2</td>
<td>4.0</td>
<td>59</td>
</tr>
<tr>
<td>Beans</td>
<td>4.2</td>
<td>0.9</td>
<td>1.5</td>
<td>0.4</td>
<td>54</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>2.8</td>
<td>1.1</td>
<td>2.2</td>
<td>0.8</td>
<td>81</td>
</tr>
</tbody>
</table>

Source: FAOSTAT for area expansion and yield growth; van Velthuizen (2015 Unpublished data) for yield gaps.
Strategic priorities for the system

Long-term agricultural growth prospects are promising and the potential for reduction of poverty is high. Five dominant pathways for reduction in farm household poverty (farm household poverty escape pathways) were documented by Dixon et al. (2001). Updated estimates of the relative importance of the different growth pathways to 2025 in the maize mixed system are shown in Table 3.6. This assessment shows the contributions to rural household income of on-farm diversification as well as non-farm activities – and makes explicit reference to exit from agriculture, where families enter non-farm occupations. The contrast between poverty escape pathways of extremely poor households and income growth pathways of less-poor households is clear. Intensification is an important pathway for all categories of household; off-farm income and diversification are essential for extremely poor households (intensification – increased productivity through increased efficiency of production; diversification – a change in farm practice, typically through new production or value-adding enterprises).

In the maize mixed system diversification is considered the most important pathway for escape from poverty. Most frequently, intensification precedes significant diversification, as farmers gain experience in managing production, risks and markets. As climate change-induced variability in rainfall increases, diversification gains importance in spreading risk and buffering maize yields. Compared with estimates in Dixon et al. (2001), the updated estimates suggest slightly increased importance of intensification and off-farm income, and reduced prospects for increased farm size (corresponding to the higher population density and lack of spare land to be brought under cultivation).

Strategic priorities for the maize mixed farming system for each system driver considered are summarized later in Table 3.8. For the farming system as a whole, without differentiating the extremely poor from the somewhat better off (less-poor) farm households, key strategic priorities include: increased use of livestock by the poor (wealth and risk management), increased integration of crop-livestock farming, increased use of inputs to improve soil fertility and allow allocation of crop residues to grazing rather than mulch, improved pest management, and diversification of farming.

Livestock production offers farmers great benefits in terms of food security and generating cash. Farmers use animal traction for draught power and the manure as a soil amendment. Where families do not have access to animal draught, household food security is often compromised by late planting and weeding. Selling livestock serves as a survival strategy in times of household stress (Christiaensen et al. 1995; Hoddinott 2006; Moll 2005). Farmers can also use cash from stock sales to invest to enhance overall

<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>% of total age pop</td>
<td>–</td>
<td>56</td>
<td>44</td>
<td>100</td>
</tr>
<tr>
<td>Intensification</td>
<td>2</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Diversification</td>
<td>3</td>
<td>3</td>
<td>4.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Increased farm size</td>
<td>2</td>
<td>1</td>
<td>1.5</td>
<td>1</td>
</tr>
<tr>
<td>Off-farm income</td>
<td>2</td>
<td>2.5</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Exit from agriculture</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: See Chapter 1, ‘Farm household decisions and strategies’ and Chapter 2, ‘Household strategies’.
Maize mixed farming system productivity. With skilful crop-livestock integration, the system can become more diverse, efficient and less risky. The livelihood benefits from feeding crop residues to livestock materialize relatively quickly (FAO 2010).

Addressing strategic priorities for the maize mixed system will require integrated solutions which include increased use of livestock, more integration of crop-livestock farming, expanded use of inputs to improve soil fertility, and diversification. In the extensive mixed subsystems (Table 3.3) there are opportunities for transitions to higher and more sustained levels of intensification and outputs by making more efficient use of crop-livestock interactions (Baltenweck et al. 2003; Tarawali et al. 2011), especially in relation to livestock feed. In the system generally, crop residues as livestock feed become more important as cropping expands into areas previously devoted to grazing (Alkemade et al. 2012). This comes at the significant potential cost to recycling crop residues for soil amendment (Giller et al. 2009; Valbuena et al. 2012). The form and intensity of such tradeoffs depend on local conditions. As a rule, higher crop yields will generate more residues for use for livestock and for return to the field. With the development of efficient livestock markets opportunities for sales of milk and meat will create demand for higher quality forages and feeds rather than their sole use as low quality crop residues.

Various subsidy options have been used to encourage the uptake of ‘productivity-enhancing inputs’. The intensification of maize through the ‘starter pack’ model for distribution of subsidized seed and fertilizer such as in Malawi could be considered, although a sustainable financing model has yet to be found. Box 3.3 outlines the original Malawi program, which was tightly focused on creating a sustainable, evidence-based approach. Not all poverty-reducing intensification will be sustainable (for example, intensification achieved through soil mining) and not all sustainable intensification will be poverty-reducing.

**Box 3.3 The Malawi universal starter pack**

The universal starter pack in Malawi (Blackie and Mann 2005) provided a subsidy for ‘best bet’ technologies (maize in Malawi) free of charge for a specific (and relatively small) land area. The intention was to provide farmers with access to improved varieties and targeted, judicious inputs that were efficient and profitable to apply. This provided a foundation for farmer experimentation, and the resources they needed to start the long haul out of poverty. The subsidy could be varied to promote crop diversification through changing the mix of inputs that are subsidized. Evaluation data showed that all participating smallholders benefited, and distribution and uptake were relatively efficient. The costs were known largely in advance and could be budgeted for. As the program was properly planned and implemented with sufficient lead time, it complemented commercial input supply and did not disrupt trade; indeed, it enhanced participation in agricultural enterprises.

Productive and profitable technologies and practices for improved soil fertility management – and more generally, improved land management and diversification – are essential. Conservation agriculture (CA) is promoted as an important technology
to achieve sustainable resource use and ensure higher crop yields (Erenstein et al. 2012; Mazvimavi and Twomlow 2009). Under this system, retaining crop residues for mulching is a key component for soil amendment and water productivity, but the full benefits materialize over time – although this can be shortened with the addition of fertilizer. A focus on fertilizer use efficiency through improved agronomic practices and enhanced cereal/legume intercropping is essential as fertilizer use efficiency is low throughout the system (Ariga and Jayne 2009; Snapp and Pound 2008). *Faidherbia albida* trees can be incorporated into the system with similar effects. The principles underlying CA will remain a key strategy for a large proportion of farmers who have the resources to invest in mechanization, agrochemicals and herbicide-resistant crop varieties (Giller et al. 2015).

Adoption of sustainable intensification practices (SIPs) (Table 3.7) can improve soil health and water retention while increasing income of adopters. Many SIPs are synergetic; for example, while improved maize varieties can increase income by 14 to 41 per cent, used with other SIPs such as zero till and residue retention, the risk of crop failure is reduced (Teklewold et al. 2013).

Biotic stress is an important cause of low productivity (Figure 3.8). The main option to address pest problems without recourse to costly and environmentally damaging pesticides, is integrated pest management (IPM), disease-resistant varieties and improved crop storage. Resistance breeding (including biotechnology) for crop pests and diseases is an essential investment.

Diversification priorities include improved development of dambo areas for vegetable production, oil seed farming with improved sunflower varieties and manual presses. Others include the promotion of intensive dairying, small-scale pig and poultry production, aquaculture and tree crops. In Kenya, labour-intensive smallholder dairy farms have evolved from previously maize-dominated systems. Improved vegetation cover and pastoral management offer prospects for carbon sequestration.

Enhancing input and output market efficiency is a major priority. Gabre-Madhin (2007) has emphasized the need for ‘getting markets right’ instead of ‘getting prices right’. Getting markets right depends on underlying institutions and supporting infrastructure, requiring guidance from a ‘visible hand’ and a concerted effort by the public sector to facilitate the role and performance of the private sector. Other critical areas include developing profitable irrigation systems, commodity exchanges, market information systems based on rural radio and short messaging systems, warehouse receipts and market-based risk management tools.

Langyintuo et al. (2010) show the dominant factors affecting the demand for improved maize seed are the price of seed and the lack of awareness by smallholder

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**Table 3.7 Adoption of sustainable intensification practices**

<table>
<thead>
<tr>
<th>Practice</th>
<th>Ethiopia</th>
<th>Kenya</th>
<th>Tanzania</th>
<th>Malawi</th>
<th>Mozambique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize-legume rotations</td>
<td>27</td>
<td>26</td>
<td>7</td>
<td>55</td>
<td>17</td>
</tr>
<tr>
<td>Maize-legume intercrop</td>
<td>16</td>
<td>73</td>
<td>54</td>
<td>32</td>
<td>68</td>
</tr>
<tr>
<td>Minimum tillage</td>
<td>24</td>
<td>21</td>
<td>30</td>
<td>5</td>
<td>21</td>
</tr>
<tr>
<td>Crop residue retention</td>
<td>17</td>
<td>48</td>
<td>54</td>
<td>47</td>
<td>89</td>
</tr>
<tr>
<td>Soil and water conservation (ridge, stone, soil bunds)</td>
<td>33</td>
<td>5</td>
<td>7</td>
<td>79</td>
<td>15</td>
</tr>
</tbody>
</table>

Source: Adapted from Tesfaye et al. (2017).
farmers of the potential of this seed (Figure 3.9). Innovative institutions such as private/public cooperation can provide a solution to this demand constraint for a range of species. For example, in October 2004, FIPS-Africa (a Kenya-based NGO) introduced Katumani bean (KB9) as part of their ‘food security package’ for drought-prone areas. The KB9 is a drought- and heat-tolerant bean developed by the public sector research agency, Kenya Agricultural Research Institute (KARI), and is suitable for areas with a short growing season. But farmers neither knew of the bean, nor could they get access to the seed. Through local stockists, FIPS set up a promotion whereby if farmers bought one of their maize mini-packs, that farmer would also get a free 250g packet of KB9 seed to try (together with the necessary agronomic information). Farmers quickly saw that the KB9 bean was well suited to their area and returned the next year to buy more seed. FIPS-Africa initially contracted a local farmer to multiply the seed to meet the immediate anticipated future demand. Today, this open-pollinated variety is produced commercially by the privately owned Western Seed Company and marketed throughout the country (Blackie et al. 2006).

The fertilizer market offers further challenges. The inefficient supply chain, combined with high costs of energy, make fertilizer prohibitively expensive to many farmers in this system. Fertilizer demand problems include affordability (given high fertilizer prices relative to the incomes of poor farmers), significant output price and weather
Figure 3.9 Smallholder farmer demand constraints in the maize seed sector.  
Source: Langyintuo unpublished data.

risks, ineffective fertilizer application practices, and hence low physical grain to nutrient responses. The current policy instrument of choice, drawing on the Malawi experience, is the introduction of input subsidies. The financial and sustainable intensification benefits of these efforts are dubious. ‘Smart subsidies’ (ones that can be used for diversification or regenerative options or as vouchers redeemable from certified rural stockists) can develop, rather than undermine, rural agricultural input markets that serve the poor (Morris et al. 2007).

Ariga and Jayne (2009) point to the potential for imaginative public/private partnerships. The government has a critical strategic role in the early stage of development, especially in remote areas, because it is unlikely that private traders will deliver research, extension and credit services to smallholders, especially to those in remote areas (see Eicher 2004 on Zimbabwe). This has to be complemented by effective support to the infant private sector by creating an enabling environment for business development – including providing macro-economic stability, investment-friendly policies and infrastructure development.

New technologies such as CA and agroforestry require further verification under local conditions (Andersson and Giller 2012; Giller et al. 2009), with research focusing on flexible, judicious input use along with supporting farmer adaptation to local priorities (Giller et al. 2011; Snapp et al. 2003). The availability of information to small farmers is critical in both intensification and diversification. New technologies (CA, agroforestry and IPM) are knowledge intensive. Farmers need the means to judge the best avenues for livelihood improvement for their circumstances. Giller et al. (2011) have developed the Nutrient Use in Animal and Cropping systems – Efficiencies and Scales (NUANCES) framework, which offers a structured approach to identify the ‘best-fit’ technologies targeted to specific types of farmers and to clear niches within their farms. Investment in farmer training, including
the revitalization of farmer training institutes and complementary village and field level education, is indicated.

The rapid development of modern ICTs offers the prospect of a quantum leap in the availability of technical and market information to farmers. Farm production could benefit from the rapid dissemination of information on disease outbreaks, as well as from market information. Financial transactions have been revolutionized in Kenya by M-PESA. As the sector develops, the prospects for job creation in rural chains, especially produce and input chains, will increase (see, for example, Smith et al. 2013). Problems of access to good quality open pollinated seeds can be addressed by promoting farmer-based seed multiplication and agribusiness development (Box 3.4).

**Box 3.4 Seed supply systems**

The seed sector in the maize mixed farming system faces problems which are common to the countries in eastern and southern Africa (but contrast with those of west and central Africa). The public sectors, which have been the engine behind development of the majority of new crop varieties, do not have adequate resources to meet the costs of bulking and distributing seeds of such varieties. The private sector faces many constraints in investing in the improved seed systems for smallholders (Langyintuo et al. 2010). Naturally, the context varies a lot from crop to crop. Through DTMA and SIMLESA, CIMMYT has worked closely with NARS and seed companies to develop a road map for maize seed system development. Through the program ‘Tropical legumes II’, ICRISAT has focused on community seed systems for pulses, including pigeon pea. In Zambia, CARE has supported a community-based seed bulking and distribution scheme for drought tolerant maize and sorghum – supported by agronomy, seed handling and post-harvest storage extension information. AGRA has also invested in strengthening private sector seed companies.

Perhaps the most strategic intervention is refocusing public policy frameworks for developing agricultural businesses and strengthening institutions to support private enterprise. In one sense, there are opportunities for improved policies in the strategic interventions outlined in Table 3.8, not least markets, trade and agribusiness. Policy makers need to address tradeoffs, of which the most challenging in the maize mixed system (and other African farming systems) is the balance between attractive incentives for producers to adopt new technologies and the need to keep cereal prices low enough such that staple foods are readily accessible to poor consumers, both urban and rural. Effective policy making requires a sound evidence base and ideally adopts a multi-sectoral approach, including agriculture, water, health and transport. The most critical long-term policy decisions for the maize mixed systems are the levels of public investments in agricultural research, rural infrastructure and support to agribusiness. Common short-term policy measures include subsidies for inputs, produce and consumption. Interest is growing in public programs to link agricultural intensification with social protection, and input subsidies with more sustainable ways of enhancing soil fertility. The availability of information to small farmers will be a critical factor in creating change within the system.
<table>
<thead>
<tr>
<th>Drivers of farming system evolution</th>
<th>Key interventions</th>
<th>Leading implementers</th>
<th>Implications for farming system structure and function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (increasing), hunger and poverty (reducing)</td>
<td>Improved labour markets and more non-farm job opportunities. Market mechanisms for famine relief, rehabilitation and recovery.</td>
<td>Ministries. World Food Program (WFP). Businesses. NGOs.</td>
<td>Wider access to off-farm employment, income and even opportunities to exit agriculture. Rural urban migration. Inflow of farmers from lower potential agropastoral and pastoral farming systems. Reduced population pressure on land. Increased (1) operated farm size, (2) household income and opportunity cost of labour, (3) yield and income stability and (4) farming system resilience.</td>
</tr>
<tr>
<td>Natural resources (improving) and climate (changing)</td>
<td>Integrated participatory natural resource management including soil fertility management. Improved forest and grassland management. Better adaptive mechanisms to variable climate.</td>
<td>Agricultural extension. Agricultural research. NGOs. Communities.</td>
<td>Improved forest, land and water resource base. Reduced degradation, erosion and flooding. Increased carbon sequestration. Increased land values. Increased crop and livestock productivity. Reduced conversion of forest and grassland to cropping. Reduced substitution of low fertility requiring and low value crops. Increased production and income stability with climate adaptation. Better system resilience.</td>
</tr>
<tr>
<td>Trade and markets (growing)</td>
<td>Invest in transport, processing and storage infrastructure. Reduce barriers to cross-border agricultural trade. Improved market information including ICTs. Expanded financing, savings and banking services. Strengthened insurance markets. Incentives for business investment</td>
<td>Agribusiness. Ministries.</td>
<td>Wider choice and better informed production and marketing decisions. Increased farm gate produce prices. Wider availability of inputs at reduced costs. Increased local trade of intermediate products, e.g. fodder. Greater comparative advantage and increased competitiveness of the systems. Increased resource, labour, input and total factor productivity. Increased farm household incomes and capital for farm improvement and expansion. Improved risk management. Growth of rural economy and initial rural transformation.</td>
</tr>
<tr>
<td>Policies and institutions (improving)</td>
<td>Harmonize agricultural and related rural policies, institutions and technologies. Improve land tenure and markets, and water management. Enable business engagement. Strengthen community institutions for common property management. Massive capacity building for policy implementation staff. Monitoring of policy implementation and impact.</td>
<td>Ministries for formulation and regional/local offices for decentralized implementation.</td>
<td>Synergies between well-calibrated policies, institutions and technologies stimulates farm productivity and sustainable land and water management. Increased benefits to women and smaller size/poorer farmers from inclusive policies and institutions, increasing incomes and reducing rural inequality. Increased rural wage rates. Lower cost and wider choice in inputs. Increased productivity. Increased farm gate grain and livestock prices.</td>
</tr>
</tbody>
</table>
Investment in farmer training, including the revitalization of farmer training institutes and complementary village and field level education, is imperative.

**Conclusion**

Food insecurity, hunger and poverty are extensive, especially among the 80 per cent of the poor who depend on farming for their main livelihood in the maize mixed farming system. There are islands of successful intensification and diversification. A broad-based reduction of poverty is feasible with better policy and institutional environments to boost agricultural productivity. The urban bias against agriculture results in a poor supply of public goods to rural areas. Transaction costs are high, which severely reduces rural incomes. Past investments in agricultural research and extension have been mixed, while terms of trade have been declining. Moreover, poor governance, civil strife, degenerating law and order situations in some areas, as well as widespread gender inequality, low levels of schooling, and HIV/AIDS, are all of deep concern.

The relative abundance of natural resources in the maize mixed system provides the basis for pro-poor agricultural development. This requires appropriate adjustments in national policies, reorientation of institutions and adequate provision of public goods and services. The strategic goal is broad-based inclusive agricultural growth benefiting the poorer sections of each community. Access to agricultural resources by poor farmers will create viable small family farms. Components include: market-based land reform, strengthened public land administration and functional community land tenure. Increasing the competitiveness of small and poor farmers will build capacity to exploit market opportunities. Components include: improved production technology, diversification, processing, upgrading product quality, linking production to niche markets, and strengthening support services including market institutions based on public-private partnerships. Household risk management will reduce the vulnerability of farm households to natural and economic shocks. Components include: drought-resistant and early varieties and hardy breeds, improved production practices for moisture retention, insurance mechanisms and strengthening traditional and other risk-spreading mechanisms.

Improved institutions, including policies and public investment portfolios, are important drivers of improved rural food and nutrition security for the maize mixed system. Better public funding of agricultural research, in particular on sustainable intensification, and transport infrastructure can generate expanded technological and market opportunities for intensification and diversification of farms. Pricing policy has to balance incentives for the adoption of new technologies with the need for affordable and reliable maize and legumes for poor consumers, both urban and rural. Support for business investments into input and produce chains, including transport, storage and processing of maize, legumes and livestock, will create new market opportunities. The availability of technical and market information to small farmers will be a critical factor in farm system transformation which, along with expanded labour markets and off-farm income opportunities, will underpin improved food security and livelihoods in the maize mixed farming system.

**Notes**

1 South Africa was a notable exception where the average farm size continues to increase.
2 For example, in Ethiopia, where the constitutional provisions leave land ownership in the hands of the government, and farmers are only given use rights to land under long-term lease arrangements, the annual average growth in agriculture has been around 6 per cent in recent years.
3 SIMLES – Sustainable Intensification of Maize–Legume Cropping Systems for Food Security in Eastern and Southern Africa Program is supported by ACIAR and managed by the International Maize and Wheat Improvement Center (CIMMYT) in collaboration with the sub-regional and national research organizations, Australian universities and other centres.

4 Corridor disease (**Theileria parva**) infection in cattle, which caused large losses in the mid-1990s, is considered a serious potential emerging disease (Mbizeni et al. 2013).

5 Nutrient quality of many of these manures is poor. The main effect is the addition of organic matter to the soil.

6 Inefficient bulk cargo and bagging handling operations at Dar es Salaam can increase the cost of imported fertilizer by 40 per cent by the time it has left the port.

References


