9 The tree crop farming system
Stagnation, innovation and forest degradation

Jim Gockowski

Key messages

• To raise the income of the existing cocoa and oil palm smallholder farming system will require the adoption of improved varieties and fertilizers by farmers. Sustainably intensifying the existing tree crop farming system will require major private investment in fertilizer marketing capacity and rural banking along with public policies supporting growth of the private sector and public sector research on tree genetics and agronomy.

• In relatively land abundant regions, large-scale foreign investment can offer immediate access to improved tree crop technology capable of employing thousands of workers and growers while generating taxable revenue bases for government investment in fundamental public goods such as education and health. However, the threat of land alienation requires significant negotiation and dialogue with local community organizations and institutions.

• Contractual out-grower arrangements between the industrial plantation system and local communities have proven widely successful in reducing poverty and assuaging land alienation among smallholders. In the oil palm sector of South East Asia smallholder production using industrial plantation technology is encouraged and accounts for roughly one-third of South East Asian output. Out-grower schemes have been tested successfully in parts of west Africa and should be scaled out.

• Without investment in sustainable intensification there is little hope of conserving the remaining forest remnants in west Africa; at the same time poverty will not be easily vanquished in the Congo basin without some trading of the environment given the extremely limited production and trade possibilities for this region of the world. New institutions such as the Roundtable on Sustainable Palm Oil are helping to minimize these trade-offs.

Summary

The tree crop farming system in Africa is distinguished from other farming systems by a greater reliance on global markets. While suited to most of the humid lowlands of west and central Africa, the competitive pressures of global markets effectively limit the tree crop farming system to west Africa where relatively efficient marketing systems link tree crop producers to those markets. Three principal tree crop farming subsystems have
been identified. The two smallholder subsystems are distinguished by their management of plant nutrients; the forest rent subsystem (FRS) relies on the inherent stock of plant nutrients in both the soil and forest biomass, whereas the smallholder intensified subsystem (SIS) maintains nutrient balances through the addition of external inputs such as mineral fertilizers, organic fertilizer or animal manures. The third subsystem is the large-scale industrial plantation subsystem (IPS), which is heavily capitalized and much more focused on profit than the typical smallholder system. The two main smallholder tree crops are cocoa and oil palm, with robusta coffee, citrus and rubber of secondary importance. The industrial plantation is mainly focused on the production and processing of rubber and oil palm.

The FRS is by far the most widespread in terms of area, output and number of households engaged. The term ‘forest rent’ refers to the subsystem’s reliance on the nutrients tied up in the forest biomass, which underlie the productivity of this system. Forest rents are finite and depreciate over time as plant nutrients are exported out of the system in the form of commodity exports to global markets. Ultimately, nutrient depletion leads to declining productivity causing some farmers to switch to less nutrient-demanding crops such as oil palm and rubber, or transitioning to a commercially oriented root and tuber crop farming system, when there is access to rapidly growing urban food markets. Historically another option was to abandon the field and seek out new forest for conversion. In much of west Africa this is no longer possible due to demographic pressure.

The SIS is extremely limited in extent for various reasons, paramount of which is the limited development of the private sector and a general lack of affordable fertilizer supply. Limited port capacity and poor road infrastructure often mean that fertilizer markets are unable to capture economies of scale in transport and blending. This raises fertilizer costs at the farm gate, increases the financial risk associated with their use and prevents many smallholders from participating in the fertilizer market. Higher variable costs associated with the intensified system can also be a strain for financially strapped smallholders. Developing financial systems that can provide short-term credit for purchasing inputs will be critical. The environmental costs of not evolving towards more intensified subsystems include those associated with potentially irreversible nutrient depletion as well as forest degradation and deforestation.

Poverty in tree crop farming communities is largely a function of the household’s productive assets. The most vulnerable are sharecroppers, whose assets mostly consist of unskilled labour. Their income is highly variable depending on commodity prices and the productivity of the land sharecropped. Demographically, many are socially isolated migrant workers with little if any formal education. To generate the employment needed to address this hotspot of poverty, greater investment in the labour intensive IPS is recommended. The increased demand for unskilled agricultural labour would lead to higher wage rates and reduced poverty.

**Description of the tree crop farming system**

The tree crop farming system has been an important component of west and central African farming since ancient times. Evidence from palm oil residues found in an Egyptian tomb, Abydos, strongly suggests that oil palm was cultivated over 5,000 years ago in west Africa. More recently, Tetteh Quarshie, a Ghanaian blacksmith and farmer, was a principal figure in the establishment of the cocoa industry in the late 19th century. After several years working on cocoa farms in Fernando Po, Tetteh returned to his village in
eastern Ghana and made the first commercial planting of cocoa on the African continent in 1879 (Simpson 1937). An ensuing land scramble was described “where land became a factor which was quantified and bought then sold on commercial terms” (Hill 1963). The founding fathers of the west African cocoa industry were groups of capitalist entrepreneurs from Akwampim in eastern Ghana that organized group purchases of largely uninhabited forest land for cocoa production.

These companies which were basically groups of friends (not relatives) from one home town, were land purchasing clubs which enabled rich and poor alike to buy land for cocoa growing, each member being allotted a strip of land of a width proportionate to the sum he proposed to contribute.

(Hill 1963)
Enthusiasm for cocoa production continued to grow and by 1911 Ghana had become the world’s largest cocoa producer. West Africa, now led by Côte d’Ivoire, maintains its dominance in the market, accounting for 73 per cent of global production over the last few seasons (ICCO 2015).

Approximately 82 million Africans live within the estimated boundaries of the tree crop farming system (Figure 9.1, Table 9.1). A large majority (88 per cent) live in west African countries with the remainder in Madagascar (7 per cent) and Cameroon (5 per cent) (Table 9.2). The rural population within the boundaries of the farming system is currently increasing by 1.2 per cent annually and will double by 2075 at this rate. The current average population density is 66 rural inhabitants per km².

Crop production is focused on cocoa, oil palm, rubber, robusta coffee and citrus, which are all traded on international markets. Palm oil produced in west Africa is primarily for the west African market. In Madagascar, the principal tree crops produced are robusta coffee and cloves.

The feasible growing region for the principal tree crops includes most of the Congo basin and the Guinea forest of west Africa. However, high marketing costs in Central Africa prevent producer access to global commodity markets, effectively limiting the tree crop farming system to those regions where market access is high (Table 9.1).

Animal production in the humid lowlands of west and central Africa is generally very extensive and has only slight interaction with the tree crop farming system. Animal production is free-range and mainly restricted to dwarf goats, sheep, pigs, fish and chickens. Cattle are scarcely present due to the presence of trypanosomiasis. Animals are slaughtered most typically on important social occasions and are rarely taken to market except in times of financial need. They are also typically exchanged in marriage arrangements. On the production side, animal manure is important as fertilizer input for tree crop farming when the tree crop farm is adjacent to the household compound. However, manure quantities are generally quite limited.

Table 9.1 Basic system data (2015): tree crop farming system

<table>
<thead>
<tr>
<th>Item</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total human population (million)</td>
<td>82</td>
</tr>
<tr>
<td>Agricultural population (million)</td>
<td>30</td>
</tr>
<tr>
<td>Total area (million ha)</td>
<td>64</td>
</tr>
<tr>
<td>Cultivated area (million ha; % of total area)</td>
<td>7.6; 12</td>
</tr>
<tr>
<td>Irrigated area (million ha; % of cultivated area)</td>
<td>0.1; 2</td>
</tr>
<tr>
<td>Total livestock population (million TLU)</td>
<td>3</td>
</tr>
<tr>
<td>Major agroecological zone</td>
<td>Tropical warm humid</td>
</tr>
<tr>
<td>Length of growing period (average, days; core range, days)</td>
<td>299; 270–330</td>
</tr>
<tr>
<td>Access to services (low/medium/high)</td>
<td>High</td>
</tr>
<tr>
<td>Distance to 50k market (average, hr; core range, hr)</td>
<td>4.7; 1–6</td>
</tr>
<tr>
<td>Agricultural population density (persons/total area)</td>
<td>0.5; 3.9</td>
</tr>
<tr>
<td>Livestock density (TLU/total area; TLU/cultivated area)</td>
<td>0.05; 0.4</td>
</tr>
<tr>
<td>Standard farm and herd size (cultivated area/household; TLU/household)</td>
<td>1.4; 0.6</td>
</tr>
<tr>
<td>Extreme poverty (% of rural population)</td>
<td>40</td>
</tr>
</tbody>
</table>

Source: Refer to Table 2.4.
Three tree crop farming subsystems are identified for sub-Saharan Africa. The most widespread is FRS, which is mainly focused on low input production of cocoa, oil palm, rubber and coffee along with food crops (Ruf 1995). The SIS employs innovations from agricultural science to achieve high yields. The IPS is similar to the SIS in its use of improved seed-fertilizer technologies and pest and disease management but is distinguished by the scale of operation and a much higher capital:worker ratio then either the FRS or SIS. It mainly grows oil palm and rubber. All three subsystems are connected to global markets and therefore subject to global competition.

The forest rent subsystem

The typical west African FRS is operated by a village-based household producing tree crops for global markets. The term ‘forest rent’ refers to the subsystem’s reliance on the nutrients tied up in the forest biomass which underlie the productivity of this system. On an annual basis a portion of the nutrient stock is used up and exported out of the system eventually leading to nutrient depletion and declining productivity. The system may remain productive for 20 to 30 years depending on a variety of factors, but eventually the land becomes fatigued. Rather than trying to rejuvenate soil fertility through application of imported nutrient inputs, cash-strapped farmers either seek out new forest to create a new farm or convert the fatigued FRS to a less demanding tree crop such as rubber or oil palm (Ruf 2008). The cocoa and oil palm FRS have both played major roles in deforestation and forest degradation across west Africa as farmers have exploited forest rents since the 1960s (Gockowski and Sonwa 2011).

The subsystem consists of a mix of production systems. The most common are coffee-, cocoa-, oil palm- and rubber-based, with the cocoa-based FRS most frequently encountered. Analysis of the cocoa-based FRS is based on data gathered by the Sustainable Tree Crops Program (STCP) from 2001 to 2012. STCP was a public-private partnership...
between west African tree crop research institutions, the International Institute of Tropical Agriculture (IITA) and the global chocolate industry. The programme was sponsored by The United States Agency for International Development (USAID) and the World Cocoa Foundation.

The typical FRS household of West Africa is headed by a 51-year-old male with limited education (Table 9.3). Four in ten household heads are migrants or descended from migrants. Female-headed households are less common, often due to restrictive, customary tenure institutions (Berry 1988). The cocoa belt of Ghana, where one in every five producers is a woman, has the highest agricultural participation by women in Africa. Berry (1988) reported female ownership of cocoa farms in excess of 50 per cent in the 1970s in certain localities of Ghana, which she attributed to matrilineal inheritance institutions common among the Akan.

The mean cocoa FRS total landholding ranges from 7 to 19 ha (Table 9.4), reflecting different land pressures facing households at the country level. In Cameroon, over half the typical household’s land was either lying fallow or in forest in 2001, compared with 12 per cent in Nigeria. While the average cocoa planting is 4.7–6.4 ha per farm, the majority of cocoa plantings are small (Figure 9.2). The 20 per cent of farmers with the largest farms (average 15 ha), account for over half of the total cocoa hectares in West Africa, while the 20 per cent of farmers with the smallest farms (average 1.3 ha) represent only 4 per cent of the cocoa area.

Differences in farm size affect the producer’s choice of technology. Farmers in the lowest quintile have developed land-sparing technologies such as multi-strata agroforests often adjacent to the producer’s homestead, that benefit from the concentration of nutrients emanating from the household: kitchen refuse, animal manure, night soil, food processing and wood ash. Large farmers opt for labour-saving innovations such as herbicides while employing sharecroppers to farm larger areas.

The cocoa FRS household typically allocates 1 to 2 ha of land for food crop production (Table 9.4). Food crop systems tend to be managed by women with men mainly responsible for slashing the fallow field in preparation for planting. Food production is typically for household consumption and can represent a significant portion of the overall household income. In the cocoa belt of Côte d’Ivoire, home-produced consumption accounted for 32 per cent of total agricultural household income (Benjamin and Deaton 1993).

Table 9.3 Demographic characteristics of household heads in the cocoa-based forest rent subsystem

<table>
<thead>
<tr>
<th></th>
<th>Cameroon</th>
<th>Côte d’Ivoire</th>
<th>Ghana</th>
<th>Nigeria</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of household head (yrs)</td>
<td>51</td>
<td>49</td>
<td>47</td>
<td>56</td>
<td>51</td>
</tr>
<tr>
<td>Proportion of household heads younger than 40 yrs (%)</td>
<td>28</td>
<td>30</td>
<td>40</td>
<td>21</td>
<td>30</td>
</tr>
<tr>
<td>Length of residency (yrs)</td>
<td>32</td>
<td>27</td>
<td>34</td>
<td>38</td>
<td>33</td>
</tr>
<tr>
<td>Migrant (%)</td>
<td>26</td>
<td>56</td>
<td>41</td>
<td>48</td>
<td>44</td>
</tr>
<tr>
<td>Female head of house (%)</td>
<td>2</td>
<td>4</td>
<td>11</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Primary school certificate or higher (%)</td>
<td>60</td>
<td>42</td>
<td>58</td>
<td>7</td>
<td>44</td>
</tr>
</tbody>
</table>

Source: IITA (2002).
Note: Sample sizes for Cameroon, Côte d’Ivoire, Ghana, Nigeria and All were 906, 1140, 908, 1081 and 4035 respectively.
In areas with good access to urban centres, commercial food production takes on increasing importance. More of the household’s land and labour is allocated to food crop production, and less to tree crops: FRS cocoa producers earning more than 40 per cent of cash income from food crop sales cultivated 2.7 fewer hectares of tree crops than those below this threshold (STCP unpublished data). Both eastern Côte d’Ivoire and eastern Ghana are examples of regions where the majority of households have transitioned out of cocoa-based FRS to the root and tuber farming system in response to rapidly growing urban centres. It should be said that these transitions have also been driven by the disappearance of the forest rent following 60 years of cocoa cultivation.

Food crops are often grown in association with newly planted tree crops during the establishment period. These associations contribute to the household’s food basket while also providing shade to the young cocoa and coffee seedlings. In land-abundant areas such

**Table 9.4** Average land and labour endowments of cocoa-based forest rent subsystem

<table>
<thead>
<tr>
<th></th>
<th>Coca</th>
<th>Food crops</th>
<th>Other tree crops</th>
<th>Fallow fields</th>
<th>Forest land</th>
<th>Total farm size</th>
<th>Family size</th>
<th>Land-labour ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cameroon</td>
<td>6.0</td>
<td>2.5</td>
<td>0.3</td>
<td>3.6</td>
<td>6.4</td>
<td>18.8</td>
<td>12.9</td>
<td>1.5</td>
</tr>
<tr>
<td>Côte d’Ivoire</td>
<td>5.6</td>
<td>1.6</td>
<td>0.3</td>
<td>3.4</td>
<td>1.9</td>
<td>12.9</td>
<td>10.4</td>
<td>1.2</td>
</tr>
<tr>
<td>Ghana</td>
<td>6.4</td>
<td>1.5</td>
<td>0.7</td>
<td>1.3</td>
<td>0.9</td>
<td>10.7</td>
<td>9.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Nigeria</td>
<td>4.7</td>
<td>1.3</td>
<td>0.5</td>
<td>0.7</td>
<td>0.2</td>
<td>7.4</td>
<td>9.9</td>
<td>0.7</td>
</tr>
</tbody>
</table>

Note: Total sample size for this study was 4035.
Source: IITA (2002).
as south central Cameroon, the FRS household also produces food crops in a fallow rotation system. By commodity, the most important food crops grown in the cocoa-based FRS are cassava, plantain, cocoyams, maize, yams and upland rice. Another important source of household sustenance comes from various fruit trees commonly found in the cocoa field and elsewhere on the farm. These generally include avocado, citrus, mango, bush mango, African breadfruit and the African plum. Most typically these perishable crops add variety to the household diet, although when market access exists they can contribute significantly to household income.

It is common for FRS farmers to manage several different tree crop production systems. In decades past, differences in the seasonal labour demand of cocoa and robusta coffee allowed for their joint production by many smallholders in Côte d’Ivoire. However, the emergence of Vietnam in the 1980s as the largest global producer of robusta coffee depressed prices. Undercut Ivorian coffee producers responded by uprooting and replanting with oil palm and rubber (Cheyns and Rafflegeau 2005; Gockowski and Sonwa 2011). Palm oil is the most common cooking oil in the humid lowlands of west and central Africa, and unlike cocoa, coffee or rubber, it is in great local demand by both rural and urban households. One in five cocoa FRS households produces oil palm for commercial purposes (International Institute of Tropical Agriculture unpublished data).

Most mature cocoa plantings in Ghana and Côte d’Ivoire FRS are grown in full sun or at best limited shade. With more light the cocoa tree gives higher yields but can become physiologically stressed by high levels of production and as nutrients in the system deplete. Since the late 1970s the locus of cocoa production in both countries has moved from east to west as farmers have used up the forest rent. Shaded cocoa fields are more common in parts of Cameroon and Nigeria where some have been in continuous production for nearly 100 years (Jagoret et al. 2011) (Figure 9.3). This is normally attributed to the greater capacity for nutrient cycling when deep-rooted shade trees are included in the production system.

*Figure 9.3* A farmer in his shaded cocoa plantation, Nkhol Bang village, Central Region, Cameroon.

Source: Cynthia Gidoin.
Table 9.5 Adoption of improved (F1 hybrid seedlings) versus unimproved (local land race) cocoa planting material in cocoa-based forest rent subsystems (%)

<table>
<thead>
<tr>
<th></th>
<th>Unimproved</th>
<th>Improved</th>
<th>Both</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cameroon</td>
<td>81</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>Côte d’Ivoire</td>
<td>88</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Ghana</td>
<td>58</td>
<td>27</td>
<td>15</td>
</tr>
<tr>
<td>Nigeria</td>
<td>91</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Grand total</td>
<td>80</td>
<td>12</td>
<td>8</td>
</tr>
</tbody>
</table>

Source: IITA (2002).

The majority of cocoa FRS households use seeds taken from their own tree stocks, instead of certified hybrid seeds (Table 9.5). Ghanaian cocoa producers reported the highest usage of improved planting material, but the majority still used their own planting material despite acknowledging the superior performance of hybrid selections (Ahenkorah et al. 1987; Edwin and Masters 2005; Gockowski et al. 2011). The use of improved

Figure 9.4 Phytophthora megakarya rot on cocoa pods, Ozom, Lékié Department, Cameroon. Source: Martijn Ten Hoopen.
hybrid seed is higher among smallholder operators of oil palm and rubber FRS, mainly due to the production and distribution of improved planting materials by the industrial plantation system who make it available to FRS smallholders.

Most operators of the FRS do not use fertilizers (Table 9.6), as explained earlier. Pesticides are more frequently used, especially fungicides in Nigeria and Cameroon where a particularly toxic strain of black pod disease ( Phytophthora megakarya ) mandates their use to prevent potential total crop failure (Figure 9.4). In addition to black pod disease, the majority of cocoa FRS households across all countries of the cocoa belt, spray insecticides to control ubiquitous plant-sucking insects known as capsids ( Distantiella theobromae and Sahlbergella singularis ). Capsid resistance is a recurrent problem faced by producers.

Ownership of durable goods is low in forest rent tree crop farming subsystems (Table 9.7). Pesticide sprayers are used by more than half of FRS households, with a slight difference between larger and smaller farms. The limited availability of simple transport such as single axle tractors, pushcarts and wheelbarrows means that most cocoa is transported from the field to the farm gate by human head load.

The size of the tree crop holding determines overall labour demand. For a representative, 6.7 ha cocoa-based FRS farming system just north of Yaoundé, Cameroon, the estimated annual agricultural labour demand for the farm was 629 days, of which 54 per cent was allocated to cultivation of the mixed food crop field, 24 per cent to the cocoa FRS system and the remaining 22 per cent to tomato production. Some tasks are gender-specific and some are undertaken jointly. Overall, women were estimated

<table>
<thead>
<tr>
<th>Table 9.6 Percentage of producers using agrochemicals on cocoa and food production systems in the cocoa-based forest rent farming system</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Food crops</strong></td>
</tr>
<tr>
<td><strong>Fertilizer</strong></td>
</tr>
<tr>
<td>Cameroon</td>
</tr>
<tr>
<td>Côte d’Ivoire</td>
</tr>
<tr>
<td>Ghana</td>
</tr>
<tr>
<td>Nigeria</td>
</tr>
<tr>
<td>All</td>
</tr>
</tbody>
</table>

Source: IITA (2002).

<table>
<thead>
<tr>
<th>Table 9.7 Frequency of tool ownership among FRS households by size of cocoa planting (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Farms &gt;4 ha</strong></td>
</tr>
<tr>
<td>Chainsaw</td>
</tr>
<tr>
<td>Irrigation pump</td>
</tr>
<tr>
<td>Pick up truck</td>
</tr>
<tr>
<td>Pushcart</td>
</tr>
<tr>
<td>Wheel barrow</td>
</tr>
<tr>
<td>Knapsack sprayer</td>
</tr>
<tr>
<td>Motorized sprayer</td>
</tr>
</tbody>
</table>

Source: IITA (2002).

Note: Sample sizes for the three cocoa farm size categories were 1850 for farms > 4 ha, 2185 farms ≤ 4 ha and 4035 for all sizes respectively.
**Figure 9.5** Total monthly crop production labour requirements for men and women on a forest rent farming subsystem in southern Cameroon. This example system comprises 2.6 ha cocoa, 0.4 ha commercial tomato and 0.3 ha in a mixed food production system.

Source: Author’s calculation.

**Figure 9.6** Cocoa bean extraction after the cocoa pod harvest.

Source: Régis Babin.
to have supplied 58 per cent of the labour and men 42 per cent. Prior to the introduction of cash crops such as cocoa and tomatoes, women accounted for an even higher proportion of total labour supply (Boserup 2007; Guyer 1984). Women’s workloads are highest in the months of March and again in September when field preparation for mixed food-crop fields occurs (Figure 9.5). Peak demands for men occur in March when field clearing of the wife’s mixed food-crop field intersects with tomato field preparation, and in May when tomato weeding coincides with cocoa pest and disease control. Addressing labour shortages during periods of peak workloads is most commonly achieved by working in reciprocal labour exchanges with family and friends or hiring temporary workers (Figure 9.6).

For many large landowners, the labour demand often exceeds the household’s (family) capacity. Most large landowners meet their labour demand by employing sharecroppers. Cocoa producers with total landholdings above 4 ha were twice as likely to engage sharecroppers as those below (IITA unpublished data). However sharecropping is not without its issues (Box 9.1).

**Box 9.1 Ethnicity, migrant labour and farm size in the cocoa belt of Côte d’Ivoire**

A village chief in the cocoa growing region of southern Côte d’Ivoire explains how access to labour influences the scale of cocoa farming:

> You will notice that the Mossi own large farms and produce a lot of cocoa because they recruit workers while other producers cannot afford workers. The Mossi go to Burkina Faso and bring back their brothers to come and work as farm workers, and so they establish large farms... The other producers do not recruit workers and so work with their children. However, since most of the children attend school, they cannot help every day. That is why producers who are not Mossi cannot create large farms... else who will work in them? If you cultivate a large farm and have no workers, all your cocoa will rot in the bush and you would have toiled for nothing.


The most typical share-cropping arrangement in the west African cocoa sector involves sharing the commodity 67:33 between the landowner and the sharecropper, with the landowner covering the cost of purchased inputs. Sharecroppers are generally under the age of 30 and from impoverished rural areas such as the Mossi plateau in Burkina Faso, the western highlands of Cameroon, eastern Ghana and the southeast of Nigeria. The incidence of poverty among shareholders is high, but for some it may be transitory if they are able to acquire their own cocoa farms. This is becoming increasingly difficult, and sharecropper households comprise a disproportionate number of the chronic poor in the tree crop farming regions of west Africa.

When labour markets or low commodity prices do not allow the use of hired labour, either the scale of the farm will be adjusted by abandoning less productive lands, or children from within the household may be asked to forsake their education and shoulder the extra burden (Bazzi-Veil and Kambou 2002).
In the SIS, the majority of farmers have adopted innovations developed by agricultural research that has significantly increased productivity and household income. These are principally improved seed-fertilizer technologies and the chemical and biological management of pests and diseases. The areas where the SIS predominates are few, and ephemeral as a result of commodity price fluctuations and/or unsustainable policy interventions.

At the start of the 21st century, more than 100 years after the establishment of the cocoa industry by the migrant farmers of Ghana, no area in the west African cocoa belt could be defined as intensified, and there was essentially zero support for farmers’ use of modern inputs. However, starting in 2001, fertilizer and pesticide programmes implemented by the Ghana Cocoa Marketing Board began to transform the cocoa FRS in the western region of Ghana (at least for a time). By 2009, these programmes generated yield growth rates comparable to the green revolution in India. These gains were achieved primarily by supplying subsidized fertilizers and pesticides to smallholders on a significant scale. At a programme cost of US$172 million, 130,000 metric tonnes of cocoa fertilizer were purchased and distributed to farmers at subsidized prices by the Ghana Cocoa Marketing Board in 2010/11, mainly in the Western Region.

A survey of 4,357 participants in a 2010–2011 farmer field school training programme by the STCP revealed that between 62 and 79 per cent of producers from six growing districts in the Western Region had applied subsidized fertilizer in 2009. Only 20 per cent of producers from other regions reported likewise. A more detailed survey of 170 producers in 2011 in the Bia district, Western Region, found that 75 per cent of producers had applied fertilizers, on average 225 kg/ha, which was largely responsible for a doubling in yield. Women used fertilizers more commonly than men; however, due to smaller farms and poorer access to credit, they used less fertilizer per hectare.

Farmers create their cocoa farms by planting a newly cleared field contemporaneously with food crops, primarily cassava and plantains in April or May. The location of each planted seed is marked with a stake so that as the field develops, the young cocoa seedling is not accidentally weeded. This practice, known as ‘planting at stake’, is common across west Africa. Despite the higher productivity of hybrid cocoa in farmers’ fields, less than 7 per cent of bearing acreage was planted to hybrid cocoa. Unlike agrochemical innovations, women cocoa producers have lower use of hybrids than men. The average hybrid area planted per woman was less than half the area planted by men.

Fertilized cocoa farms are essentially no-shade systems, with an average of only six trees per hectare. These levels of shade are low compared with the cocoa-based FRS of west Africa (Gockowski et al. 2010). CRIG recommends no more than 15 shade trees per ha for improved, fertilizer-responsive cocoa varieties, based on over 20 years of shade-fertilizer trials (Ahenkorah et al. 1987).

Relative to the FRS, the cocoa-based SIS has a higher use of pesticides to control cocoa pests and diseases. Capsid bugs account for the largest total pesticide cost. This is followed by black pod disease, which requires an average application of 1.9 kg copper fungicide per hectare. Herbicide use is also increasing and applied to approximately one out of every three hectares of harvested cocoa. Cheaper generic formulations of glyphosate on the market have made herbicide use affordable. Herbicide use is more frequent among farmers with larger field size because it means less labour to control weeds manually (Table 9.8). As with fertilizer, women cocoa producers participate equally with men in the increased use of phyto-sanitary products (Gockowski et al. 2011).
Empirically, the adoption of chemical innovations is relatively independent of cocoa farm size (Table 9.8). However, the intensity of fertilizer use per hectare declined significantly with farm size ($\rho = -0.25$) with a farm of 1 ha receiving twice as much fertilizer per hectare as a farm of 10 ha (Table 9.9).

Analysis of the ratio of cocoa land to total farmland suggests that adoption of the SIS is associated with an increase in cocoa specialization. More than one-third of SIS producers indicated complete specialization in cocoa production (100 per cent of planted area is cocoa). Specialization could have repercussions for household food security if cocoa crowds out household crop production or if local food markets are incomplete. Analysis showed the share of staple food consumption purchased in local markets was negatively related to farm size (Figure 9.7). Of the producers indicating complete specialization, nearly one-third made no staple food purchases, while only 25 per cent indicated complete dependency on market purchases. The majority grew mixed associations of cocoa and food crops, with one of four food production strategies: (1) fruit tree integration in the shade canopy of the cocoa field, (2) shade-tolerant cocoyam at low density in the understory, (3) plantain and cassava with cocoa seedlings when replanting gaps in the cocoa canopy and (4) food crops (cocoyam, plantain, and cassava) during the first several years following establishment of new cocoa or replanting of old cocoa (Figure 9.8).

Table 9.8 Frequency of chemical innovation by size of cocoa holding in the western region of Ghana, in 2011 (%)

<table>
<thead>
<tr>
<th>Size of cocoa holding (quartiles)</th>
<th>I (%)</th>
<th>II (%)</th>
<th>III (%)</th>
<th>IV (%)</th>
<th>All (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer</td>
<td>76</td>
<td>60</td>
<td>78</td>
<td>86</td>
<td>75</td>
</tr>
<tr>
<td>Fungicide</td>
<td>66</td>
<td>58</td>
<td>71</td>
<td>69</td>
<td>66</td>
</tr>
<tr>
<td>Insecticide</td>
<td>88</td>
<td>88</td>
<td>93</td>
<td>100</td>
<td>92</td>
</tr>
<tr>
<td>Herbicide</td>
<td>24</td>
<td>33</td>
<td>39</td>
<td>36</td>
<td>33</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size of cocoa holding (quartiles)</th>
<th>I (%)</th>
<th>II (%)</th>
<th>III (%)</th>
<th>IV (%)</th>
<th>All (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer</td>
<td>78</td>
<td>65</td>
<td>72</td>
<td>85</td>
<td>79</td>
</tr>
<tr>
<td>Fungicide</td>
<td>68</td>
<td>61</td>
<td>78</td>
<td>74</td>
<td>73</td>
</tr>
<tr>
<td>Insecticide</td>
<td>93</td>
<td>89</td>
<td>90</td>
<td>99</td>
<td>95</td>
</tr>
<tr>
<td>Herbicide</td>
<td>24</td>
<td>32</td>
<td>36</td>
<td>31</td>
<td>32</td>
</tr>
</tbody>
</table>

*Farm size categories are defined as: quartile I (<2.83 ha), II (2.83 to 4.85 ha), III (4.85 to 9.30 ha), and IV (9.30 to 61 ha).

Source: IITA (2011).

Table 9.9 Intensity of fertilizer application as a linear function of farm size in the cocoa SIS

<table>
<thead>
<tr>
<th>Farm size (ha)</th>
<th>Predicted fertilizer use (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>232</td>
</tr>
<tr>
<td>3</td>
<td>204</td>
</tr>
<tr>
<td>7</td>
<td>147</td>
</tr>
<tr>
<td>10</td>
<td>105</td>
</tr>
</tbody>
</table>

Source: IITA (2011).
**Figure 9.7** Proportion of staple food crop consumption procured from food markets versus home production for four farm size categories in Bia district of the Western region of Ghana.
Source: IITA (2011).

**Figure 9.8** Newly planted cocoa associated with cassava and plantain as temporary shade, in Bia District, Ghana.
Source: Valentina Robiglio.
The area under newly established cocoa is thus critical in ensuring the household’s food security. This is particularly so for the smallest producers, most of whom did not include a separate food crop production system in their farm. The problem faced by the producer who relies on the food production from among newly planted cocoa is the lumpiness of this output in time. With the average life of a cocoa farm ranging from 20 to 35 years, new planting or replanting may not occur every year.

The industrial plantation subsystem

The IPS first emerged during European colonization in the late 19th and early 20th centuries. Plantations with historical links to this period include Unilever palm oil plantations in the Democratic Republic of Congo, the Firestone rubber plantations in Liberia, and the rubber, oil palm and banana plantations on the rich, volcanic soils of Mount Cameroon operated by the government-owned Cameroon Development Corporation (CDC), with the original plantations established by German colonials prior to World War I.

The oil palm IPS is by far the most common industrial farming system, followed by rubber. The ownership of this subsystem is variable and often mixed, including private corporations, state governments and sovereign wealth funds. In some countries of west and central Africa, well-connected political elites are often proprietors of IPS. In the years after independence, many countries established state-run industrial plantations, such as the aforementioned CDC.

In the case of oil palm the perishable nature of harvested, fresh fruit bunches necessitates the co-location of production and milling. This limits the optimal size of the processing unit and accompanying plantation area as at some point diseconomies of scale will begin to increase costs.

The IPS pursues a high fixed-cost, profit-maximizing business model. Capital investments are high and upfront. In the case of an oil palm plantation, capital inputs include oil milling facilities, farm-to-factory roads, vehicle fleets for transporting the commodity, heavy equipment for field clearing and facilities for the production of hybrid seedlings (Figure 9.9). Capital investments also include worker housing and social amenities such as health clinics, recreational facilities and schools. IPS investments in an oil mill facility and vehicle fleets expand the demand for fresh fruit bunches and enables the development of associated SIS out-grower (contract farming) schemes linked to the IPS. The IPS investment also provides a market for independent smallholders who do not wish to enter into contract farming arrangements.

The smallholder tree crop system may be affected both directly and indirectly by IPS. Out-grower schemes are especially common in the oil palm sector. The IPS enters into a contractual relationship with selected smallholders living relatively close to the processing unit. In exchange for the provision of marketing services, technical support, input supply and credit, the smallholder is obligated to deliver the tree crop commodity to the IPS at an agreed price (Vermeulen and Goad 2006). In this manner farmers can gain access to modern agricultural technology in a complete package.

Smallholders may also benefit from IPS investments in skills training received while employed by an IPS or by employing former IPS workers with such experience. The rapidly growing smallholder rubber sector in Côte d’Ivoire is a case in point (Ruf 2008). Smallholders are employing the services of rubber tappers and tree grafters who have been trained and employed by an IPS.

Not all interactions are so positive. In some cases communities may lose some of their access to forest land and waters that are important livelihood assets for the poor. These assets, and the benefits that they generate, are difficult to measure and evaluate.
Population, hunger and poverty

Population density in the humid lowlands of west and central Africa was historically low mainly due to disease pressures. However as modern medicine has developed, this has permitted migration into regions that 100 years ago were not considered habitable. Often these migrations were motivated by the development of tree crop export markets. As lands were acquired and tree crops planted, the demand for labour grew – this has been met largely by migrant workers from outside the humid lowlands with the exception of Ibo sharecroppers from southeastern Nigeria. In precolonial times much of the land was not inhabited and covered in tropical rainforest; today the average rural population density is 66 persons per square kilometer, the forest is gone and 40 per cent of the population live in extreme poverty (Tables 9.1 and 9.10). Angus Deaton (1999), the Nobel winning economist, holds that the font of labour in west Africa and elsewhere in the developing world that is willing to work for near subsistence wages is a principal factor explaining the trendless behaviour of commodity prices over the last 100 years.

Household endowments of land and labour

The theory of induced innovation can be used to explain the historical development of agriculture in countries with differing endowments of land and labour (Hayami and Ruttan 1985; Hicks 1932). In countries where land was abundant relative to labour, such as the United States and Canada, science focused on technologies that used land and capital while saving on labour. In economies where labour was abundant but land was scarce (e.g. rural Japan), innovation focused on land-saving and labour-using technologies.
The tree crop farming system has double the rural population density of the root and tuber farming system, and nearly ten times the density of the forest-based system (Table 9.10). Thus, the choice of commercial tree crop farming (high value, intensively managed crops) where markets are available may be a response to increasing land pressure. As discussed earlier, household food production and employment depends on the availability of land, farm size and degree of farm intensification and specialization. Within the tree crop farming system there is wide variation in endowments of land and labour (Table 9.4). In parts of Cameroon, farmer access to forest land is essentially unlimited given the capital, tools and labour available for its exploitation. In such situations, FRS subsystems that optimize the return to labour prevail. In southeast Nigeria, higher population pressure, inalienable land rights and patrilineal inheritance have resulted in extreme fragmentation of the farming system. Here rural livelihoods are heavily dependent on employment in the non-farm economy.

**Urbanization**

Another major driver of change in the tree crop farming system is the rapid growth of urban centres. Urban populations in west Africa are doubling every 14 years, swelled by a tide of rural to urban migration. Other things being equal, this causes the price of food to rise relative to tree crops, leading to increased quantities of food grown and supplied, and decreased quantities of export commodities. Offsetting this influence is an increased preference for convenience foods by urbanites, which has increased imports of rice and wheat. Countries with the marketing infrastructure to export tree crop commodities can use that infrastructure to also import rice and wheat. Thus, there is a complementarity between tree crop production and the importation of staple food crops. Capital investments in port facilities and road infrastructure will facilitate both types of trade. The foreign exchange generated by the production of tree crops also ensures the capacity to import these staple commodities.

**Hunger and poverty hotspots**

Rural populations are still growing, albeit at rates significantly lower than those of urban populations. This continued pressure on the natural resource base leads to increasing land fragmentation and, in areas such as southeast Nigeria, has led to soil nutrient depletion. This can entail a descent into poverty. Eventually, households are either forced to exit the agricultural sector or to seek off-farm employment.

### Table 9.10 Population densities of the three principal farming systems of the humid low land tropics in 2010

<table>
<thead>
<tr>
<th>Farming system</th>
<th>Rural population density (Pers/sq km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree crops</td>
<td>66</td>
</tr>
<tr>
<td>Root and tuber</td>
<td>26</td>
</tr>
<tr>
<td>Forest-based</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Within most commercially oriented tree crop farming regions, there are communities of landless workers engaged by larger farmers. This segment of the population is typically the most vulnerable. They are often dependent on the landlord for lodging and meals. With little in the way of support structures and social capital, some workers have reported abusive treatment.

The distribution of landholdings within many tree crop farming communities is not as egalitarian as one might expect under customary tenure institutions. As shown in Figure 9.2, the distribution of farm size is skewed. Thus, even in relatively prosperous regions, a significant number of smallholder households face poverty and hunger. In the western region of Ghana, which is the leading region for cocoa production, 27 per cent of children under the age of five were estimated to be chronically malnourished in 2008 (Ghana Statistical Service 2009).

**Markets and trade**

As part of global markets, the African tree crop farming system is impacted by the events occurring thousands of miles from its shores. When Vietnam resettled nearly one million persons in the central highlands in the mid-1980s and offered subsidized credit for the creation of robusta coffee farms, the impact was felt around the coffee-growing world. As Vietnam established itself as a major producer, the ensuing decline in price led many west African farmers to abandon coffee production (Figure 9.10).

The global production of palm oil has increased by 141 per cent since 2000 and now represents 40 per cent of the global vegetable oil supplies, with an annual production of 65.5 Mt (USDA 2013). Indonesia and Malaysia account for 53 and 33 per cent of global output, respectively. Demand for palm oil has been spurred by the growing global market for biofuels. Biodiesel feedstock demand in Europe increased from 0.4 Mt in 2006 to 1.9 Mt in 2012 with a projected increase to 2.6 Mt by 2020 (Gerasimchuk and Koh 2013). The development of biodiesel from palm oil is expected to keep global prices firm, which is important for the encouragement of greater foreign investment in this industry to provide jobs and state revenues.

Numerous studies have found tree crop producers in west and central Africa responsive to price incentives (e.g. Akiyama and Trivedi 1987; Gilbert and Varangis 2003). In general, the supply response to an increase in price will be greater in the long term because of the biological lags between planting or replanting and production that characterize most perennial tree crops. In the short term, the producer is able to adjust only his or her labour or the quantities of inputs applied. If input markets and rural credit are not well developed, the short-term supply response to price will be further muted.

Globally, increased commodity demand, including a growing middle class in China, India and South East Asia, and European policies mandating the use of biofuels as a tool in meeting Kyoto CO₂ commitments, have contributed to upward pressure on prices. Prices have increased on average between 3 to 6 per cent per annum (P<0.01) for at least 21 years (Figure 9.11). Robusta coffee is the only tropical tree crop not to have experienced a significant increase in price over this period. Wheat and rice, the two most significant African food imports, also experienced increases in price but at rates lower than the major African tree crops. This implies an improvement in the agricultural terms of trade for the tree crops sector in the humid forest zone of Africa. Tempering the upswing
Figure 9.10 Change in robusta coffee production and acreage in West Africa and Vietnam, 1980–2012.

in global commodity markets has been a significant increase in the price of NPK fertilizer at annual rates in excess of tree crop commodity prices.

Tropical commodity prices also tend to be highly variable and are often correlated with increasing the riskiness of smallholder intensified production systems, particularly where crop insurance is not available. The volatility of smallholder tree crop income is thus impacted by both price risk and production risk.

Concerns over the environmental and social impact of tree crop farming have been raised in recent times. The rapid expansion of extensive cocoa and oil palm production systems in the last 20 years is often cited as a major cause of deforestation and forest degradation (Gockowski and Sonwa 2011; Norris et al. 2010). Certified production systems based on ‘good agricultural practices’ are being proposed to west African cocoa and oil palm farmers by partnerships of environmental NGOs and industry stakeholders in order to address the lack of innovation and the degrading natural resource base. Programmes such as the Roundtable on Sustainable Palm Oil, UTZ certified, Fair Trade Certified and Rainforest Alliance Certified seek to assure Western consumers that the chocolate or coffee that they consume has been produced in an environmentally and socially sustainable fashion. After training farmers on good agricultural practices, which includes both environmental and labour practices, third-party agencies then certify that sustainable practices are in place. Facing class-action lawsuits and potential prohibition of cocoa from Côte d’Ivoire over the use of child labour on west African farms, major producers of chocolate such as Hershey’s chocolate, Mars and Nestlé have committed to third-party certification, with Mars and Hershey’s both committed to sourcing 100 per cent certified cocoa by 2020. Currently premiums range from $140/t to $200/t of certified cocoa. The producer-benefits from certification depend on: (1) the extent to which consumers

![Figure 9.11 Monthly average global prices for selected tree crop commodities, 1991–2012. Source: IMF Primary Commodity Prices, Monthly Data (2015).](image-url)
are willing to pay premiums for process attributes such as ‘child labour-free’ or ‘shade-grown’ cocoa, (2) the efficiency of market actors in passing through premiums to the producer of certified cocoa, and (3) the productivity of the proposed certified practices relative to the farmer’s typical practice (Gockowski et al. 2013).

**Policies and institutional reforms**

In response to growing global demand for palm oil, rubber and cocoa, many large transnational corporations are in the process of investing in production and processing facilities in various countries of west and central Africa. These investments have been encouraged by government tax breaks and long-term concessions of land at minimal cost. While such investments are able to find abundant land in the underpopulated regions of the Congo basin in Central Africa, finding labour is more problematic. In land-scarce west Africa where labour is abundant, the opposite is true. Cameroon has moderate land and labour endowments and has been particularly attractive to such initiatives. While there are definitely risks of alienation and loss of land access, the remarkable reduction in rural poverty achieved in Indonesia and Malaysia through policy-led intensification of smallholder palm oil production cannot be denied (Sheil et al. 2009; Vermeulen and Goad 2006). At the same time, this development outcome has come at an environmental cost.

Stabilization or marketing boards were introduced during the colonial era, purportedly to buffer producer income from weather and price shocks. The boards established stabilization reserve funds from surpluses generated during periods of price spikes, which were to be drawn upon to support prices when they fell below their long-term average. While price volatility was reduced, the long-term average price received by producers typically ranged between 40 and 55 per cent of the free on board (FOB) border price. Producers had very little incentive to innovate their production systems at these low prices. In essence, these structures became important sources of state revenues that were often beset by rent-seeking behaviour and ill-advised investments.

In the 1980s and 1990s, the dismantling of marketing boards was often a condition of structural adjustment. Almost all of these boards are now closed, with the notable exception of the Ghana Cocoa Board. In their place the private sector has assumed marketing functions. In Cameroon and Nigeria, producers have benefited from a higher share of the FOB border price, which has been trending upward. In Côte d’Ivoire, although marketing is now a private sector activity, high export taxes have reduced producer prices. While the improved price incentives in Cameroon have led to an 8 per cent growth rate in cocoa production since 2000, nearly all of the additional growth has come from the area expansion of the FRS. This is in contrast to Ghana, where increased land productivity has accounted for the bulk of sector growth since 2000. Cameroon completely liberalized its markets in 1994 and no longer taxes producers. Côte d’Ivoire liberalized marketing in 1994 with the elimination of the CAISTAB (La Caisse de stabilisation et de soutien des prix des productions agricoles), but the government continues to collect taxes from exporters, which are passed along to producers. Ghana maintains its marketing board, which annually sets a pan-territorial producer price at a level of 70 per cent of net FOB.

Empirically, cocoa output in Ghana has grown at a rate of nearly 6 per cent since the mid 2000s and is a success story for the country and the region (Kolavalli and Vigneri 2011). Underlying this achievement was the adoption and application by smallholders of
granular fertilizers (subsidized) and an increase in the producer’s share of the ‘net’ FOB price (Gockowski 2012). Other countries in the region are considering such policy-led intensification efforts.

Several innovations in institutions have recently emerged, which are improving the delivery of goods and services. They include the provision of fungicides and insecticides on credit by purchasers of cocoa in Nigeria and Cameroon. Similarly, cocoa fertilizers have been provided on credit by Ghana’s licensed cocoa buying agents. In both cases the employment of clerks from the community has helped firms to overcome information constraints that prevent formal financial institutions from effectively administering small loans to smallholders (Gockowski et al. 2008).

Land tenure institutions in areas of higher demographic pressure appear to be achieving more secure tenancy through a mix of customary and statutory law. In West Africa, unallocated idle lands not under protected status as national parks or forest reserves, are now miniscule relative to 30 years ago when new land for farming could be easily obtained. Blocher (2006) noted that the 1990s and 2000s witnessed a considerable slowdown in the allocation of land by Ghanaian chiefs under customary law. Persons acquiring land during this period did so either by outright purchase, generally accompanied by a transfer of land title, or through a variation of the ‘abunu’ sharecropping tenancy institution.

In the abunu arrangement, Ghanaian landowners who have customary rights to land but lack sufficient labour for its development sometimes negotiate a contract with landless workers to develop forest land into a cocoa or oil palm farm. Once the farm was developed and producing (usually six to eight years), the improved land with its productive tree assets was shared equally between the worker who created the farm and the landowner. In 2010, one in every seven cocoa farms and one in every six oil palm farms had been acquired through such arrangements (Gockowski et al. 2011). Customary law recognizes this transfer of stool land from the landowner to the worker and accords the worker inheritable rights to pass this land onto his or her heirs. This institution provides an avenue for asset development among the landless and has important poverty-reducing impacts, but the incidence of such arrangements appears to be waning. Ruf (2008) reported a similar institutional innovation that emerged in the 2000s in Côte d’Ivoire in both the cocoa and rubber subsectors.

Science and technology

The green revolution was founded upon the development of improved crop varieties and the increased use of inputs which increased yield when adequate water, nutrients, pest control and sunlight were also present. The multibillion-dollar development of the oil palm sector in South East Asia was similarly the result of sustained funding over the course of the last 50 years in genetic and agronomic research. The extent to which South East Asian results will spill back into Africa, with the wave of oil palm investment by South East Asian companies, remains to be seen. The largest benefit may be the introduction of improved clones of oil palm, and their multiplication and distribution to satellite growers.

Transformative growth in the agricultural sector is closely linked to the adoption and spread of improved varieties. Genetic improvement in Africa has been impeded by a lack of sustained funding, which is particularly important given the biological lags associated with tree crops. On the supply side, long lags between planting and production slow the development of new cocoa varieties by research. On the demand side, farmers
have infrequent opportunity to improve the genetic quality of their tree stock because of the long productive life of perennial tree crops. Most farmers will only replant after 25 or more years, which is a long time to wait for repeat customers. The limited demand for improved cocoa planting materials has thus far restricted the research and development of new varieties almost exclusively to the public sector. Despite these impediments, improved planting materials have been developed for rubber, palm oil and cocoa.

However, the lack of local availability of improved planting materials has been a major limitation to their adoption. In all countries, government-sponsored seed gardens and nurseries have been the main source of improved cocoa materials. Unfortunately, nearly all of these institutions have been beset by logistical failures and supply constraints (Asare 2011). Farmers can spend an entire day travelling to a seed production unit, only to be told that there are no seed pods available.

Where research budgets have been stable and adequately funded over the years, such as the CRIG, innovations such as cocoa fertilizers and improved planting materials offer the potential for a broad-based pathway out of poverty.

**Natural resources and climate**

Land degradation is a common outcome of African agriculture. The negative nutrient balances which characterize most African farming systems are a fundamental constraint to rural development in sub-Saharan Africa (Sanchez et al. 1997). Average losses of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O were 42, 10 and 23 kg/ha of cocoa in Côte d’Ivoire, and very similar in Ghana, at 40, 8 and 23 kg/ha of cocoa (Stoorvogel and Smaling 1990). Productivity will gradually decline as nutrients are exported and not replaced. When forests were abundant, the sustainability of the farming system was based on long-term fallow rotations. This is no longer possible for the majority of tree crop producers, and an integrated approach to improving the degraded fertility status of African soils is essential.

With degradation of the tree crop system, build-ups of pests and disease inoculum can prevent the rehabilitation and replanting of the production system, and they force the farmer to diversify. The disappearance of mammalian and avian seed dispersers is another degradation which affects forest regenerative capacity. Local climatic conditions are also impacted by vegetation changes as the landscape transitions from forest to a patchwork mosaic of scrubland and agricultural use.

In nearly all instances, the tree crop farming system of Africa is rainfed and not irrigated. At the landscape level, a preponderance of tree crop production systems will generally improve water quality relative to annual cropping systems, through lower levels of sedimentation and soil erosion with year-round vegetation cover. There is some concern about the potential misuse of agrochemicals and the effects on water resources. Although pesticide use is still well below the levels found in developed country agriculture, these concerns are being addressed in the certification programmes mentioned earlier by the introduction of management practices such as riparian buffer strips and ultralow volume (ULV) pesticide applications.

Tree crop farming systems have played a major role in the near disappearance of rainforest in west Africa, where Mayaux et al. (2013) estimated that only 12 million ha of dense rainforest remains compared to 179 million ha in Central Africa. Tree crop production accounts for 1 in every 4 ha farmed in west Africa, versus 1 in every 40 ha cultivated in central Africa.
**Energy**

Energy use at the household level is relatively minor. There are energy costs embedded in the manufacture and distribution of the agrochemical inputs used by tree crop farmers. However, energy use in the production of most tree crops is relatively low as powered machinery is not widely used. There is an energy component in marketing.

Given the current small energy requirements in the production and farm gate marketing costs of tree crop farming systems, the volatility in energy prices has not greatly affect the profitability of tree crop farming in sub-Saharan Africa. As outlined earlier, palm oil markets include the growing global demand for bioenergy.

**Human capital, knowledge sharing and gender**

As earlier, smallholder education levels are low and access to resources is limited. Public sector extension services in west and central Africa have not been successful in transferring knowledge to smallholders. In an analysis of pineapple targeted for European markets and produced intensively in the eastern region of Ghana, Conley and Udry (2010) found no impact of formal extension contact on the diffusion of fertilizer use technologies. The study did find evidence that learning through farmer-to-farmer information networks, based on farmer experimentation, had a major influence on the producer’s practices. Farmer field schools (FFS) represent a more costly extension tool, which incorporates elements of adult education and farmer experimentation to strengthen the analytical capacity of farmers. The recently completed Sustainable Tree Crops Program developed FFS curricula for integrated pest and disease management, integrated soil fertility management, post-harvest management and planting/replanting practices of cocoa tree crop systems and a planting/replanting curriculum for oil palm cropping systems (David et al. 2007). Unfortunately such approaches have not been financially sustainable.

Some tree farmers are increasing capacity by employing workers who have gained skills and experience in industrial plantations. However, the underdevelopment of human capital in IPS plantation management and agronomy has constrained the growth of this particular farming subsystem. Skills are needed in a range of areas including best practice plantation management, finance and computer technology.

Male dominance of the tree crop farming system is reflected in Table 9.11, which shows over 93 per cent of cocoa farms under male ownership. The introduction of tree crop farming has mobilized male surplus labour, but it has also increased women’s workload, as demonstrated earlier for the cocoa-based FRS.

Tree crop farmers have rapidly taken up the use of mobile telephones, and SMS-based networks for extension and market information are evolving rapidly. Another important

<table>
<thead>
<tr>
<th>Mode of acquisition</th>
<th>Men</th>
<th>Women</th>
<th>Subtotals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inherited</td>
<td>5,606</td>
<td>408</td>
<td>6,014</td>
</tr>
<tr>
<td>Purchased</td>
<td>2,311</td>
<td>167</td>
<td>2,478</td>
</tr>
<tr>
<td>Other</td>
<td>217</td>
<td>12</td>
<td>229</td>
</tr>
<tr>
<td>Subtotals</td>
<td>8,134</td>
<td>587</td>
<td>8,721</td>
</tr>
</tbody>
</table>

Source: IITA (2002).
innovation since the late 2000s has been the introduction of low-cost motorcycles from Asia. Motorcycle taxi services have rapidly evolved in many rural areas and have significantly lowered the costs of communications, which facilitates knowledge-sharing between households and state extension agents.

**Farming system performance**

Most smallholder farming systems have multiple objectives which include profitability (gross revenue less purchased inputs less opportunity cost of household labour input), investment in children’s education, food security (household consumption of own production and purchase of food staples), tenured access to land, land productivity (crop yield) and sustainability issues.

As outlined earlier, fertilizer use is absent to low in the FRS subsystem and higher in the more intensified SIS and IPS subsystems, but constrained by cost and lack of availability. The use of hybrid seed is low, despite evidence that selected hybrid varieties developed by the Cocoa Research Institute of Ghana (CRIG) are four times as productive as local unimproved material (Gockowski 2012). The lack of availability of hybrid seed pods in April and May is a major constraint to their wider adoption. Currently, hybrid pods are distributed in November and December, which is the height of the cocoa harvest and also the start of the dry season. At this busy time of the year most farmers are unable to devote the time and effort required to nurse hybrid cocoa seedlings until April/May when food crop and tree crop planting occurs. If hand pollination of cocoa flowers were scheduled so that the harvest of ripe pods were to occur coincident with the April-May planting season, then farmers could plant hybrid cocoa seed at stake as is their current practice with unimproved farmer selections. Further improving farmer access to hybrid pods by reducing the distance travelled and transaction costs of acquiring hybrid pods would also help to increase adoption.

Another important determinant of productivity in the tree crop farming system is tree age. Most perennial tree crops show an ‘inverted U’ yield-age profile. Yield remains at zero the first few years after planting, then begins climbing until finally reaching a plateau as the tree reaches maturity, and then eventually declines as senescence, pests, disease and nutrient depletion manifest themselves (Ahenkorah et al. 1987). Figure 9.12 illustrates an empirical yield-age distribution from Ghana.

Annual costs and returns per hectare developed for representative cocoa FRS and SIS using Ghana field data indicate strong financial incentives for adopting intensified subsystems, with yields and income more than double the FRS (Table 9.12). Even with the fertilizer subsidy removed the SIS still outperforms the FRS by 370 Ghana cedi (GHC) ha⁻¹, although at this point the producers’ cash outlay rises to nearly 600 GHC ha⁻¹, which is a lot of cash for a smallholder especially when rural financial markets do not function well.

Table 9.13 presents yields of FRS cocoa per hectare and yields per household member across farm size quintiles. This clearly illustrates declining land productivity as farm size increases, while labour productivity per household member increases. Overall, yields are very low relative to potential yields, reflecting limited technological innovation and the continued mining of nutrient stocks.

Higher land yields among smaller producers are the result of a higher input of family labour on a per hectare basis. The relatively low yield per household member for the smallest quintile of producers suggests that even at a farm gate price of US$2/kg, returns are not likely to exceed the World Bank poverty measure of US$1.25 per capita per day for many in the distribution.
Figure 9.12  Yield-age profile of cocoa tree stocks in the Bia district of western Ghana (n=172).
Source: IITA (2011).

Table 9.12  Costs and returns per hectare for cocoa FRS and SIS enterprises based on 2009 prices

<table>
<thead>
<tr>
<th>Item description</th>
<th>Unit</th>
<th>Price GHc</th>
<th>Forest rent Qty</th>
<th>Subtotal</th>
<th>Smallholder intensified Qty</th>
<th>Subtotal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cocoa</td>
<td>Kg</td>
<td>2.2</td>
<td>288</td>
<td>636</td>
<td>650</td>
<td>1435</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>Kg</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
<td>225</td>
<td>112</td>
</tr>
<tr>
<td>Fungicide</td>
<td>Sachet</td>
<td>1.1</td>
<td>34</td>
<td>37</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>Insecticide</td>
<td>Litre</td>
<td>16.8</td>
<td>1.1</td>
<td>19</td>
<td>2.5</td>
<td>42</td>
</tr>
<tr>
<td>Herbicide</td>
<td>Litre</td>
<td>7.6</td>
<td>0.2</td>
<td>1</td>
<td>1.1</td>
<td>8.2</td>
</tr>
<tr>
<td>Hired labour</td>
<td>Worker</td>
<td>400</td>
<td>0.2</td>
<td>90</td>
<td>0.4</td>
<td>147</td>
</tr>
<tr>
<td>Family labour</td>
<td>Worker</td>
<td>0.5</td>
<td>0</td>
<td>0</td>
<td>0.5</td>
<td>0.0</td>
</tr>
<tr>
<td>Capital depreciation</td>
<td>GHc</td>
<td></td>
<td></td>
<td></td>
<td>11</td>
<td>23</td>
</tr>
<tr>
<td>Total cost</td>
<td>GHc</td>
<td></td>
<td></td>
<td></td>
<td>158</td>
<td>357</td>
</tr>
<tr>
<td>Net return</td>
<td>GHc</td>
<td></td>
<td></td>
<td></td>
<td>478</td>
<td>1079</td>
</tr>
</tbody>
</table>

US$1 = 1.29 GH cedi (2009).
Source: Author’s calculation.

Smallholder adoption of commercial oil palm production, as opposed to the tending of self-seeded wild groves of oil palm, is a relatively recent phenomenon in the economic history of west Africa. In fact, most of the growth in oil palm production over the last 20 years has occurred in the smallholder sector. Ntsiful (2010) did a comparative
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The multidimensional poverty analysis of contractually obligated outgrowers, independent oil palm growers and non-oil palm producing rural households in two regions of Ghana. His main findings were that outgrowers: (1) exceeded the incomes of independent growers by threefold and non-oil palm producers (principally maize-growing) by fivefold; (2) consumed more fruits, vegetables, meat, eggs and dairy products; (3) had better accommodation and were more likely to have electricity and running water in the household; (4) were more likely to have bank accounts and access to credit; (5) had more material assets such as refrigerators, televisions and mobile phones; and (6) made substantially higher investments in their children’s education than the other households.

The conclusion of the study was that the outgrower contract farming model was an effective tool for poverty alleviation in rural areas. This corroborates well with the South East Asian experience where the growth of the palm oil sector has had an enormous impact on poverty reduction. World Growth (2011) cites poverty reduction of 6 million persons from palm oil production in Indonesia. Indeed, the spectacular rise of the oil palm industry in Malaysia and Indonesia has been one of the most noteworthy achievements in poverty reduction by agricultural science to date.

Social values and environmental performance of the subsystems are also relevant. Phalan et al. (2011) comprehensively measured income and biodiversity conservation for land use systems in what was formerly the high forest region of southern Ghana, and concluded that more biodiversity would be conserved through the pursuit of land-sparing, high-yielding technologies such as the SIS as compared to land sharing FRS type systems as described earlier. Although relatively high levels of biodiversity are maintained by the cocoa FRS, the average yields are low (Jagoret et al. 2011). Several types of cocoa and oil palm subsystems were evaluated; in regions where access to fruit and forest product urban markets was good, shaded cocoa agroforests had the highest income, environmental and biodiversity values (Gockowski et al. 2005). However, this win-win outcome was contingent upon urban market access for the secondary products produced by these agroforests. When markets are not accessible the income performance of these ‘land sharing’ multi-strata subsystems declines significantly. Low rates of land use productivity in the FRS have had disastrous consequences on the west African Guinea rainforest (Gockowski and Sonwa 2011). Resolving the debate requires empirical investigation of these trade-offs.

### Table 9.13 Partial productivity measures for cocoa producers across west Africa, for five categories (I to V) of cocoa productive area per household

<table>
<thead>
<tr>
<th>Quintile</th>
<th>Yield per ha (kg)</th>
<th>Yield per HH member (kg)</th>
<th>HH members per producing ha (kg)</th>
<th>Output per HH (kg)</th>
<th>Share of producing area (%)</th>
<th>Share of total output (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>415</td>
<td>69.8</td>
<td>5.9</td>
<td>548</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>II</td>
<td>357</td>
<td>87.3</td>
<td>4.1</td>
<td>918</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>III</td>
<td>323</td>
<td>123</td>
<td>2.6</td>
<td>1,267</td>
<td>13</td>
<td>17</td>
</tr>
<tr>
<td>IV</td>
<td>272</td>
<td>148</td>
<td>1.8</td>
<td>1,657</td>
<td>21</td>
<td>22</td>
</tr>
<tr>
<td>V</td>
<td>210</td>
<td>236</td>
<td>0.9</td>
<td>3,259</td>
<td>53</td>
<td>43</td>
</tr>
<tr>
<td>Grand total</td>
<td>260</td>
<td>143</td>
<td>1.8</td>
<td>1,530</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: IITA 2002; see Table 9.8 for definition of the farm size (quintile) categories.
Strategic priorities for the system

A ranking of poverty escape pathways for populations in the tree crop farming system regions of west and central Africa must begin with the question of who are the chronic poor in these systems and how do they currently earn their livelihoods? All evidence points to a landless or near landless class of migrants working as sharecroppers for the extensive FRS tree crop subsystem. The fact that a one-third share of an FRS tree crop system – representing a few hundred dollars – provides an incentive for migration speaks to their impoverishment. They have little capacity for intensification or diversification, cannot increase farm size and often have never been to school. Improving their livelihoods depends first and foremost on expanding opportunities within the unskilled agricultural labour market (Table 9.14).

Direct investment in industrial plantation subsystems are estimated to create anywhere from 10 to 20 jobs per square kilometre of plantation development. In many underdeveloped regions that is more jobs than there are rural inhabitants. As an example, the Cameroon Development Corporation employs over 18,000 permanent workers and nearly 1,000 supervisors and managers on an area of 420 km² – a density of about 45 jobs/km². Today Malaysia and Indonesia stand at the top of the multibillion-dollar palm oil industry and have witnessed unprecedented and largely unrecognized reduction in rural poverty because of this growth.

While the formal jobs generated by the industrial oil palm plantations account for the largest share of South East Asian poverty reduction, the growth of the smallholder palm oil sector has also contributed to poverty reduction. Smallholders account for over one third of the total area of planted oil palm in Malaysia and Indonesia and as much as 33 per cent of the output. Elsewhere, as in West African countries that produce mainly for domestic and regional markets, smallholders produce up to 90 per cent of the annual harvest.

The IPS outgrower schemes are another form of contractual engagement with smallholders, which link them to global markets through the marketing and processing infrastructure of the IPS. Smallholders are able to access inputs and knowledge which allows them to transform their FRS tree crop systems into more sustainable intensified production systems.

Through investment in plant breeding and agronomic research, Malaysian and Indonesian science have developed the world’s most productive oilseed production system. Investments in these systems have resulted in the conversion of 13 million ha of South East Asian tropical forest, which is a substantial environmental cost. Against this cost, policy makers must weigh the benefits from eliminating rural poverty.

Other hotspots of chronic poverty within the tree crop farming system domain include the more remote areas bordering the forest-based farming system, where land is still relatively abundant but difficulties in getting goods to markets presents a heavy tax on production. These regions are enticing for IPS investment because land is still abundant and labour is also available. Some communities in such areas are negotiating long-term leases with industrial plantation entities for a portion of their lands. In exchange, the community receives: (1) access to new production technology through smallholder outgrower schemes; (2) access to new markets through investments in processing and transport capacity; and (3) social infrastructure such as schools and clinics help to develop human capital.

With suitable land increasingly scarce in South East Asia, many large corporations are looking to develop tree crop plantations in west and central Africa. The Congo Basin has over 179 million ha of extant tropical forests, while over 50 per cent of its population...
lives in abject poverty. African leaders need to consider the responsible development of a portion of its still immense stock of forest in order to provide jobs for the poor.

Tree crop producers have more scope to generate positive growth from their existing assets. Much can be learned from Ghana’s policy-induced episode of intensification that is pertinent for broad-based growth. How can state interventions in input markets build on the existing private sector institutions and infrastructure? What were the institutional successes and failures of the programme? What were the linkages between input supply and credit that permitted broad-based adoption of yield-augmenting fertilizers? Achieving the transformation will require a broad range of interventions and investments to address strategic constraints and to capitalize on emerging opportunities.

The principal constraints are:

- the lack of a shared vision and strategic framework for the sustainable intensification of agriculture among policymakers, private investors, research managers, extension services, consumers and most importantly farmers and their organizations over all sectors and farming systems
- underinvestment in human capital
- underdeveloped rural markets (credit, input and outputs)
- gross underinvestment in both applied and basic research, which are prerequisites for effective extension
- a lack of modern port facilities, roads and rail infrastructure, especially in central Africa.

The principal emerging opportunities include:

- increased financial flows from IPS subsystems and affiliated outgrower schemes
- penetration and investment into African markets by large multinational agricultural commodity enterprises
- steady growth in global demand for tree crops
- global certification of production standards
- rapid uptake of mobile phone technology among the rural population.

Multinational agricultural commodity firms with interests in cocoa, oil palm, tropical timber and coffee have recently invested in sustainability certification schemes with groups of African smallholders. Avoiding irreversible soil impoverishment is a necessary condition.
for system sustainability. Multinational-backed cocoa buyers are providing inputs on credit using the farmer’s standing crop as collateral. Greater formalization of these institutions is an important first step in the development of rural financial markets. The recent wave of foreign investment in IPS subsystems presents both an opportunity and a threat. The share of physical capital in smallholder African agriculture is extremely low. The capacity of a large-scale multinational to invest millions in essential capital goods such as oil milling plants can instantly create a market where none existed prior to the investment. There is a threat, however, that an enclave sector develops with little benefit to local communities (Cotula et al. 2009).

Crosscutting priorities: research, extension, public infrastructure, land tenure reform

In recent years, private capital markets have shown a renewed interest in African agriculture. Unfortunately the essential public investments needed to support a modern science-based agricultural sector are less evident. High-priced commodity markets are signalling to farmers and their governments that now is the time to innovate, invest and increase agricultural productivity.

The first priority for government investment is to revitalize the capacity of agricultural science after many years of neglect. The situation has not changed since Ruttan and Thirtle’s (1989) study of technological and institutional change in African agriculture expressed concern over Africa’s underinvestment in the human capital needed to invent, diffuse and effectively deploy new agricultural technology. Increasing investments in rural education, research and extension remain critical priorities for the sustainable intensification of farming systems in the humid tropics.

R&D must address three main areas of need: (1) the development and introduction of improved planting materials and their delivery systems adapted to farmer planting preferences; (2) integrated soil fertility management practices tailored to local agroecological and socioeconomic situations; and (3) integrated pest and disease management. There is a trove of research knowledge on cocoa, rubber, coffee, citrus and particularly oil palm in the commodity research institutes of the pan-tropics, including the Rubber Research Institute of Sri Lanka, the Indonesian Oil Palm Research Institute, the Malaysian Palm Oil Board and the Cocoa Research Institute of Ghana. Developed country research institutes such as Penn State, Centre de coopération internationale en recherche agronomique pour le développement (CIRAD) and the United States Department of Agriculture (USDA) are working on molecular approaches with African partners to speed up the process of tree crop genetic improvement. Any new investment in R&D should build on this foundation of knowledge.

While a lot of lost ground can be made up quickly through south-south research collaborations and through the encouragement of foreign investment, a good portion of productivity growth is location and system specific and will require substantial investment to develop local research capacity for innovation.

A knowledge-based agricultural sector will also require substantial investments in the human capital employed in the agricultural sector, whether as managers of intensified smallholder tree crop farming systems, or as managers of 5000 ha oil palm plantations. This will require investments in education as well as public health.

The development of well-trained managers versed in the best management practices for plantations and estate outgrower projects will encourage the foreign direct investment needed to create additional jobs and generate public revenues through taxation.
Beyond skills in plantation management and agronomy, successful managers must also have knowledge of geographical information systems, financial management systems, environmental best practices and community development approaches.

Agriculture has become one of the most globalized trade sectors, with high reward for marketing efficiency. In today’s global economy, public investments in port and transport facilities are important for encouraging the private investments needed for transformational growth.

The costs of marketing commodities in Africa are excessively high and are a constraint to growth. One of the keys to sustainable agricultural intensification is the development of a viable private sector input supply sector. Smallholder intensification induced by the policies of the Ghana Cocoa Marketing Board achieved remarkable accomplishments and demonstrated the willingness of smallholders to adopt new technology when it works and improves their livelihoods. But despite all the indisputable achievements, it is not yet clear whether the foundations have been laid for a viable and competitive input supply sector.

One question is the role of input subsidies. An argument is sometimes made that fertilizer and pesticide subsidies, although distorting efficient market outcomes, are necessary to ‘prime the pump’ for adoption by smallholders. Others argue in support of fertilizer subsidies as a correction to the failure of markets to reflect all of the environmental costs of not using external soil amendments (Gockowski and Sonwa 2011). The main argument against the use of subsidies is that they are costly and detract from other, more essential, public investments. Another critique against the use of subsidies is that poorly designed programmes can threaten the emergence of a private input supply sector, particularly when a state agency is employed in their distribution. Finally, the non-participation of the poor and landless in these programmes is a common result. In fact, if the cost of such programmes is netted out of the price paid to producers, as is the case in Ghana, input subsidies can actually make non-adopters worse off (Gockowski 2012). The history of commodity-based input subsidy programmes is not replete with success stories. Ideally a responsive input supply sector would be able to meet the demands and supply the needs of the whole range of production possibilities from tree crops to food crops. This would allow for more rapid adjustment to market fluctuations and increase the propensity for diversification.

Farmer extension is another important public good that has habitually been underfunded. New communication technologies present a potentially revolutionizing means of delivering knowledge to smallholders as well as receiving knowledge from farmers. Extension services need to reconsider the village-based extension agent model and incorporate new information technology approaches.

One of the criticisms made of the green revolution was that large landowners benefited much more than small landowners and landless workers (Hayami and Ruttan 1985). Agriculture is a competitive business. Over time, the efficient farmers tend to accumulate productive resources while the inefficient are forced eventually to either seek alternative production enterprises in which they are more competitive, or to exit agriculture and search for alternative livelihoods. The important issue is to make technology accessible to small and large producer alike. If the technology tends to be land saving and labour using (as most biological and chemical innovations are), then that technology is likely to support the gradual transformation of small family farms (Hayami and Ruttan 1985). Land tenure institutions that allow equitable redistribution of land assets, and well-developed credit markets, are required to facilitate broad-based and equitable participation in growth-oriented technical change. Customary land tenure and inheritance institutions in Africa
can be a constraint to economic development as they may, over time, lead to excessively small farm sizes to the point that farming becomes just a part-time occupation for the majority of households, as has happened in south-eastern Nigeria. However, the statutory land laws inherited from colonial times have not proven effective in dealing with an excessive number of land disputes. Efforts to combine customary and statutory law are showing some promise.

More knowledge is needed about the magnitude and type of climate change likely for west Africa in order to design adaptive measures. There is a pressing need to rebuild the climate monitoring network in Africa, linking the weather stations to global reporting networks and integrating with satellite observations. Tree crop production systems have been proposed as potential carbon sinks when targeted at already deforested land (Jagoret et al. 2012). Rapid advances in remote sensing of land use change offer the potential for a globally consistent means of monitoring land use change at a spatial resolution with relevance to local communities (Hansen et al. 2013).

System conclusions

The drivers of change affecting the intensification of tree crop farming system of Africa should interest opinion leaders, decision makers, business leaders and stakeholders seeking to transform the smallholder agricultural sector and improve its associated livelihoods. Transforming from traditional low-input low-output farming systems to intensified knowledge-based systems is among the chief aims of the African Union as expressed in the Malabo Declaration on Accelerated Agricultural Growth and Transformation (African Union 2014). Rural transformation should also interest environmental planners and conservationists looking to stem the rates of deforestation and forest degradation associated with extensive agriculture.

Evidence has been presented to suggest that sustainable agricultural intensification will be fundamental to achieving development goals regarding poverty, economic growth and the environment. Africa failed to capitalize on the development of palm oil as the pre-eminent vegetable oil in global trade. Capital investors now wish to bring the South East Asian model of oil palm development back to Africa, presenting an opportunity to capture market share in this rapidly growing US$45 billion industry. The impact of doing so could be transformational, and African opinion leaders are calling for it to happen (Ayodele 2010).

Note

1 Rainforest was defined as having an average canopy height of 35 to 40 m and a canopy coverage of more than 70 per cent.

References


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