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Changes in Ghanaian Farming Systems

Stagnation or a Quiet Transformation?

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Contents

Tables

Figures

ABSTRACT

This research was designed to understand better the patterns of agricultural intensification and transformation occurring in Africa South of the Sahara using the Ghanaian case. The paper examines changes in farming systems and the role of various endogenous and exogenous factors in driving the conversion of arable lands to agricultural uses in four villages within two agroecologically distinct zones of Ghana: the Guinea Savannah and Transition zones. Using essentially historical narratives and land-cover maps supplemented with quantitative data at regional levels, the research shows that farming has intensified in the villages, while farmers have increased their farm size in response to factors such as population growth, market access, and changing rural lifestyle. The overall trend suggests a gradual move toward intensification through increasing use of labor-saving technologies rather than land-saving inputs—a pattern that contrasts with Asia's path to its Green Revolution. The findings in this paper provide evidence of the dynamism occurring in African farming systems; hence, they point toward a departure from stagnation narratives that have come to prevail in the debate on agricultural transformation and intensification in Africa South of the Sahara. We conclude that it is essential for future research to expand the scope of this work, while policies should focus on lessons that can be learned from these historical processes of genuine change.

Keywords: intensification, farming systems, stagnation, Green Revolution, Ghana

JEL codes: Q12, 012, 013, 033

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1. INTRODUCTION

Agricultural Transformation and Farming Systems in Africa South of the Sahara

Intensification of farming systems has been essential for agricultural transformation in many developing countries. However, on the African continent, the debate about agriculture intensification has been dominated traditionally by stagnation narratives (see, for example, Amanor and Pabi 2007; Hazell 2010; Djurfeldt and Djurfeldt 2013). Many scholars have sought to explain the shortcomings of African agriculture in light of major progress made in Asia during the Green Revolution (GR) in the 1960s, which was characterized by an increase in land productivity as land became increasingly scarce owing to rapid population growth. The most influential arguments held that, for a number of reasons, agriculture had not intensified among smallholders on the African continent despite decades of efforts (Johnson et al. 2003; Djurfeldt et al. 2005; Pingali 2012). First, population densities in Africa had for a long time been lower than they were in Asia during the GR. Second, the state of rural infrastructure (for example, roads and irrigation) had been relatively weaker in Africa. Third, markets in general had been less developed in Africa. Finally, the idea that cereal crops (for example, wheat and rice in Asia's GR) could spur a green revolution in Africa had been discounted by many experts because a wide variety of crops are grown across the continent's diverse agroecological and climatic landscapes.

The pessimism surrounding a stagnant African agriculture derives from the evidence of low technology adoption rates and productivity growth occurring over many decades (Evenson and Gollin 2003). Even today, the evidence appears to point toward similar conclusions. For example, Djurfeldt and Djurfeldt (2013) reviewed data from eight African countries and concluded by drawing a picture of overall stagnation and little evidence of structural transformation within smallholder agriculture. More specifically, these authors asserted that while grain production had intensified, productivity gains could be explained by more intensive use of labor rather than by technological change. A more recent study by Nin-Pratt and McBride (2014) for the case of Ghana also found no evidence of an Asian-style agricultural intensification occurring as a result of rising population densities—pointing to the persistence of high labor costs despite rapid population growth.

Furthermore, the insufficient uptake of new technologies in African agriculture at the continent-wide level has often led scholars to seek for any evidence of either changes occurring in underlying conditions that would stimulate greater intensification in the future or intensification taking place at a more localized level. Pingali (2012) and Djurfeldt et al. (2005), for example, pointed to the simple fact that the dominant pessimism of stagnation and doom in African agriculture is no different from that regarding Asia prior to the Asian GR—a fact often ignored, leading to the persistence of certain perspectives, even in the presence of counterevidence (Amanor and Pabi 2007). In contrast, conditions in Africa have witnessed significant changes in more recent times, including a rise in population densities, growing land scarcity, improved access to modern inputs (especially among major cereals, root crops, and legumes), growing urban demand for major food staples, and generally, a more favorable policy environment for African agriculture (Pingali 2012). These changes have rekindled the debate as to whether Africa is on the verge of experiencing a GR, and if so, whether it will follow the Asian style (through the adoption of labor-intensive and land-saving technologies) or adopt a uniquely different pathway (through labor-saving technologies, for example).

Rather than focusing on the macro- or continent-wide level, other scholars have chosen to explore changes in farming systems at the micro level to point to examples of successful intensification in certain countries and regions as local conditions have changed. Netting et al. (1989) indicated that for a little more than 30 years, farmers in the Kofyar communities of the Plateau State of Nigeria spontaneously and voluntarily expanded food crop production for the market using indigenous low-energy technology, changed from shifting cultivation to intensively tilled and fertilized homestead farms, and reorganized their labor to address seasonal bottlenecks and to provide the careful discipline that intensive agriculture requires. Headey, Dereje, and Taffesse (2014) showed that, to the East, intensification occurred in Ethiopian villages with high potentials. Some irrigation schemes in Ghana have also proven to be highly intensive, achieving rice yields of six tons per hectare—as high as yield level in Asia—so long as sufficient infrastructure and support institutions were in place, as well as markets (see, for example, Takeshima et al. 2013). Wiggins (2009) also emphasized similar conclusions that whenever marketed output has increased owing to greater market access, small-scale farmers on the African continent have been quick to take up new technologies (or technical advances). These examples share the common perspective of seeking evidence of an Asian-style intensification process in African agriculture. Even so, conditions in Africa can be quite different from those in Asia, as Pingali (2012) has pointed out. Drawing from the Ghanaian case, Amanor and Pabi (2007) tried to explain the differential pattern of agricultural intensification in Africa relative to Asia, arguing that changes in farming practices in Africa have been driven more by other factors, such as a response to modern conditions and commodification.

Perhaps the key questions for Africa are (1) whether farming systems are tending toward greater intensification, and if so, (2) which form the transformation is taking, and (3) what the plausible explanations and drivers of change are. This paper attempts to answer these questions by documenting changes in farming systems at the village level in Ghana's Guinea Savannah and Transition zones. More specifically, it examines changes in farming systems and the role of various endogenous and exogenous factors in driving the conversion of arable lands to agricultural uses in four villages within two agroecologically distinct zones of Ghana: the Guinea Savannah and Transition zones.

The findings in this paper are based essentially on historical narratives shared by the communities visited and village land-cover maps supplemented with quantitative data at regional levels. Although the research draws extensively on some of the fundamental theories of agricultural intensification motivated by Boserup's theory (Boserup 1965), the analysis expands to include qualitative narratives that express a broader sociological and human ecology perspective. This approach allows for sufficient flexibility in understanding what is observable on the ground without restricting the analysis to a single lens or theory. Appropriate studies of transformation in farming systems at the village level are scarce for Africa South of the Sahara (SSA); instead, published surveys often describe the situation at one point in time and provide little insight into change while others describe just a small part of the farming systems (Wiggins 1995). The present work is also partially a response to the call for more village-level studies to document signs of dynamism at the micro level in African farming systems (see, for example, Djurfeldt and Djurfeldt 2013).

Results from our observations show that farming systems clearly intensified in the four villages we visited, a pattern that was broadly consistent with regional-level trends. We found that most farmers in the communities started small but went through a transition process from using hand tools to tractor plowing and from planting traditional and late-maturing crop varieties to early-maturing ones. Farmers also transitioned from using no chemical input (fertilizer and herbicides) to increasing their use of chemical inputs and from subsistence to market-oriented production. Further, they adapted as they confronted both external and internal forces, such as improved infrastructure (roads and electricity), shifts in consumption patterns (partially from inmigration and rising incomes), and rising population density but also growing labor bottlenecks, improved market access for both inputs and outputs, and overall changing rural lifestyles.

To respond adequately to endogenous and exogenous factors, most farmers in the communities we studied increased their farm size in the process. Even those whose holdings remained small introduced major changes into their farming systems. The evidence suggests that although crop yields have increased only slightly, both labor and land productivity (in terms of consumption expenditures and value of production, respectively) have increased substantially, suggesting that farmers are better off today than in the past. These changes have been incremental, and the transition has not been a linear process. Our research acknowledges the multiplicity of factors that led to changes in Ghanaian farming systems. The village narratives here are essential for informing the debate on SSA agricultural intensification, and perhaps contribute to the conceptualization of an SSA-specific path to agricultural transformation that tends to be characterized more by labor-saving than by land-saving intensification.

2. LITERATURE REVIEW, THEORETICAL FRAMEWORK, AND METHODS

Literature Review and Theoretical Framework

A number of theories have been commonly referred to for explaining agricultural intensification in a developing-country context. This process began with Boserup's (1965) theory on population growth and technical change, which was expanded later by Hayami and Ruttan (1978) with the induced innovation model and Johnston and Mellor's (1961) thesis on agricultural transformation and growth linkages. Boserup (1965) is credited as being the first scholar to theorize an evolutionary process of farming systems that directly responded to the more pessimistic viewpoint of the time (the Malthusian hypothesis), which posited declining per capita agricultural production as population grows.

According to Boserup (1965), farming systems (defined here as the mix of agricultural activities, inputs, and farming practices used to achieve a desired level of production) follow an evolutionary intensification process that drives the adoption of various inputs—from forest fallow, to bush fallow, then short fallow, annual cultivation, and finally, multicropping, as shown in Table 2.1. These stages have their distinctive characteristics, which will not be discussed in details here. However, they all entail a gradual change toward more frequent and intensive use of cropland, with population growth and market access being critical driving factors aside from local agroecological conditions.

Table 2.1 Evolution of farming systems

Stage	1	2	3	4	5
	Forest fallow	Bush fallow	Short fallow	Annual cultivation	Multicropping

Source: Boserup (1965).

Boserup's main argument focuses on how population pressure stimulates technological innovation and intensification due to reduced fallow and access to virgin lands (used, for example, for shifting cultivation in traditional societies). However, other scholars would later introduce policy as a third driver through the induced innovation model (Hayami and Ruttan 1970). The induced innovation model focuses more attention on relative resource endowments that can be affected by policy, and ultimately, lead to technical change as farmers seek to substitute one input for another (that is, from the relatively scarce one to the relatively abundant one). Looking at the broader perspective that links intensification to overall growth and agricultural transformation, Johnston and Mellor (1961) introduced the concept of growth linkages between the farm and nonfarm sectors. This concept stresses the role of agriculture in developing countries—as initially providing cheap labor, cheap food for urban areas, and foreign exchange earnings (from export crops) while stimulating greater demand for industrial inputs from the nonagricultural sector as farming systems intensify over time.

In examining the links between population growth and agricultural intensification, much of the evidence from Asia's GR has focused on the important role of both labor intensification and access to new technologies (Ruthenberg 1980; Lipton 1989; Pingali, Bigot, and Binswanger 1987). A key finding was the appearance of a higher degree of substitutability of capital and labor for land over the long run. Additionally, agricultural intensification appears to have been induced by policy, and not by population growth alone, as relative resource endowments changed as a result of both policy and population growth—measured by the land-to-labor or fertilizer-to-land price ratios, for example. Such changes, according to the induced innovation model that followed Boserup's work, would induce technological change that substitutes a relatively abundant factor (for example, labor) for a relatively scarcer one (for example, land) in order to remove the constraint on productivity growth. For the examples used here, the constraint on land (as the relatively scarce factor) is relaxed by inducing the adoption of improved and high-yielding crop varieties (which demand more labor per hectare, as the abundant factor), a scenario that is typically used to explain the success of the Asian GR. Policy is a factor in this case by affecting not only access, but also the price ratios of technology inputs and know-how, as well as access to stable output markets and prices. Based on this evidence, some scholars argue that Boserup (1965) ignored the importance of policy-induced responses and assumed that changes would stem autonomously from population increases. Lipton (1989) in particular affirmed that Boserup's understanding of the process of change is too slow, stressing that government interventions are necessary to facilitate it.

Applying Boserup's (1965) theory to the African context also has been more challenging, especially because her theory derives mostly from the Asian GR experience and has yet to be widely tested on the continent, except for a few case studies. The main challenge of applying Boserup's theory stems from the fact that land has been relatively abundant on the African continent throughout much of the period since independence. However, this situation is now changing, as evident in Table 2.2. Whereas Africa's rural population density was below that of Asia's in the 1960s, the story has been quite different at the country level. For example, rural population density (per hectare of arable land) in Ethiopia reached that of India by the 1990s—approximately five persons per hectare of arable land. Malawi, on the other hand, has maintained the same levels of population density since the 1980s. In Nigeria, the rural population density is no closer to that of India than it was in the 1960s. Ghana and Malawi seem to be exceptions—probably the result of outmigration, which has kept Malawi's population density unchanged for much of the time, while density has actually fallen over time in Ghana owing to economy-wide labor constraints, urbanization, rural urban migration, and nonagricultural sector growth (Diao et al. 2014).

Table 2.2 Rural population densities per hectare of arable land area in Africa and Asia, 1961–2012

Region	1960s	1970s	1980s	1990s	2000s	2010s	Annual growth (%)
Asia							
Bangladesh	6.2	7.2	8.4	10.8	13.1	14.2	1.9
India	2.6	3.0	3.6	4.3	5.0	5.4	1.7
Africa							
Ethiopia	2.1	2.4	3.2	4.9	5.3	4.9	2.3
Ghana	3.3	3.8	3.7	3.2	2.7	2.6	–0.7
Malawi	2.4	2.4	3.2	3.7	3.5	3.5	1.0
Nigeria	1.5	1.9	2.6	2.1	2.2	2.4	0.8
Africa	1.6	1.9	2.3	2.4	2.7	2.8	1.2
Asia	3.5	4.1	4.5	4.6	4.9	4.9	0.7

Source: Compiled from FAO statistics (2015).

Only recently have countries in Africa started to reach their land frontiers. A number of case studies have begun to emerge to test Boserup's theory in the African context. A review by Wiggins (1995) revealed earlier cases in support of Boserup's theory, such as the work by Pingali, Bigot, and Binswanger (1987) on the low adoption of mechanization during the 1980s. More recently, Headey, Dereje, and Taffesse (2014) found strong evidence favoring the Boserupian theory for explaining intensification at the village-level in Ethiopia. Ricker-Gilbert, Jumbe, and Chamberlin (2014) also found similar evidence in Malawi. More specific to Ghana, Codjoe and Bilsborrow (2011) found some evidence supporting Boserup's intensification argument for farming systems in the Guinea Savannah and Transition zones.

However, a few studies have also suggested the possibility of a differential pattern of agricultural intensification in Africa within the realm of economics. One of the earliest was the work by Hill (1961), who based his study on field observations that derived from both economic and anthropological approaches to examine cocoa farming systems and labor migration—especially the role of migrant workers in Southern Ghana. Another important study was the work by Amanor and Pabi (2007), who argued that it is overly simplistic to conclude that changes in Ghanaian farming systems are simply a product of evolutionary sequences of responses to population pressures or local market dynamics that have led to the adoption of modern varieties. These authors indicated that detailed studies of African farming systems suggest that declining fallow intervals are not necessarily a sign of population density or intensification, nor is extensive agriculture with long fallow necessarily a function of low-population densities, as theorized by Boserup (1965). Instead, they suggested that changes in farming systems arise more out of a complex set of factors that interact with local (and often difficult and unpredictable) ecologies, the policy environment (for example, past public infrastructure investments, input subsidies), and wider regional economies that are increasingly commodified and commercialized and subject to global pressures. More recently, Nin-Pratt and McBride (2014) suggested that agricultural intensification in Ghana has not been driven by population density but by the adoption of both labor-saving (mechanization) and land-saving (improved seeds and chemicals) technologies.

In summary, the foregoing observations have revived the debate as to whether Africa is experiencing a uniquely different path to intensification. What is also clear is that the process of intensification has not occurred through population growth alone. Rather, policy has played a large role, as others have argued with regard to the Asian GR (Hayami and Ruttan 1970; Pingali, Bigot, and Binswanger 1987; Hazell 2010). In addition to policy, external shocks (for example, droughts and/or global market shocks) are influential because they can either slow, inhibit, or speed up the process toward intensification.

Study Areas and Methods

This study was conducted in the Ejura–Sekyedumase district of the Ashanti region and in the Savalegu–Nanton district of the Northern region. These districts are located in the Transition and Guinea Savannah zones, respectively. In 2012 and 2013, the Ejura–Sekyedumase and Savalegu–Nanton districts were among the top five producers of grains (cereals and legumes) in their respective regions (SRID 2012, 2013). Using district agricultural officers' knowledge of the areas, as well as recently collected community data (IFPRI/SARI 2013), we selected two representative villages in each district as follows (Table 2.3):

Table 2.3 Village selection

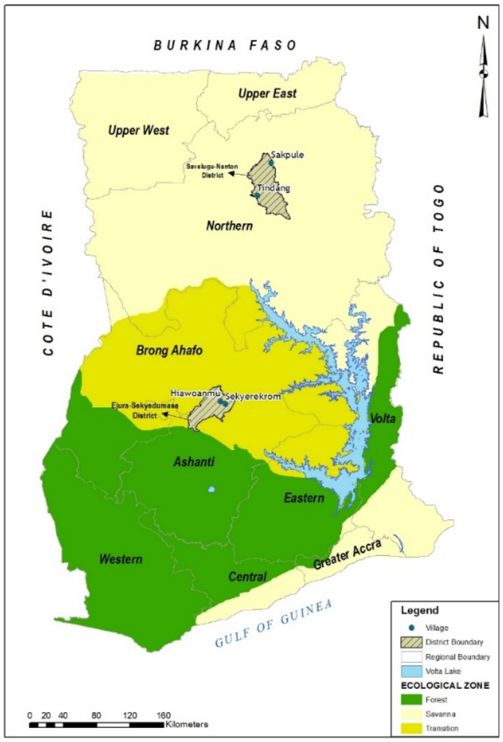
Agroecological zone	District	Village	
		Type I	Type II
Transition	Ejura–Sekyedumase	Hiawoanwu	Sekyerekrom
Guinea Savannah	Savalegu–Nanton	Tindang	Sakpule

Source: Village studies (2015).
Note: Sekyekrom and Sakpule are also known as Sakiryiakura and Saakpuli, respectively.

Type I refers to a village that has reached its land frontier (that is, unable to expand farmlands any further within its own community boundary but may have access to land in neighboring communities). Type II refers to a village that still has some virgin lands available for expansion, or at a minimum, sufficient fallowed lands. The village of Hiawoanwu is located along the main road crossing the Ejura–Sekyedumase district, whereas Sekyerekrom is located further inland, 7 kilometers away from the district capital. The village of Tindang is located in the Savalegu–Nanton district, a few-minute drive from Tamale Metropolis in the Northern Region, whereas Sakpule is located further north, 56 kilometers from the district capital. By selecting two types of villages within the same locations, we intended to factor in potential spatial differences in patterns within the same districts and agroecological zones. Figure 2.1 shows the locations of the villages in the agroecological zones.

We documented changes in farming practices, systems and input mix, and their underlying perceptions through historical narratives and our own observations. The primary objective of our interviews was to create a historical narrative that describes how changes in the physical and socioeconomic environment affected the type of farming systems and technologies adopted over time. These included changes in resource availability and growth patterns (land and labor, including population dynamics, migration patterns); soil fertility and rainfalls patterns; and knowledge and access to technologies (for example, public sector extension efforts, improved access to markets). Additionally, certain local, anthropological/sociological, and national political factors may have been at play, whether abruptly, in the form of a shift due to conflict or policy change, or gradually, as new policies and investment strategies were introduced or removed. This work builds up narratives of change using interviews with farmers and seeks to establish the concordance or divergence of perception-based patterns from existing research findings and to single out what is potentially different about Ghana.

Figure 2.1 Agroecological zones of Ghana



Source: Compiled from HarvestChoice and GADM data (2015).

We used essentially in-depth qualitative methods: focus groups and key informants to collect data from the villages. In each village, we conducted three focus groups and three key informant interviews on issues related to village characteristics and infrastructures: farming as it was practiced in the 1980s and how is has evolved since then, cropping patterns, use of inputs (modern and traditional), farm size dynamics, land issues, and the major events/changes that have affected life in the village since the 1980s. The focus groups consisted of farmers (small, medium, and large) with considerable farming history and experiences; key informants consisted of senior district agricultural officers, village chiefs, or residents knowledgeable about the changes that have occurred in farming systems in the villages visited. As much as possible, we supplement qualitative data with available quantitative information from the agroecological zones covered.

Land-Cover Classifications and Analysis

We used satellite images from Landsat to determine the nature and extent of land-cover changes in and around the immediate vicinities of the four villages. Landsat images taken over the four villages were acquired over four periods: 1986, 1990, 2000, and 2014 (see Table 2.4). The mapping exercises were conducted by the Center for Remote Sensing and Geographical Information Services (CERSGIS, University of Ghana).

Table 2.4 Sources of Landsat images

Year	Landsat sensors
1986	Landsat 4-5
1990	Landsat 4-5
2000	Landsat 7
2014	Landsat 8

Source: CERSGIS (2015).

The areal extent of each village was identified, and the images were then stacked and clipped accordingly. We adopted the unsupervised classification method to organize all our images. In unsupervised classification, the spectral variance displayed by the features in the image is partitioned into a specified number of spectral classes, after which the partitioned classes are identified and labeled by the analyst. In this case, each image was put through ten iterations yielding 100 different spectral classes. The partitioned classes were then separated into five major classes, as follows:

- Closed canopy forest: dense forest areas, virgin forests, and some plantations;
- Open canopy forest: Savannah bushes and grass with a limited number of trees, root-based crops;
- Bush lands and shrubs: a mix of low tree density and height, bush fallow;
- Herbaceous cover: grasslands, annual crops, and/or fallow lands; and
- Settlements and bare lands: houses and cleared lands.

Images acquired in 2000 over the villages in the Transition zone were cloudy, and as such, the resultant classifications included clouds. This led to the introduction of a sixth (minor) class for that year: Cloud. The results of our classification scheme showed that certain spectrally distinct target land-cover classes could be identified and segregated. These land surfaces included closed canopy forest, open canopy forest, and herbaceous cover. Other classes, however, caused occasional confusion and proved difficult to distinguish. These classes included settlements and bare lands (necessitating their combination into one class) as well as herbaceous cover and bush lands. Several factors contributed to such difficulty in the classification. Some were related to conditions on the surface and some were related to conditions of the remote imagery, that is, the images over the four villages showed very small spectral differences among some of the classes, indicating that they followed essentially similar patterns of land use changes.

3. CHARACTERIZATION OF THE VILLAGES: INFRASTRUCTURES, LIVELIHOODS, AND POPULATION

Infrastructures and Livelihoods

Perhaps the first most visible characteristic that identifies the villages is their road infrastructures. The two villages that have reached their land frontier (Hiawoanwu and Tindang) host some tarred roads, while the land-abundant or type II villages (Sekyerekrom and Sakpule) host only graveled/sandy roads, with the road to Sekyerekrom being in poor condition, suggesting a relationship between good road infrastructure and land availability.

In the 1980s, there were no tarred or accessible roads to the villages and virtually no means of transport to markets, except on foot, and farmers (especially in type II villages) had to walk long distances to reach the market. The road in Hiawoanwu, which was constructed in 2000, is a main road leading to Ejura–Sekyedumase center, Ejura–Sekyedumase market, and other districts, while the road in Tindang was built in 2011 mainly to link to a sand quarry in a nearby village on the shorelines of the White Volta River. The river sand was not explored until recently but has now become a huge industry, supplying sand for housing and construction projects in Tamale and neighboring areas. Now, Tindang is well connected and the road infrastructure links the village directly with the main market in the Savalegu–Nanton district. In addition to the proximity of this market, traders come to the village mainly to buy agricultural products. The same can be said of Hiawoanwu in Ejura–Sekyedumase. The construction of the tarred road has improved market access considerably for farmers in type I villages compared with type II villages in both agroecologies. Currently, the means of transportation across the four villages are quite diverse, including motorbikes, Chinese-made tricycle motorbikes, tractors, cars, and trucks, most of which are owned by large-scale farmers.

An increasing level of education is one of the changing features of village life, as all the villages house or have housed one or more schools. The educational transition is occurring much faster in Hiawoanwu village than in the other villages. A primary school was established in the Hiawoanwu village as early as the 1980s and has since increased to three schools. Currently, there are no operational schools in Sakpule. There the community initiated a basic school (from primary grades one to three) in 2009, but the school has since been closed because the community is unable to pay its only teacher. Nowadays, the communities have better access to potable water (boreholes). Dates of access to boreholes vary across villages, but prior to the introduction of these water sources, women in the communities had to travel long distances to other communities to fetch water from the streams. The distance traveled could be as long as 16 kilometers or more. As concerns electricity, only Hiawoanwu has had a connection since 1998. In Sekyerekrom, the connection of the community to the national grid is under way, while in Sakpule, five solar street lights were distributed within the community in 2000. In Tindang, farmers indicated that for political reasons, their community was not provided with power despite the fact that an electrical grid crossed the village to provide power to a neighboring community.

Massive transformation has occurred in terms of communication. The usage of mobile phones has increased drastically over time in the four villages. In Sekyerekrom, for example, mobile phones were introduced in 2005, and only one person had a mobile phone (the assemblyman). Today, farmers indicated that nine out of ten adults in the village have mobile phones. The introduction of mobile phones has eased information flow in terms of input and output prices between the communities and the markets. During the 1980s and 1990s, credit was accessed mainly through informal sources, such as family, relatives, and friends who charged no interest. However, farmers indicated that they started accessing credit from banks, credit institutions, and money lenders during the 2000s, but at high interest rates ranging between 30 and 50 percent. Even credit from relatives and friends now carries some interest, they added.

Apart from farming, other sources of income that have emerged across the four villages include livestock and poultry (as savings and to mitigate risk), shea nut picking, firewood and charcoal production, petty trading, and purchases of motorbikes for transportation. In Tindang, additional sources of off-farm income include work in the sand industry (as laborers or truck owners), house rental (as some farmers own houses in the Savelugu–Nanton and Tamale districts), tractor service provision, and fish farming in the White Volta. Some of the infrastructural improvements, such as increased access to education and communication, have come at a cost. As a result, household consumption expenditures have been increasing in the communities.

Trends in Population and Settlements

With regard to settlement history, most of the households in the villages located in the Transition zones are either first- or second-generation immigrants, usually from the northern part of the country, and this pattern has not changed since the 1980s. Migrants in search of the fertile lands of the South have brought with them their culture, traditions, and farming practices, which have also shaped the current way of life in the villages. This was not the case in the two northern communities we visited.

Farmers unanimously indicated that the population has grown considerably in the four villages since 1980. For example, in Sakpule, farmers indicated that the population grew from 30 in 1980 to 455 in 2014. Likewise, a former assemblyman from Hiawoanwu reported that the village population had grown from 2,000 in 1989 to 5,000 in 2015. In Sekyerekrom, farmers indicated that the population grew from 400 in 1980 to 700 in 2015. Unfortunately, no official records of the village populations in 1980 exist. Recent census data suggest that between 2000 and 2010, the population has grown only in two of the villages (Table 3.1).

Table 3.1 Village populations, 2000 and 2010

Agroecological zone	District	Village	Population		Household size		Number of houses	
			2000	2010	2000	2010	2000	2010
Transition	Ejura–Sekyedumase	Hiawoanwu	2,582	2,718	7.5	7.2	264	310
		Sekyerekrom	524	523	7.2	9.3	54	56
Guinea Savannah	Savalegu–Nanton	Tindang	452	451	7	9.8	32	47
		Sakpule	186	854	8.1	20.8	18	37

Source: Ghana Statistical Service (2000, 2010).

Farmers indicated that since 1980, more migrants have moved to the Ejura–Sekyedumase areas (Hiawoanwu and Sekyerekrom) to farm, whereas growth in Tindang in the North has resulted mainly from internal growth. Nowadays, seasonal inmigration is more common than permanent migration in both type II villages, which are infrastructure-poor but land-abundant compared with type I villages. For example, an inflow of migrants arrives during the minor season in Sekyerekrom. In Hiawoanwu, outmigration rates are low, whereas inmigration has been a strong driver of population growth in the village. On the other hand, in Sekyerekrom, farmers indicated that approximately 40 percent of the youth have migrated to urban areas to pursue employment opportunities (some working as electricians, mechanics, and drivers, among other occupations) or attend school. In short, better infrastructural conditions as well as land resource endowments seem to have shaped the pattern of labor movements in the villages.

With regard to housing, farmers in Tindang indicated that there were only a few houses (15) with iron sheet roofs, but now a considerable number of houses have iron sheet roofs, which may indicate an increase in village wealth. On the other hand, we observed that in Sakpule, the majority of the houses are still made of thatched and grass roofing, and only five houses were built with cement and aluminum roofing.

4. AGRICULTURE AND FARMING SYSTEMS IN THE VILLAGES

Evolving Farmers' Objectives: From Subsistence to Market-Oriented Production

The narratives gathered from the interviews revealed that, typically, farmers' decisions as to which crop to cultivate, how much to cultivate, and what methods to use depend on a combination of factors. These factors include the household's needs for staple foods (for example, maize); type and fertility of the farm plots (for example, crop rotation between legumes and maize in poor soils, yam and maize in newly cleared lands, and topography [lowlands versus highlands]); cash and input needs; and market forces (for example, commercialization and prices). Farmers normally store and market their crops in a piecemeal fashion. For example, farmers in Tindang indicated that they prefer to store their maize and rice and to sell off other crops until the onset of the next season, when market prices are high and input requirements are imminent. A focus group in the village revealed that groundnut is the first crop to be sold, followed by soybean, then rice, and finally maize. Maize is sold last because farmers rely mainly on this crop for their staple food needs. The consumption of maize as a staple illustrates a shift in diet in the village since the 1980s and earlier, when sorghum and millet were the main crops consumed. This shift may have been triggered by the 1983 drought and the subsequent state introduction of white maize along with intensification of extension activities.

Farmers seldom sell all their produce immediately after harvest. However, urgent needs for cash can compel some farmers (especially small ones) to sell off their maize and to purchase the same crop at high a price from the market later in the same year. There seems to be gender-related differences in market participation: women farmers or spouses in the households indicated that they grow their crops mostly for commercial purposes, independently and without any help from their husbands. They use the income from crop sales to purchase items such as spices to fulfill a cultural role, and to help pay for other household expenses, for example, school fees.

In summary, nearly all the farmers sell a portion of their produce on the market, indicating that they are both subsistence- and commercially oriented, though the degree of commercialization varies depending on the type of farm (small, medium, or large). Consistent with this pattern, farmers in Sakpule indicated that there is a market for agricultural products, adding that occasionally traders come to their village to buy agricultural goods but offer low prices for them. Some farmers also send their produce to other markets in Diare and Savelugu, which are farther from the community. Use of mobile phones has facilitated information flow between farmers and markets. However, farmers' objectives also have evolved with time. Going back to the 1980s, farmers indicated that they were trying to fill essentially subsistence needs, and their farms were small. Even in the precolonial era, most farmers had little marketable surplus, as they were using only hand hoes and cutlasses for cultivation. In Tindang, for example, farmers were cultivating yellow maize and yam for consumption only, and there were no markets for these crops. Virgin lands were abundant and soils were fertile. Today, yams are no longer grown in the village because soil fertility has declined in the area. Yam is now a special meal that can be bought only from the market. Likewise, the rainfall pattern was favorable to agriculture in the 1980s. In Sakpule, farmers reported that only surplus was sold in the 1980s, with the exception of groundnut, which was purposely grown for commercial reasons; at that time, there was no market for yam surplus.

Consistent with this report, in Hiawoanwu and Sekyerekrom in the Transition zone, farmers indicated that during the 1980s, the primary objective for producing maize, cassava, and groundnut was to feed the family and only occasionally to sell the surplus. In addition, the market for maize was very limited. Since then, the market for maize has expanded tremendously, and traders have come from Techiman, Kumasi, Tamale, Accra, and neighboring countries such as Burkina Faso to buy maize in Ejura–Sekyedumase. Hence, farmers indicated that farming is profitable and less tedious nowadays than previously owing to the availability of markets and modern inputs. In contrast, yam production was very intensive in the 1980s, and a considerable portion of the harvest was intended for sale; now yam is produced for consumption, and the major varieties grown have changed over time.

The overly subsistence orientation of farmers, as well as the high soil fertility, also may have dictated the trajectory of modern input use during the 1980s, when farmers indicated they were not using any fertilizer inputs. That is to say, markets and commercialization were not that important in driving farmers' decisions during this era. This factor, combined with low population densities, allows one to assert that intensification was unexpected, following Boserup's theory (1965), as major driving forces such as market access and population density were not present at that time. Predictably, public and global efforts to "intensify" agriculture based on the Asian model did not bear much fruit. Today, farming systems in the villages have been transformed through both an evolutionary process and commodification (see, for example, Amanor and Pabi 2007). The narratives we obtained are consistent with these transformative patterns.

Land Availability and Dynamics of Farm Size

Various forces have affected land allocation and distribution within the villages over time. These factors are essentially linked to the driving forces behind the evolution of farming systems (Boserup 1965). Land was abundant in the 1980s, the population was very low, and farms were closer to homesteads. Access to land was free: migrant farmers needed only to gift cola nut and a bottle of schnapps beverage to the chief to access farmlands. During that time, cultivated lands were left fallow, and farmers moved to clear virgin lands every three to four years using shifting cultivation methods, allowing burnt trees to die off with time. Now, farmers do not wait for the trees to die off; rather, they remove the stumps as soon as possible in order to hasten land clearing. Forest cover was abundant in the 1980s, but over the past decades, deforestation has taken place as trees have been cut down for timber, firewood, and charcoal.

Currently, land has become scarce in both type I villages as a result of the rising population. In Hiawoanwu, farmers indicated that anyone who needs farmlands must now buy them, but the frontiers are expanding far from the village center, as far away as the Nkoranza district in the Brong–Ahafo region. Likewise in Tindang, no more land is available, and farmers are forced to move far into neighboring land-abundant communities to acquire new lands. Although the village has reached its land frontier, land constraints are relaxed owing to the availability of lands in neighboring villages, leading to an increase in farm size. According to community members, as many as 500 farmers cultivate farmlands outside the village's boundaries. Hence, it is likely that the path toward intensification of the village's farmlands has been affected by access to external land resources.

Where virgin and/or fallow lands are still available (for example, in Sakpule and Sekyerekrom), the size of these lands has shrunk. For example, in Sekyerekrom, farmers reported that in the 1990s, virgin lands accounted for 60 percent and cultivated lands 40 percent of total farmlands. In the 2000s, virgin lands accounted for 40 percent and cultivated lands 60 percent of total farmlands. Today, no virgin lands remain in the community, but only lands that can be left fallow for five years or more. Likewise in Sakpule, farmers indicated that they can expand their farm size if credit constraints are removed, even though parts of the village's virgin lands have been classified as forest reserve, restricting farm expansion into them. Nonetheless, fallow lands are available in the village for further farm expansion. Focus group discussions in the community suggested that smallholder farmers cultivate 20 percent of their lands, while the remaining 80 percent is fallowed; medium-scale farmers cultivate 30 percent of their lands and leave 70 percent of it fallowed; and large-scale farmers cultivate 70 percent of their lands and leave 30 percent of it fallowed. On some farms, lands are cultivated with fertilizer inputs, implying that shorter time periods are needed for soil fertility recovery.

Farm size is a key criterion used by villagers to differentiate among fellow farmers. Interactions in Tindang also show that farmers can be classified by the main type of crop that is produced. For example, a rice farmer cultivates 50 percent of his land with this crop. The distribution of farm size across time as reported by community members in the villages is presented in Table 4.1.

Table 4.1 Village-level dynamics of farm size—farm categories (number of farmers in %)

Agroecological zone	Village	Period	Categories of farm size (number of farmers in %)		
			1–5 acres	*>5–15 acres*	*>15 acres*
Transition	Hiawoanwu	1980s	100	0	0
		2015	20	30	50
	Sekyerekrom	1980s	50	30	20
		2015	30	40	30
Northern region	Tindang		*1–10 acres*	*>10–25 acres*	*>25 acres*
		1980s	100	0	0
		2015	30	20	50
	Sakpule		*1–5 acres*	*>5–30 acres*	*>30 acres*
		1980s	100	0	0
		2015	50	20	30

Source: Village studies (2015).
Note: 1 acre = 0.40 hectare.

Table 4.1 shows that as land has become scarcer, transitions have occurred in the villages within both agroecological zones since the 1980s. In other words, although there were small farmers in the past, nearly half of these farmers have increased the area they cultivate. The percentage breakdowns in Table 4.1 are indicative, but the overall picture is that of a transition from all small-scale farming to a mix of small, medium, and large-scale farms at the village level across communities, irrespective of their level of development. For example, a key informant in Sekyerekrom reported that farms are getting larger and that this transition started 15 years ago, adding that farmers who made this transition have been exposed to more knowledge regarding farming compared with those whose holdings remained small. Likewise, there seems to be a higher concentration of small farmers in the more isolated or type II villages than in the villages that have reached their land frontiers, indicating that there is more dynamism where there is proximity to markets and greater populations. These results are broadly consistent with regional trends observed in Ghana Living Standards Survey data (Table 4.2).

Table 4.2 Trends in farm size (cultivated areas) by agroecological zone, 1998–2012

Farm size categories	**Transition zone**			**Guinea Savannah zone**		
(% of rural households)	1998	2005	2012	1998	2005	2012
<5 acres	57.2	54.4	44.2	47.7	38.8	36.6
≥5–12 acres	25.7	31.7	36.5	46.7	39.5	42.4
≥12–25 acres	9.3	11.4	13.5	5.6	12.0	14.0
≥25 acres	7.8	2.5	5.8	—	9.7	7.0
Total	**100**	**100**	**100**	**100**	**100**	**100**

Source: Ghana Statistical Service (1998, 2005, 2012).
Notes: 1 acre = 0.40 hectare. Transition zone includes parts of the Brong–Ahafo, Ashanti, Eastern, and Volta regions. Guinea Savannah zone includes the Northern, Upper East, and Upper West regions.

In summary, many of these farmers could have continued to provide adequate subsistence for themselves and their families, but rather than continue at a subsistence level, they chose to embrace new sources of cash and produce for the market. The key questions with regard to such transitions are, why and how did farmers in these communities expand their farm size over time? As to why, we rest our argument on Netting et al. (1989), who indicated that without the incentives of what farmers consider an adequate return to their efforts and a market that provides nonagricultural goods, it would be difficult to foresee such changes. As to how, these farmers had increased their farm size by essentially reinvesting in agriculture. Indeed, these farmers indicated that along with increasing market access, part of the income they earned from farming activities was largely reinvested into the farm to support its gradual expansion. Farmers also diversified their portfolios in the process, especially in type I villages where more off-farm opportunities are available. They invested in capital-intensive assets, such as tractors for their own farm use and to provide services, tipper trucks (for the sand business in Tindang), and housing (for example, in the Tamale and Savalegu districts) as well as livestock, petty trade, dressmaking, chemical shops, fuel stations, and transportation business, among others. The income generated from these off-farm activities were also used to support farming, and remittances from relatives living in cities such as Accra and Kumasi played a role in some cases. We illustrate these patterns using narratives from two key informants (Appendix A).

In short, a feedback loop of investment/reinvestment was created within agriculture and between agriculture and nonagricultural activities in response to changing opportunities and incentives (see, for example, Djurfeldt and Djurfeldt 2013). Likewise, improvements in road infrastructure may have fostered farm expansion into distant communities when land availability became a constraint. A reliable road network has also encouraged traders to come to the villages to buy produce at the farm gate, taking the burden of output transportation off farmers. This interaction gives farmers more options for selling their crops and to consider the most advantageous choice. For example, in Sakpule, farmers reported that traders come to the village to buy produce from farmers because of the better road conditions. However, where the road is bad, farmers have to transport the produce themselves and sell it off at the market by any means. In Sekyerekrom, farmers reported that no trader comes to their village, and they sell off their produce even if prices are low; otherwise, they incur extra transportation costs in returning the produce home. This is an obvious disincentive to agricultural intensification and growth, though the use of mobile phones has likely mitigated the effects of the poor road network, as farmers can now inquire about market prices before moving their produce to market.

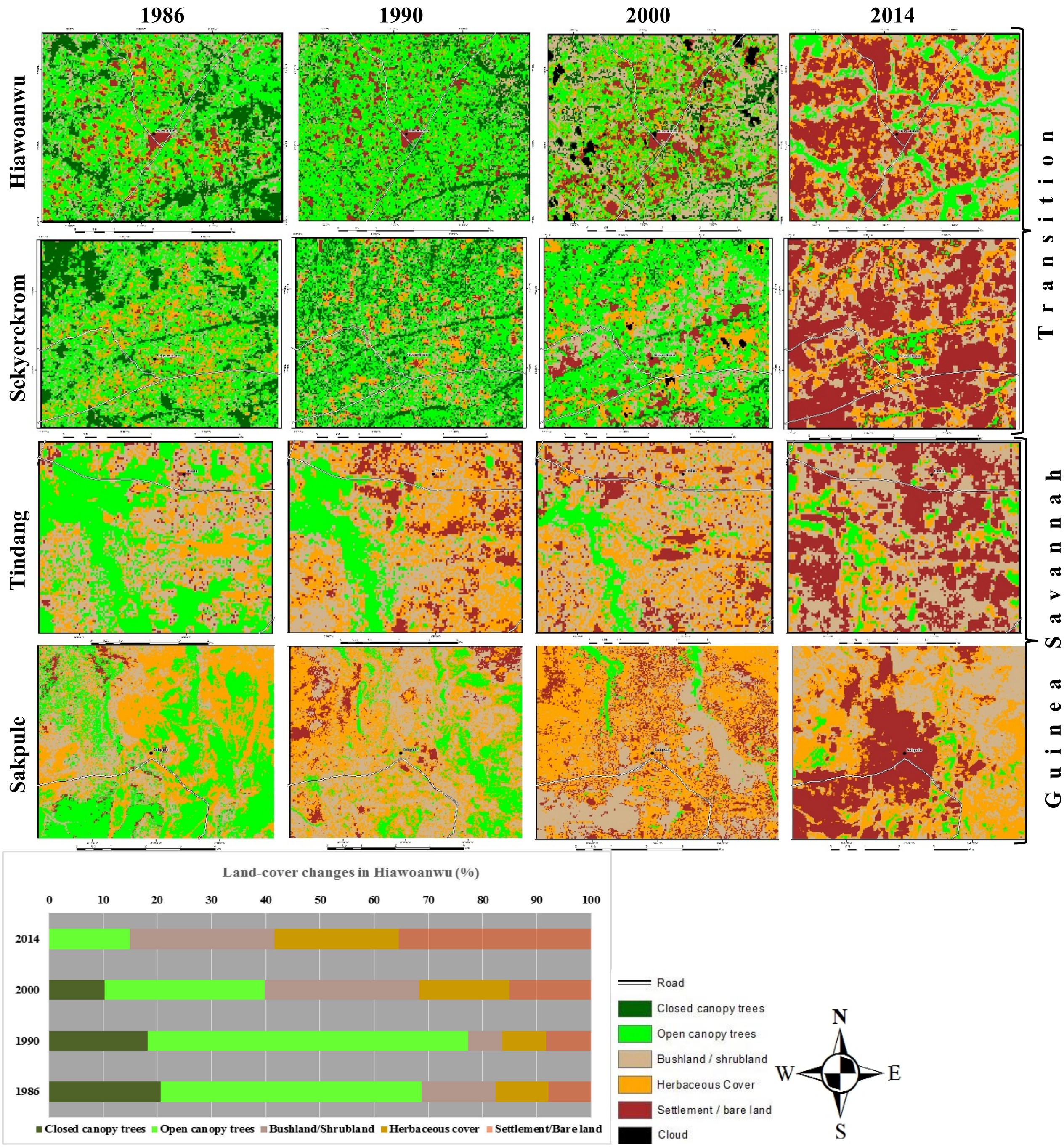
In summary, a confluence of factors drives farm expansion. In turn, as farms expand, farmers have to tackle emerging constraints or sudden changes that are both endogenous and exogenous to farming systems. Therefore, it seems fair to say that the process of expansion is not necessarily a linear sequence of events.

Land Use and Land-Cover Trends

As mentioned earlier, we used remote sensing to map out farming system changes in the villages and their surroundings in relation to historical narratives of change. We estimated changes in land cover by computing the difference in land-cover statistics over four time periods: 1986, 1990, 2000, and 2014. The land-cover maps are presented in Figure 4.1. The estimated changes in land use and land-cover statistics are presented in Appendix B.

A visual assessment of the maps in Figure 4.1 suggests that, from 1986 to 2014, the composition of land cover has changed considerably, while the overall pattern shows a general transition to less vegetation cover. The dark spots on the maps of Hiawoanwu and Sekyerekrom in the Transition zone represent data gaps in which persistent cloud cover occurred during satellite imaging in 2000 (see also US Geological Survey, 2013). Consistent with differences between the two agroecologies, spatial differences are apparent in the types of vegetation between the villages. In 1986, for example, most of the lands were occupied by closed and open canopy forests and bush lands and shrubs in villages situated in the Transition zone, whereas in villages located in the Guinea Savannah zone, there was no closed canopy forest; rather, open canopy forest bush lands, shrubs, and herbaceous vegetation represented the main land covers.

Figure 4.1 Land-cover maps and proportions of landscapes in four villages, 1986–2014



Source: Compiled from Landsat images by CERSGIS (2015).

In the Hiawoanwu area, closed canopy forest areas decreased slightly (from 20 to 18 percent) from 1986 to 1990. In 2000, closed canopy forests represented only 10 percent of the land cover, and by 2014, all closed canopy forests had disappeared, consistent with farmers' narratives describing no virgin lands in the area. On the other hand, between 1986 and 1990, the total land area under open canopy forests increased considerably, from 48 to 59 percent. However, between 1990 and 2000, the areas covered by this form of vegetation fell to 29 percent. In 2014, only 15 percent of these areas were covered by open canopy forests. Likewise, bush lands and shrubs had decreased to 6.3 percent in 1990 but rapidly rebounded to 29 percent in 2000, when they stabilized, with only a slight change in 2014. Herbaceous cover decreased slightly between 1986 and 1990 but increased steadily from 1990 to 2014. Settlements and bare lands occupied only 8 percent of the land cover in 1986, but by 2014 represented 35 percent of the lands. Most of the increase in settlements and bare lands occurred between 2000 and 2014.

The broad patterns in the Hiawoanwu area suggest that, between 1986 and 1990, closed canopy forests, bush lands, and shrubs were converted into open canopy forests, which indicate the production of root-based crops such as yam, which according to Amanor and Pabi (2007) are usually associated with landscapes with high tree densities. The increase in open canopy forests may have been the result of slash-and-burn cultivation leaving patches of natural vegetation as remnants of the land cover. The subsequent reduction in open canopy forests and the increase in bush lands and shrubs from 1990 to 2000 suggest an increase in yam and charcoal production and the appearance of bush fallows. The rise in herbaceous lands during the same period suggests an increase in croplands (growing cereal and legumes) as well as the appearance of herbaceous fallows and grasslands. The expansion of settlements and bare lands indicates increases in population density and newly cleared farmlands. Furthermore, the simultaneous disappearance of closed canopy forests, the decline of open canopy forests, and the rise in herbaceous lands, settlements, and bare lands from 2000 to 2014 suggest an intensification of human activity during that period. This intensification is corroborated by farmers' reports indicating increases in farm size and commercialization of production systems in the community.

In Tindang area, a rapid contraction of open canopy forests (from 40 to 17 percent) occurred between 1986 and 1990, while herbaceous lands, settlements, and bare lands increased by a total of 22 percent during the same period. This period corresponds to the time when the government stepped up efforts to promote agriculture, following the drought of 1983. From 1990 to 2000, open canopy forests declined from 17 to 9 percent and bush lands and shrubs increased substantially, while herbaceous cover shrank by 4 percent. Most of the drastic changes in herbaceous cover, settlements, and bare lands occurred between 2000 and 2014, when herbaceous cover contracted by 18 percent, and settlements and bare lands expanded by 26 percent, indicating an intensification of human activity and land use in terms of population density and grain production. Similar patterns can be observed in the Sekyerekrom and Sakpule areas.

In summary, settlements, bare lands, and herbaceous lands were increasing in all areas, suggesting increasing human activity and expansion of agricultural production, especially of annual crops. While open canopy forests were increasing in the Transition zone, the areas covered by closed canopy forests were declining. In the Guinea Savannah zone, by contrast, there were no closed canopies, and open canopies decreased steadily. Conversely, bush lands and shrubs increased and then decreased in this zone, whereas in the Transition zone, they increased and then stabilized. The land-cover analyses also suggest that villages within the same zone followed similar patterns of land-cover changes, suggesting that similar processes of transformation had occurred during the previous 28 years in the zone. Even so, expansion was uneven across the four villages and ecological zones studied.

The trends derived from the maps indicate changes in land cover and dynamism in the villages' land-use systems. These trends are illustrated by a transformation of the land cover from a variety of vegetation types to crop-dominated landscapes, which corroborate reported narratives of changes in crop mix and local cropping patterns across the villages. As cropland areas increased, formerly uninterrupted forest and Savannah land areas have fragmented. Most of the observed trends seem consistent with farmers' narratives of land-cover changes.

Dynamics of Local Cropping Systems

The composition and structure of the crops grown in the study area have changed over time. In Hiawoanwu, the crops grown in the 1980s and 1990s included maize, cowpea, cassava, yam, tomato, groundnut, cotton, and tobacco. In the 2000s, groundnut and tomato production was halted, though groundnut production resurfaced in 2010. To date, yam, cassava, and groundnut production have now declined to subsistence levels, while cotton and tobacco have completely disappeared from the crops grown in Hiawoanwu. This change is also the case in Sekyerekrom (see Table 4.3), where farmers attributed decline in crop production to pest and diseases, decline in soil fertility, and exhaustion of virgin lands, especially for yam, which is a heavy feeder crop.

Table 4.3 Changes in crop importance in Tindang (Guinea Savannah) and Sekyerekrom (Transition zone)

Region	Year	Crop type (% of farmers growing)						
		Yam	Cassava	Maize	Cowpea	Groundnut	Soybean	Rice
Tindang	1980s	50	10	30	—	10	—	—
(Guinea Savannah zone)	2015	—	—	34	—	17	18	31
Sekyerekrom (Transition zone)		Crop type (% of area cultivated)						
	1980s	50	10	20	—	20	—	—
	2015	10	5	50	30	5	—	—

Source: Village studies (2015).

In terms of crop mix, maize and groundnut were intercropped on the same field in the 1980s in Hiawoanwu, but these crops are now monocropped, indicating that grain production has increased and intensified. In connection with this change, farmers indicated that the herbicides introduced to them (especially for maize) are not selective enough and may kill other crops when intercropped, so they prefer monocropping for that reason. In contrast, yam and cassava were grown as monocrops in the 1980s, but they are now intercropped and produced at a small, subsistence scale. The few farmers who cultivate yam today must also farm far from the village, that is, in the forest areas. Conversely, in Sekyerekrom, monocropping of maize and groundnut and intercropping of yam and cassava have remained standard practice since the 1980s, when farmers were not cultivating cowpea in that village as they were in Hiawoanwu. Cowpea was introduced later in the 2000s into the village and is now cultivated by a sizable number of farmers (see Table 4.3). This period coincides with an increase in the price of cowpea; as a result, farmers expanded their farm size in response to markets and to meet their households' growing needs (for example, school fees). Grain production has intensified in Hiawoanwu as well, where maize and cowpea are produced on a large commercial scale (although at times, some small-scale farmers do not produce surplus for sale). Farmers in the village indicated that 70 percent of the cowpea produced is sold on the market. When asked why they shifted from yam to cowpea production, they indicated that they gradually shifted because markets became important, and yam is an annual crop fetching low prices, whereas cowpea prices have been very good and its production is seasonal. The trend in commercial yam production in the 1980s has also been documented by Amanor and Pabi (2007) in the Brong–Ahafo region, which forms part of the Transition zone.

In Tindang in the Guinea Savannah zone, during the precolonial era (before 1900), farmers were cultivating yellow maize, yam, Bambara beans, late-maturing and pesticide-free cowpea, red sorghum, millet, and groundnuts for subsistence using only hand hoes and cutlasses as tools. White maize, rice (Tox variety), soybean, pesticide-dependent cowpea, groundnut (purple and white and Chinese varieties) and similar grains were introduced in the village following the 1983 drought and subsequent food crisis. Today, just a few farmers in the village cultivate yellow maize on a very small scale. In Sakpule, sorghum and millet were grown solely as monocrops in the 1980s, but currently, sorghum is intercropped with white maize and millet with groundnuts. Consistent with this pattern, the ranking of crops in the village (Table 4.4) shows that crops traditionally grown in the 1980s, such as millet and sorghum, have disappeared, whereas white maize, soybean, cotton, and rice, which were introduced to farmers in the village, top the list of the most important crops since 2010. Root crops have also been relegated to the margins. Today, soybean is the most commercialized crop in the village, followed by cotton, rice, and then maize. Conversely, in Tindang, farmers revealed that groundnut is the first crop to be sold, followed by soybean, then rice, and finally maize.

Table 4.4 Rankings of crops grown in Sakpule (Guinea Savannah) by order of importance

Rankings	Crops grown in the 1980s	Crops grown since 2010	Most commercialized crops since 2010
1	Sorghum	Maize	Soybean
2	Millet	Soybean	Cotton
3	Maize	Cotton	Rice
4	Groundnut	Rice	Maize
5	Cassava	Groundnut	
6	Yam	Cassava	
7	Cowpea	Yam	
8	Pigeon pea	Cowpea	
9	Bambara beans		

Source: Village studies (2015).

Time-specific events likely shape local cropping patterns. For example, the pace and kind of dynamism emerging from the farming community is determined by how farmers learn from such events and respond accordingly in their farming systems by reallocating their resources, changing their crop mix and production, and adjusting their investment behavior, both inside and outside the agricultural sphere. These patterns are likely to be invisible in research scenarios if not traced through narratives. For example, many farmers in Hiawoanwu were producing garden eggs, but their price had declined on the market and farmers were not able to store the highly perishable crop to fetch better prices later on. Production of this crop therefore stopped as farmers quickly adjusted to such market changes. Rosette virus also reduced groundnut production in Sekyerekrom.

In summary, over time cropping patterns have changed from root-based subsistence crops (such as yam and cassava) to grain-based and mostly monocropped and commercially produced crops (such as cereals and legumes). The cropping mix has changed from a subsistence-driven system of intercropping based on multiple crops to a mixed subsistence–commercial system based on a few crops, in which commercialized crops are mostly monocrops, such as maize, cowpea, groundnut, and soybean. These patterns reflect various changes in the following areas:

- Consumption patterns;
- Population growth;
- Access to markets;
- Decline in soil fertility (for example, curtailing yam production because of its higher nutrient requirements compared with grains);
- Increasing learning from peer/progressive farmers or extension agents;
- Changing rainfall patterns and;
- Increasing consumption expenditures (for schooling/education, weddings, funerals, motorbikes, mobile phones, and so on).

Similar conditions such as rainfall patterns, soil fertility decline, and decline in producer prices were found to be responsible for a shift from cocoa to maize-based cropping systems in Wenchi in the Brong–Ahafo region, and in the Transition zone (Adjei–Nsiah and Kermah 2012). Nowadays, production has also become commercialized with the introduction of grains and legumes and the increased scale of farming. As cropping patterns have changed, diet has also changed. For example, in Tindang, farmers now buy their yam and cassava from the market.

Changing Patterns of Farm Input Use and Technology Adoption

Use and adoption of modern inputs are essential in the process of farming system intensification. The combination of inputs determines the intensification level as well as the outcome of intensification. This section discusses the use of labor and mechanization, fertilizers, pesticides, and seed inputs.

Trends in the Use of Labor

Labor is invariably an important component of farming systems. The type of labor available during each season has long determined the area that can be put under cultivation, as well as the type of crops that can be grown, especially within a low-mechanical-input system. Labor (and capital) requirements also determine to some extent the kind of farmers who can cultivate different crops. Farmers reported that rice is more labor- and capital-intensive than groundnut, whereas soybean is more labor-intensive but less capital-intensive than rice. For example, in Tindang, discussions revealed that smallholder farmers tend to produce less capital-intensive but more labor-intensive crops (for example, soybean), whereas medium and large farms tend to produce more capital-intensive crops (for example, rice). Consistent with this pattern, community members indicated that farmers in the village allocate their lands to various crops as follows:

- Large-scale farmers: 50 percent rice, 30 percent maize, and 20 percent groundnut;
- Medium-scale farmers: 50 percent maize, 30 percent rice, and 20 percent groundnut; and;
- Small-scale farmers: 30 percent maize, 60 percent soybean, and 10 percent groundnut.

In Hiawoanwu, community members reported that large-scale farmers are not cultivating yams because they require special care and labor-intensive husbandry practices. The propensity of small farms to use more labor-intensive technologies was also documented by Hazell et al. (2010).

The structure of labor input has evolved in the villages. Back in the 1980s, mainly family and communal labor was used in the communities. Demand for such labor was high because land preparation and weeding operations were both performed manually. Today, farm size has increased while communal labor has declined significantly; farmers essentially use a mix of family and hired labor, which is the most important in the villages. This practice is consistent with regional trends in hired labor use (Table 4.5). During the farming season in Tindang, for example, young people in the village form labor "gangs" to offer their services to farmers. Today, only small farmers are more likely to use family and communal labor, and then only to meet their farm power needs in some cases. Increasing scarcity of family labor is being driven partly by increased schooling. Likewise, farmers indicated that nowadays children in their households prefer to have their own farms earlier rather than work on their fathers' farms. Women farmers usually hire outside labor for their farm activities because they have other household responsibilities that leave them less time to work on their own farms.

Table 4.5 Trends in hired labor use by farm size (% using)

Farm category	Transition zone			Guinea Savannah zone		
	1998	2005	2012	1998	2005	2012
<5 acres	66.7	60.4	60.6	47.3	31.0	37.0
≥5–12 acres	88.8	83.3	76.5	50.9	38.6	47.2
≥12–25 acres	81.3	70.1	80.6	78.1	61.1	53.2
≥25 acres	92.6	66.6	78	—	62.8	62.3
Average	75.7	68.9	70.1	50.7	40.7	45.4

Source: Ghana Statistical Service (1998, 2005, 2012).
Notes: 1 acre = 0.40 hectare. Transition zone includes parts of the Brong–Ahafo, Ashanti, Eastern, and Volta regions. Guinea Savannah zone includes the Northern, Upper East, and Upper West regions.

While hired labor has become scarce and expensive in the villages, especially during weeding and harvesting operations, locally hired labor is often insufficient to meet the demand. As a result, additional labor is supplied by migratory workers. In Tindang, laborers migrate from West Mamprusi and Savalegu to the village to offer their services during the farming season. Laborers also migrate from the Guinea Savanna zone in the North to the Transition zone in the South. However, the pattern of labor movement is being affected by changing rainfall patterns between the South and the North. As an informant from Sekyerekrom indicated:

> In the 1980s, a farmer in my village can plant and even harvest before the start of the main season in the North, where most of the laborers come from. However, the rains are almost coinciding, and this makes it difficult for people to migrate from the North to provide labor services. This is exacerbated by the fact that people who come here to offer labor services also decide to farm themselves.

Labor constraints affect different type of farmers differently. Large farms are particularly affected because they need to mobilize more laborers, who may not be available at the time needed, compared with small farms, which may need only one or two laborers. For example, in 2008, a farmer in Sakpule planted 30 acres of soybean but did not get enough labor to harvest on time, leading to a total yield loss due to shattering of the soybean pods. On the positive side, large farmers can afford to bring labor as far as the Northern region, whereas small farms can access such laborers only after they have worked on large farms. Interestingly, with increasing labor scarcity (and costs), other technologies such as herbicides and tractors for land preparation have emerged as substitutes. As a result, overall demand for labor has declined or abated over time.

Changes in the Use of Mechanical Inputs

Agriculture has traditionally relied on the hand hoe and cutlass only to prepare farmlands in the villages. The use of mechanical power, such as animal traction and tractors, has been introduced to farmers but has evolved with ups and downs. The villages have seen a progressive transformation from manual land preparation in the early 1980s to the use of tractors for plowing. In the Transition zone, tractor use was limited in the 1980s owing to the higher density of stumps in fields and small average farm size. From 1995 onward, however, farmers in Hiawoanwu reported that markets started developing for mechanical tools, with a growing adoption of tractors for plowing to date. In Sekyerekrom, the first privately owned tractor was introduced in 2007, and within eight years, 14 people in the village owned a tractor. In the Guinea Savannah zone, draft animals were introduced in 1977 in Tindang and 1981 in Sapkule, but later, farmers found the technology labor-intensive and its use declined with the increase availability of state-supply of tractors in the 1980s. This narrative is consistent with the reported presence of big rice farmers in Savalegu–Nanton district during that time. Later on, all the tractors fell into disuse, but they have recently reappeared along with increasing demands for mechanization (Diao et al. 2014). In Sakpule, tractor use became widespread in the 2000s. In addition to using tractors for land preparation, the use of tractor-mounted maize shellers surged, leading to the gradual displacement across the villages of manual maize shelling or hand beating. In the 2000s, a mechanized maize sheller was introduced in Sekyerekrom. In 2009, a farmer in the village acquired a maize sheller for his own use and to hire out to fellow farmers.[1]

Tractor plowing and maize shelling have increasingly become standard farming practices in the villages. This trend is a broadly consistent regional pattern (Table 4.6). However, access to these technologies differs depending on farm size. Whereas access to tractors is relatively easier for medium- and large-scale farmers, smallholder farmers need to organize to secure tractor services, especially in communities where there is a limited number of tractors. Some medium- and large-scale farmers also own

[1] It is important to note that, even with a high concentration of maize shellers in the Ejura–Sekyedumase district, manual shelling has not disappeared completely in the district because maize is best shelled manually when its water content is too high to withstand mechanical shelling. This is often the case during the major season, when solar radiation is not enough to dry out the wet maize harvested before the onset of the minor season.

the machines. Increasingly, mechanized farming seems to have shifted labor bottlenecks from land preparation to weeding and harvesting operations. Some consequences of tractor plowing have also been the disappearance of farming practices such as ridging in maize fields, where it was previously practiced.

Table 4.6 Trends in the rental of mechanical equipment by farm size (% renting)

Farm category	Transition zone			Guinea Savannah zone		
	1998	2005	2012	1998	2005	2012
<5 acres	0.0	4.7	7.6	6.9	3.1	12.5
≥5–12 acres	4.5	2.4	9.6	6.0	4.8	25.6
≥12–25 acres	0.0	12.1	18.1	12.5	6.5	38.4
≥25 acres	3.7	22.5	9.0	—	7.7	35.8
Average	1.5	5.3	9.8	6.8	4.6	23.3

Source: Ghana Statistical Service (1998, 2005, 2012).
Notes: 1 acre = 0.40 hectare. Transition zone includes parts of the Brong–Ahafo, Ashanti, Eastern, and Volta regions. Guinea Savannah zone includes the Northern, Upper East, and Upper West regions.

Increased Use of Chemical Inputs

Herbicides

Perhaps one of the most important labor-saving innovations was the introduction of herbicides in the villages. The use of herbicides has led to a drastic reduction in the use of hoes, cutlasses, and manual labor for weeding. Herbicide use has also replaced the practice of slash-and-burn cultivation. In the 1980s, farmers were using only cutlass and hoe for weeding; there were no herbicides. As weeding became necessary and labor-intensive, farmers gradually started adopting herbicides. The introduction of herbicides for land preparation (nonselective) and weed control (selective) on the farms occurred in the early 1990s in Hiawoanwu and the early 2000s in Sekyerekrom. Today, the use of herbicides to clear lands before plowing is widespread in the villages. However, on-farm weed control by resource-constrained smallholder farmers is sometimes done manually using family labor. Manual weed control by medium- and large-scale farmers requires hired labor, but the unpredictable availability of labor (especially in the major season) and its high cost, coupled with the time needed to weed large acreages, makes it more efficient for these farmers to opt for the use of herbicides. Trends at the regional levels also show considerable increase in herbicide use in both agroecological zones (Table 4.7), though farmers in the Transition zone use more herbicides on their crops than those from the Guinea Savannah zone.

Table 4.7 Trends in the use of herbicides by farm size (% using)

Farm category	Transition zone			Guinea Savannah zone		
	1998	2005	2012	1998	2005	2012
<5 acres	1.0	24.3	65.0	0.4	1.3	35.9
≥5–12 acres	1.1	18.6	84.8	0.4	1.9	65.3
≥12–25 acres	0	27.4	83.9	0	3.9	82.1
≥25 acres	0	34.5	90	—	3.5	80.9
Average	0.9	23.1	76.2	0.4	2.1	58.0

Source: Ghana Statistical Service (1998, 2005, 2012).
Notes: 1 acre = 0.40 hectare. Transition zone includes parts of the Brong–Ahafo, Ashanti, Eastern, and Volta regions. Guinea Savannah zone includes the Northern, Upper East, and Upper West regions.

Increased use of herbicides can be attributed to decline in soil fertility, which created breeding grounds for weeds and the subsequent quest to reduce manual and hired labor needs and transaction costs and to speed up weeding operations, especially among larger farmers. For example, farmers indicated that herbicide use has helped reduce the time needed to clear farmlands from five hours to one hour per acre in Hiawoanwu and, thus, has alleviated the farmers' heavy dependence on labor for weeding. However, the extent of herbicide use depends on farm size and crop type. In Sakpule, for example, manual weeding with hoes is still predominant in cotton fields and among some smallholder farmers. Use of herbicides has also contributed to the increased scale of farming. A farmer in Sekyerekrom indicated that in the absence of herbicides, many medium- and large-scale farmers would have to scale down their farming.

Farmers' beliefs have also shaped the use of herbicides. For example, farmers in Sekyerekrom think that plowing to clear the lands without first applying herbicides limits plant health, lowers the rate of germination, and leads to lower yields. According to these farmers, while spraying with herbicides kills the weeds, tractor plowing completely turns over and mulches the debris back into the soil, leading to earlier germination and higher yields. A key observation we made is that the use of herbicides in the villages visited in the Guinea Savannah zone seems less pronounced than in villages in the Transition zone.

Patterns of Fertilizer Use

Inorganic fertilizer has been a major chemical input introduced into the villages' farming systems. As soil fertility declines, fertilizer is used to maintain or increase yields amid increasing populations and market access. In the 1980s, farmers rarely used fertilizer because the land was fertile, or at least they could meet their subsistence needs without applying fertilizer. Among the few farmers who used chemical fertilizers during that time, the intensity of use was very low. For example, fertilizer use in Sekyerekrom started in the early 1990s, and since then, its intensity has been increasing.

Today, fertilizer use is widespread and its adoption rate is high among farmers because the fertility of most of the lands they farm has declined. Trends across both agroecological zones confirm this pattern (Table 4.8). However, farmers use less than the recommended rate of fertilizer for many reasons, including financial constraints, risk management (as spreading fertilizer over more acreage will mitigate risk), outdated recommendations or knowledge of their own soils, and the availability of fallow lands (offering them the option of shifting their location in case of decline in soil fertility). For example, in Sakpule, only 50 percent of farmers in the village applied ammonia in addition to the compound fertilizer (NPK), while 75 percent of farmers applied only half of the recommended rate of NPK (15:15:15) per acre. Without chemical fertilizers, it seems clear that yields could not have been maintained or the farming systems might have ended up stuck in a low-level steady state. Organic fertilizers such as manure are rarely used, except in Tindang, where is it used on a limited scale by cattle owners.

Table 4.8 Trends in inorganic fertilizer use by farm size (% using)

Farm category	Transition zone			Guinea Savannah zone		
	1998	2005	2012	1998	2005	2012
<5 acres	9.1	24.2	27.9	17.1	26.5	41.4
≥5–12 acres	15.7	31.3	48.2	15.2	33.6	56.2
≥12–25 acres	9.4	31.2	47.5	6.3	29.5	53.3
≥25 acres	11.1	64.3	55.8	—	43.7	68.2
Average	11.0	28.3	39.6	15.6	31.4	51.2

Source: Ghana Statistical Service (1998, 2005, 2012).
Notes: 1 acre = 0.40 hectare. Transition zone includes parts of the Brong–Ahafo, Ashanti, Eastern, and Volta regions. Guinea Savannah zone includes the Northern, Upper East, and Upper West regions.

With regard to soil fertility management, in Hiawoanwu and Sekyerekrom in the Transition zone, a standard practice is to use maize–cowpea rotation between major and minor seasons to maintain soil fertility. Likewise in Tindang, farmers practice soybean–maize rotation. In short, crop succession is planned, with cowpea or soybean coming first, followed by maize, which benefits from the nitrogen fixed in the soil by the legume crops. Hence, farmers are able to apply less or no chemical fertilizers, thereby reducing their production costs.

Trends in the Use of Seed Varieties

Planting materials have not been left out of the dynamic process witnessed by farmers since the 1980s. Local and late-maturing varieties of crops were planted in the early 1980s (especially maize). From the early 2000s, farmers gradually adopted improved varieties of maize introduced to them by extension officers.

Currently, early-maturing varieties are used mostly amid increasingly erratic rainfalls but also increasing access to markets. For example, in Sekyerekrom, farmers indicated that they have gradually shifted away from the cultivation of local maize varieties to improved varieties such as Aburotia, Okomasa, and Obatampa. According to Jatoe (2014), these varieties were released in 1984, 1988, and 1992, respectively. In Tindang, the introduction of white maize followed a major drought in 1983, part of what is known as the "Rawlings chain" (see also Codjoe and Bilsborrow 2011), which led to major improvements in extension services, farming practices (for example, row planting and contour topography), farm size management, use of early-maturing varieties, and organic manure, among others. In Sakpule, farmers indicated that the pattern of rainfall has changed in the past 30 to 40 years, and they have switched from local to improved and early-maturing varieties of maize such as Okomasa and Obatampa and new crops such as soybean and cotton. Soybean varieties such as Jenguma have also been adopted by farmers in the Guinea Savannah zone owing to the crop's resistance to shattering, which helps reduce yield losses resulting from late harvesting. Soybean harvesting is a labor-intensive activity, and with the labor bottlenecks that occur during harvesting periods, farmers often run late in harvesting the crop, hence preferring to grow the Jenguma variety. However, there are trade-offs: farmers in Sakpule indicated that they have disadopted the Jenguma variety because it cannot generate high yields compared with the varieties of soybeans that shatter more easily.

With respect to seeds, although farmers have adopted improved and early-maturing varieties, most of them do not purchase seeds on the market but rely instead on recycled seeds selected from the previous seasons, a pattern that is consistent with that reported by Ragasa et al. (2013). Furthermore, with declining soil fertility and exhaustion of virgin lands, the major varieties of yam grown have changed. In the 1980s, Puna and Lariboko or white yam belonging to the *Dioscorea rotundata* species were the major varieties of yam produced mainly for the markets. These varieties have higher market values (see, for example, Otoo et al. 2013). Today, there has been a shift to planting more Matches or water yam varieties belonging to the *Dioscorea alata* species. These cultivars are more tolerant of drier conditions and can thrive in less fertile soils, producing big tubers that are consumed domestically but have limited market potential. Shifts in yam varieties may also be explained by the effects of fertilizer use on the crop. According to Amanor and Pabi (2007), the application of synthetic fertilizer to soils has a detrimental effect on the quality of the yams harvested. In these authors' own words, yams planted with synthetic fertilizer grow to be very large, but they develop an unpleasant hairy appearance that repels urban consumers.

Structure of Farm Input Costs

The structure of farm input costs has also changed, as shown in Table 4.9. For example, the share of hired labor in total crop expenditures declined between 1998 and 2012, while mechanical inputs (rented equipment) and herbicides contributed an increasing share to total crop expenditures during the same period (except in 2005 in the Guinea Savannah zone). Additionally, fertilizers and insecticides as a share of total crop expenditures increased, indicating a rise toward intensification. However, the share of seed costs declined during the same period. Although farmers indicated that their planting materials had changed, they invested less on seeds.

Table 4.9 Selected farm input costs (% of total crop expenditures)

Input type	Transition zone			Guinea Savannah zone		
	1998	2005	2012	1998	2005	2012
Hired labor	43.3	39.6	31.6	18.4	23.3	13.4
Inorganic fertilizer	2.8	8.5	12.5	6.9	16.2	26.2
Seed	6.2	4.9	3.2	4.2	7.7	2.3
Insecticides	0.9	2.3	2.7	1.0	1.8	3.0
Herbicides	0.3	6.0	22.1	0	0.3	12.1
Rented equipment	0.1	0.4	1.9	11.4	4.6	10.8

Source: Ghana Statistical Service (1998, 2005, 2012).

Notes: 1 acre = 0.40 hectare. Transition zone includes parts of the Brong–Ahafo, Ashanti, Eastern, and Volta regions. Guinea Savannah zone includes the Northern, Upper East, and Upper West regions.

5. AGRICULTURAL PRODUCTIVITY AND FARMER WELFARE

While changes in farming systems are essential for agricultural transformation, the ultimate goals underlying these changes are improvements in productivity and farmer welfare. This section assesses the extent to which the changes described by the farming communities have led to increases in crop yields, labor productivity, and quality of rural life. Farmers were unanimous about yield trends, indicating that land was very fertile in the 1980s, no fertilizer was used, and yields were very good, at least meeting their subsistence needs. Currently, in order to obtain comparable yields, farmers indicated that they must apply fertilizer (Table 5.1), though they use it sparingly.

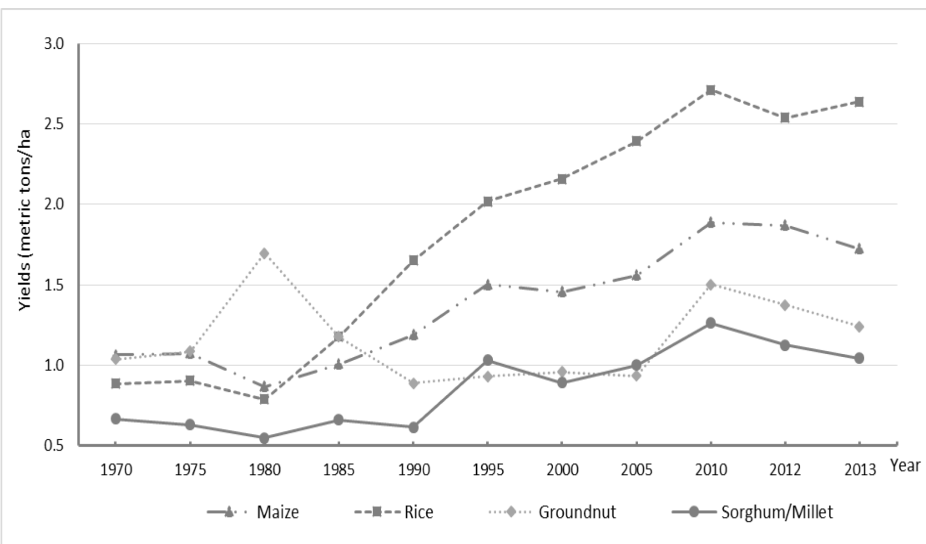
Table 5.1 Trends in maize yields (metric tons per hectare)

		Hiawoanwu	Sekyerekrom	Tindang	Sakpule
1980s (without fertilizer)		0.8	1.0	1.0	1.3
Current yield	*Without fertilizer*	—	0.5	0.4	0.6
	With fertilizer	1.6	1.3	1.0	1.4

Source: Village studies (2015).

Table 5.1 shows that reported yields have been maintained or have increased only slightly, expect in Hiawoanwu. Consistent with farmer reports, FAO data indicate that cereal yields (especially of maize and rice) have increased slightly at the national level, suggesting that land productivity has increased only marginally.

Figure 5.1 Grain yields in Ghana



Source: Compiled from FAO statistics (2015).

In contrast with the rise in yields, the value of production has increased steadily in the farm sector (Table 5.2). This trend indicates that land productivity (in terms of value of production) has improved considerably even though cereal yields have not increased much in the country. Most importantly, real expenditures increased among farming households in both agroecological zones between 1998 and 2012, indicating that labor productivity and living standards have improved. Increasing numbers of farmers participate in off-farm activities and/or wage employment, with the nonfarm sector contributing 20 to 30 percent of their total income.

Table 5.2 Value of agricultural production and consumption expenditures (real $US)

Indicators	Transition zone			Guinea Savannah zone		
	1998	2005	2012	1998	2005	2012
Estimated value of agricultural production (real US$/hectare)	168	219	353	128	187	297
Participation in nonfarm activities (%)	35.8	46.5	67.9	28.0	45.4	52.2
Share of nonfarm income (%)	16.8	20.2	28.4	11.3	14.6	20.8
Annual per capita expenditures (real US$)	284	320	734	156	219	512

Source: Ghana Statistical Service (1998, 2005, 2012).
Notes: 1 acre = 0.40 hectare. Transition zone includes parts of the Brong–Ahafo, Ashanti, Eastern, and Volta regions. Guinea Savannah zone includes the Northern, Upper East, and Upper West regions. Nonfarm sector includes wage employment.

Overall, the results here suggest that farmers have invested in both mechanical and chemical inputs over time, but the pattern of transformation seems to suggest that they have either saved more labor or invested more in labor-saving technologies (such as herbicides and tractors) that allow them to expand farmlands where possible. Conversely, they have invested less in land-saving inputs, such as seeds and fertilizers, essentially resulting in a marginal increase in crop yields. But more importantly, these farmers are better off today than in the past.

Some of the changes may have been facilitated by the government and some nongovernmental organizations (NGOs), especially extension workers and development practitioners. These actors were important in spreading technical knowledge about new crops and farming techniques, roads and markets, and other rural infrastructure (for example, schools and health facilities). For example, farmers indicated that access to extension services in the 1980s was very limited but improved starting in the 1990s. Others recalled that extension services intensified from 2008 with the inception of the Millennium Development Authority project, which according to some farmers significantly impacted agriculture in some of the villages. In one village, farmers reported that the interventions of the Adventist Development and Relief Agency (ADRA) in terms of training in agricultural practices, credit, food aid, and animal traction brought significant changes to their lives.

6. CONCLUDING REMARKS

This paper documents changes in Ghanaian farming systems using a combination of historical narratives, land-cover maps, and data at the regional level. Farmers' reports suggest that population has been increasing in all areas since 1980, either through permanent inmigration and/or internal growth, whereas census data indicate that population has either increased or stagnated between 2000 and 2010. Farmers have also expanded their farms' size. As more lands were brought into cultivation, virgin land area declined gradually, and some villages reached their land frontiers.

With increasing land scarcity, farmers were compelled to reduce fallow periods or move to other communities to access farmlands. This shift resulted in numerous changes, including decline in soil fertility, increased use of fertilizer essentially to maintain yields, changes in crop mix, and introduction of soil fertility management practices (for example, legume–cereal rotation). Increases in farm size and use of modern inputs indicate that outputs have increased in volume. Likewise, the composition of outputs has changed from root-based to grain-based cash crops that are increasingly commercialized, though yields have increased only marginally.

With regard to land use, considerable changes have occurred in the composition of land cover. Since 1980, observed trends have indicated dynamism in land use systems, which are generally transitioning to less vegetation cover, suggesting an intensification of human activity and land use in the villages. In the villages studied, family and communal labor were dominant in the 1980s, but since then communal labor has largely declined, while hired labor has become the norm. Hired labor has also become expensive and may have contributed to reducing the production of some traditionally labor-intensive crops. With growing labor bottlenecks, farming methods have changed (for example, increased herbicide use, tractor plowing, and changes in crop mix). Notably, herbicides and tractors have become important substitutes for costly hired labor. However, differential access to labor inputs also influences prevailing cropping patterns among farmer groups.

An increasing concentration of infrastructure in farming communities, along with changing rural lifestyles, compelled farmers to initiate changes in their farming systems. The need to shift from subsistence- to market-oriented production became essential and translated into responsive strategies, such as increased in farm size, increased use of modern inputs (crop varieties, fertilizers), increased production of certain crops, and reduction or abandonment of other crops. For example, with better roads (and increased market access), electrification, mobile phones, and schooling, new opportunities arose but also new challenges emerged (for example, the high cost of labor and an increase in consumption expenditures), to which farmers responded by intensifying their production on impoverished soils and/or increasing their farm size. Time-specific events have also shaped the pace of dynamism in farming communities as farmers learned from such events and responded in their farming systems by reallocating resources, changing crop mix, altering production, and adjusting investment behavior, both within and outside of the agricultural sphere. Our results also suggest that farmers adopted some technologies and practices disseminated by public and nonpublic extension workers, while government investments in roads and markets may have opened up new opportunities to the rural peasantry. Improvements in markets have also enabled farmers to produce more maize and groundnut, as well as newly introduced cash crops such as soybean and cotton.

The most important technological innovations in farming have been the adoption of new crops, new varieties of traditional crops, tractor use, inorganic fertilizer, herbicides, and in some cases, cropping practices. Farmers have also reinvested in agriculture. Most of these investments have been private, ranging from small to large market-acquired productive farm assets (hand tools, draft animals, tractors or tractor services, seeds, herbicides, and fertilizers). The capital invested came mostly from increased crop commercialization, and marginally from off-farm activities. Likewise, some farmers have diversified into other occupations, out of agriculture.

Several key factors emerged from the case studies. Differential access to resources drove the behavior of farmers in making certain production and allocation decisions. Farmers, no matter how small, tended to reinvest in agriculture. Their main incentives came from both supply and demand sides. As soils were no longer adequate for root-based and heavy feeder crops such as yam, and as rainfall patterns changed, farmers shifted to grain production and early-maturing varieties. However, they also had to produce to meet market demand for specific high-value crops and varieties that appeal to consumers. Markets seemed to be a major factor, for without market opportunities, farmers were not going to develop their farming in ways that would enhance their incomes or contribute significantly to national development goals (Wiggins 2000). Facilitating access to markets is a necessary condition of change, but changes in rural lifestyle (as in increasing consumption expenditures and perhaps aspirations) and pressure on farmlands have also induced changes in terms of adoption of new varieties of seeds, farm inputs, and labor-saving innovations such as herbicides and mechanization.

There was little evidence of quick change; instead, most changes came about gradually, and some of them occurred and disappeared, leaving no trace behind. Even so, these changes are important for understanding some of the local patterns observed in agriculture in the regions. As Wiggins indicated:

> New varieties of existing crops are introduced, new crops are planted on old fields, fields once hoe[d] get plowed by oxen or a tractor, existing crop receives fertilizer as soil fertility and availability decline, herbicides are introduced to kill weeds as the soil becomes weedy and labor requirements increase. New ways are fitted into existing farming systems, cultural, and sociological settings (Wiggins 1995).

Finally, with regard to the issue of stagnation, the evidence suggests that farmers' response to both endogenous and exogenous factors has led to the emergence of a farming system that has both elements of intensification and extensification. This system involves new cropping systems, combinations of technologies, and specialization of crops as well as expansion of farm size. Overall, the tendency seems to be toward more intensification through increasing the use of labor-saving technologies rather than land-saving inputs, resulting in only marginal yield increases. Most importantly, however, land and labor productivity have increased considerably and farmers are better off today than in the past. Although the narratives of change in farming systems are consistent with regional trends, the observed patterns broadly contrast with Asia's path to its Green Revolution. The findings here seem inconsistent with the predominant narratives of stagnation in SSA agriculture. Future research should expand the scope of this work, while policies should focus on lessons that can be learned from these historical processes of genuine change.

APPENDIX A: HISTORICAL NARRATIVES

Farmer in Hiawoanwu (Ejura–Sekyedumase district, Transition zone)

Mrs. N. started farming about 30 years ago with 1 acre of maize and harvested more than ten bags. She then traveled to Togo, a neighboring country, to trade using the proceeds from crop sales, but she was not successful. Therefore, she came back to the village and started farming again with 1 acre of maize (Obatampa variety) around the mid-1990s. She indicated that she was very successful as she obtained good yields and, therefore, decided to expand the following season and progressively thereafter. In the 2000s, she cultivated 20 acres (10 acres of maize and 10 acres of cowpea) using part of the money from the farm, while the rest of the income was invested in houses and to support families and relatives. In 2005, she diversified partly into livestock, following the advice of extension agents. She now owns 34 cattle (6 calves), 20 goats, and 16 sheep. She indicated that she experienced poor rainfalls in some years, resulting in crop failure, but used her livestock to support her farming activities. She is also engaged in a nonfarm activity, including the sale of agrochemicals, which she started two years ago, and catering for the school feeding program in the community. She also offers cash credit to other farmers and takes in-kind payments (for example, bags of maize) in return. Currently, she cultivates 51 acres of farmlands in total. Achieving this scale has been possible owing to the investment of income from the sale of farm produce, livestock, and other nonfarm business activities. Finally, she indicated that, in the past, farming was meant for survival (for consumption), but currently, farming is more of a business and farmers are now respected in her community.

Farmer in Tindang (Savalegu–Nanton district, Guinea Savannah zone)

Mr. Y. started farming with 1 acre of groundnut using a hand hoe and cutlass. Yields were high, and he was able to get surplus to sell. In 1977, the Savannah Agricultural Research Institute (SARI) came to introduce animal traction to his village. He managed to save income from crop production to buy two bullocks and was subsequently able to expand to 6 acres. Using savings from crop sales, he bought two more bullocks and some cows. In 1980s, he bought a milling machine and used part of the money from the operation of the machine to buy grains to add to the stock of produce. In 1986, he bought a second-hand Massey Ferguson tractor with money from the sale of cows, operations of the milling machine, and farm produce. After buying the tractor, he moved to another village to acquire farmlands, as land availability had become a constraint in his village. In 1987, he expanded his farm size from 6 to 20 acres in the village, of which 10 acres were of groundnut, 5 acres of maize, and 5 acres of rice. In 1988, he added 5 acres of groundnut and 6 acres of maize (11 acres) to his existing farm. In 1992, he expanded his rice farm from 5 acres to 15 acres (adding 10 acres). In 1994, he increased the size of his maize farm to 20 acres. Today, he cultivates a total of 65 acres of land. These farms are located in another village (30 acres of groundnut, 20 acres of maize, and 15 acres of rice), and he has 5 acres of soybeans from the 20 acres in his village. (He has given 15 acres to children to cultivate.)

When asked what motivated him to expand his farm, he indicated that he was lucky with groundnut cultivation (that is, he got a better yield). But later, he realized that rice was less labor-intensive than groundnut cultivation, so he decided to add more acres of rice. He has not expanded since 1994, which he attributes to ill health. Cattle is still part of his livelihood. He sold about 30 old heads of cattle and used the money to buy a tipper truck for his sand business. The cattle have been put under the control of Fulanis, who takes care of the animals, and in exchange, collects the cows' milk and uses their manure to fertilize their croplands.

APPENDIX B: SUPPLEMENTARY FIGURES AND TABLES

Figure B.1 Land-cover changes

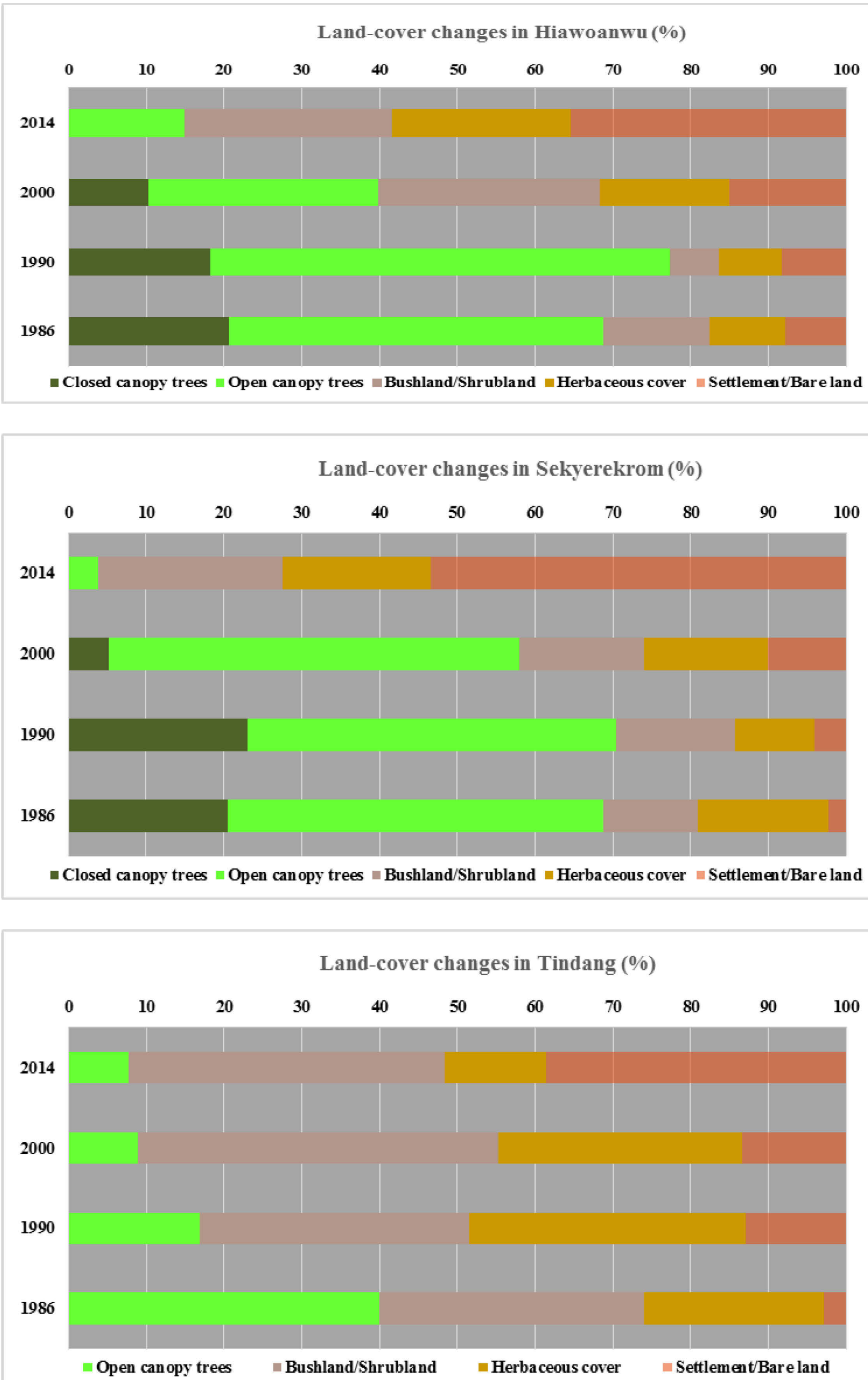
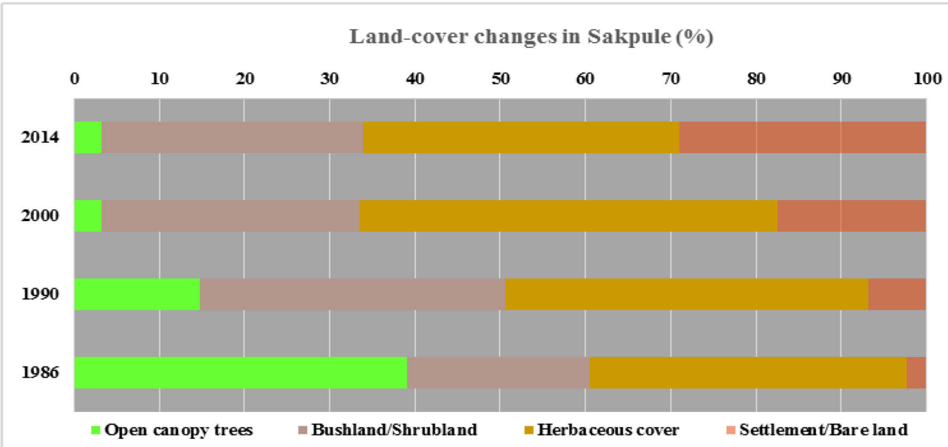
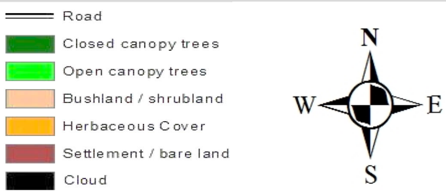


Figure B.1 Continued





Source: Compiled from Landsat images by CERSGIS (2015).

Table B.1 Land-cover statistics in Hiawoanwu and Sekyerekrom, 1986–2014

Land classification	Hiawoanwu 1986	Hiawoanwu 1990	Hiawoanwu 2000	Hiawoanwu 2014	Sekyerekrom 1986	Sekyerekrom 1990	Sekyerekrom 2000	Sekyerekrom 2014
	Area in hectares							
Closed canopy forests	571.2	504.8	277.02	0	479.9	540.1	121.2	0
Open canopy forests	1,333.6	1,638.5	790.4	413.7	1,125.7	1,105.4	1,222.5	90.7
Bush land/Shrubs	379.27	173.3	765.4	741.4	286.2	358.3	372.24	551.8
Herbaceous cover	272.2	224.1	446.2	635.6	389.25	236.5	368.5	444.2
Settlements/bare lands	216.1	231.6	404.3	981.6	54.99	96.0	234.8	1,249.2
Cloud cover	—	—	(89.1)	0	—	—	(46.8)	0
Total area	2,772.4	2,772.4	2,772.4	2,772.4	2,336.0	2,336.0	2,336.0	2,336.0

Source: Compiled from Landsat images by CERSGIS (2015).

Table B.2 Land-cover statistics in Tindang and Sakpule, 1986–2014

Land classification	Tindang 1986	Tindang 1990	Tindang 2000	Tindang 2014	Sakpule 1986	Sakpule 1990	Sakpule 2000	Sakpule 2014
	Area in hectares							
Open canopy forests	494.5	209.7	111.0	94.7	1,652.7	627.39	133.9	136.9
Bush land/Shrubs	420.6	427.5	572.6	502.4	904.1	1,516.5	1,280.8	1,298.7
Herbaceous cover	284.9	439.9	385.7	162.5	1,575.7	1,800.6	2074.1	1,568.0
Settlements/bare lands	35.6	159.7	166.2	476.0	98.3	286.2	742.0	1,227.2
Total area	1,235.5	1,236.8	1,235.5	1,235.5	4,230.7	4,230.7	4,230.7	4,230.7

Source: Compiled from Landsat images by CERSGIS (2015).

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