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Space, Time, Rhetoric and Agricultural Change in the Transition Zone of Ghana

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Abstract This paper examines change within farming systems in the Brong Ahafo Region in Ghana, and the impact of agricultural modernization and mechanization on the regional economy and local farming systems. It combines anthropological, historical, and remote sensing techniques to document changes in farming practice and land use and land cover. It argues that change is not the product of simple evolutionary sequences of responses to population pressures or adoption of modern technologies, but arises out of a complex set of factors interacting within wider regional economies, which are increasingly commodified and commercialized and subject to global market pressures. These include technical, institutional, market, movements of labor, and transport infrastructure development dimensions, which often create new opportunities for local farmers other than those envisaged in agricultural development policies. Tracing the opening up of the transition zone over the last 40–50 years through the development of state farms and mechanized synthetic agriculture, the paper examines the changing fortunes of farming systems within a radius of 30–40 km from agricultural technology hubs and the implications for models of agricultural development.

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Introduction

This paper examines the ways in which farming systems adapt to change and initiate change, in the context of the interplay of knowledge, technology, institutional policy frameworks and ideologies, and markets. It examines the expansion and contraction of various farming systems both temporally and spatially, the ways in which different farming systems influence each other, and the impacts of agricultural policies. It focuses on areas surrounding former state farms and centers of modern agricultural technology dissemination to examine the effects of agricultural modernization on agricultural development and the responses of local farming practice to these interventions. Agricultural modernization is defined here as state supported initiatives to transform agriculture through mechanization, synthetic inputs, new high-yielding varieties, and standardized recommended practices. The research methods used consist of anthropological and historical analysis of regional economies and local farming strategies, and remote sensing techniques. The research builds up narratives of change based on interviews with various actors, and uses remote sensing techniques to attempt to locate these changes spatially over time. We also attempt to examine the usefulness of remote sensing in accounting for change in farming systems, and to suggest future directions for remote sensing research at the local level.

In recent years, a number of detailed local-level case studies on African agrarian systems have shown the complex adaptive strategies and responses of farmers to social, economic, and ecological change (Scoones and Wolmer, 2002; Mortimore, 1998; Guyer, 1997; Fairhead and Leach, 1996; Amanor, 1994; Tiffen *et al.*, 1994; Richards, 1987). While these new perspectives have received academic recognition, they frequently fail to influence agricultural policy and policy implementation, which continues to use narratives of deforestation, land degradation, desertification, soil infertility, and neo-Malthusian population pressures (Keeley and Scoones, 2003; Fairhead and Leach, 1998; Leach and Mearns, 1996). Keeley and Scoones (2003) argue that policy knowledge is often embedded in institutional and organizational arrangements that are linked with political and economic interests and prestige. This enables particular perspectives to persist in the face of counter evidence. The narratives are often used to justify the technical interventions and mandates of development programs.

Lambin *et al.* (2001) argue that models for land use and land cover change need to be informed by a better understanding of the causes of change, and move beyond the dominant myths that influence environmental and development policies. These myths are based on simplifications which fit into prevalent worldviews and rest on generalized models of change based on technical or population control measures, for example, the linking of high rates of deforestation with population growth, poverty, and shifting agriculture. Lambin *et al.* (2001) argue that tropical deforestation is largely driven by changing economic opportunities linked to social, political, and infrastructural change. Evidence from some case studies suggests that high populations can result in agricultural innovation and sustained production (Mortimore, 1998; Tiffen *et al.*, 1994). However, low population areas can also be associated with deforestation resulting from development interventions to induce intensive agriculture. Some of the factors that Lambin *et al.* (2001) identify as repeatedly being associated with deforestation include weak state economies in forest frontiers; institutions in transition; induced innovation and intensification; new economic opportunities linked to new market outlets; changes in economic policies and capital investments, and inappropriate development interventions.

In Ghanaian agricultural policy, many of these simplified models tend to predominate. These characterize indigenous farming systems as based on outmoded models of shifting cultivation which have failed to adapt to contemporary conditions and which promote deforestation and environmental degradation. The current Food and Agriculture Sector Development Plan for Ghana (Ministry of Food and Agriculture, 2002), for instance, makes use of these crisis narratives:

> The productivity of most agricultural lands in Ghana is declining at an alarming rate due to widespread land degradation caused by soil erosion, deforestation, soil nutrient mining, uncontrolled bush burning and other poor management practices. MOFA [Ministry of Food and Agriculture]....will create awareness and train farming communities to adopt sound land and water management practices to restore and maintain the productivity of agricultural lands. These practices include mixed farming, use of agro-forestry systems and effective use of organic and inorganic fertilisers (p. 14).

Mainstream development policy sees development as the product of the transformation of existing indigenous farming systems—which either move along an evolutionary sequence transforming themselves to conform to Western notions of agricultural intensification, or which spiral downwards into a cycle of poverty and land degradation until transformed by external assistance and new scientific technology. However, much farming practice in Africa is modern in that it is a response to modern conditions, commodification, and change. The evidence from many detailed case studies of African farming suggests that extensive agriculture with long fallow is not only a function of low population densities but also a strategy for managing difficult and unpredictable ecologies. Equally, declining fallow intervals are not necessarily a sign of population density or intensification: they can equally be associated with improvement and deterioration of agroecological conditions (Guyer, 1997). Innovations in many African farming systems have often been associated with the transformation of crops and the management of crop mixtures and cropping sequences rather than in a movement towards intensification through more permanent cultivation of land (Guyer, 1997; Richards, 1985).

Guyer (1997) argues that African farmers have largely been able to meet the demands of feeding rapidly increasing urban populations, in spite of constraints of transport, storage, and lack of securities markets. This achievement involves a complex interplay of factors and influences including the ability of farmers to mediate a multitude of institutions and innovations rooted in state organizations, capital investment, and local practice through which they have been able to respond to prices, mobilize resources, and develop skills and assets (Guyer, 1997).

In this paper, we argue that African agriculture is not characterized by a differentiation between modernization and traditional farming practices, but consists of a series of differentiated farming belts and socially differentiated farming strategies, which are the product of processes of modernization and commodification. Change in these farming systems is complex and multidirectional. This paper focuses on the boundaries and changing fortunes of mechanized food production and yam and maize cultivation under systems characterized by rotational bush fallowing in the transition zone of Brong Ahafo in central Ghana. It examines the history of the now defunct Wenchi and Branam State Farms; the areas immediately surrounding them in which there was a large uptake of mechanized input farming; and the adjacent areas where mechanized agriculture failed to penetrate and farmers continue to cultivate food crops within a bush fallowing system. The latter areas include the maize belt around Badu, and the yam belt around Mansie and Weila. The patterns of change within these different farming systems are rooted within the development of the regional and national economy.

Methodology

This study tracks changes in farming systems and landscape from the 1960s to the present in the northern Brong Ahafo transition zone. This area became the setting for a project in agricultural modernization which took the form of state farms in the early 1960s. By the 1970s the model of agricultural modernization involved the promotion of privatized estate agriculture around the state farms and the development of associated agricultural services. By the mid-1970s mechanized agricultural services and extension services promoting new seeds and fertilizers were disseminating these new technologies to smallholder cultivators. By the early 1980s the state farms were no longer functioning, and the large private estates collapsed as structural adjustment began to influence agricultural policy and subsidies and credit-support programs were removed. The majority of aspiring agricultural capitalists have since moved out of mechanized food production. They are now moving into plantation development of exotic fruits for export, including cashew and mango, and teak for electricity poles and timber.

The social and remote sensing components of this study were not initially integrated. After the completion of a study (from which much of the social data originates) which examined innovative strategies for natural resource management in the forest–agricultural interface in Ghana (Amanor *et al.*, 2002), the remote sensing research was commissioned by the Natural Resource Management Programme (NRSP) to provide an overview of the impact of agricultural systems on forest resources in the transition zone (Pabi and Morgan, 2002). The present study is an attempt to integrate some the findings of these two projects more closely to address the dynamics of agriculture, land use, and land cover change.

The social and historical reconstruction is based on a number of formal questionnaire surveys and informal surveys in the area, including questionnaires administered to 227 farmers in seven settlements in 1993, and to 389 farmers in six settlements in 2000–2001, and informal surveys and group discussions with tractor drivers and employees of the state farms carried out in 2000–2001. Both Mansie and Subinso were included in the 1993 and 2000–2001 questionnaires, enabling changes in farming systems to be documented. The interviews with the employees of state farms and tractor drivers enabled the history of agricultural mechanization and its influences on surrounding farmers to be reconstructed. These patterns of change are related to historical policy interventions and complex configurations among policies, socioeconomic factors and farmer decision-making strategies, and land use strategies and land cover dynamics.

Remote Sensing

Remote sensing compared satellite images for 1984 and 2000–2001. The use of only two dates was conditioned by financial constraints and the original research program under which the imagery was acquired, which was concerned with examining broad patterns of land cover change and the interface of forestry and agriculture. The earliest date for which reliable Landsat satellite imagery was available for Brong Ahafo was 1984, and 2000–2001 represents the period in which research was conducted and the images were classified with ground-truthing. Using the localities identified in the histories of agricultural change, remote sensing analysis attempts to determine the nature and extent of land use/cover change.

Two main problems had to be confronted in selecting images for the studies—securing data with little cloud cover and without extensive burnt vegetation scars. Data captured in rainy seasons were covered with thick clouds whereas those for the dry seasons had extensive coverage of burnt vegetation scars. Data for December 1984 and January 2000 and 2001 were used, despite cloud cover, smoke from active burning sites, and scars of burnt vegetation. Using data captured at the beginning of dry season meant a trade-off of potentially important land use/cover information that would have been present in the cropping season.

The 2000 and 2001 images which were registered served as base-year images to correct the 1984 image by image-to-image registration. Radiometric correction was conducted for atmospheric differentiation by normalizing the 1984 to the 2001 data. An enhanced image of bands 3, 4 and 5 was interpreted and explored for probable distinct land use/cover classes using an unsupervised classification algorithm called Iterative Self-Organizing Data Analysis Technique (ISODATA) (Tou and Gonzalez, 1974).

Land use classification is dependent on proxy information inferred from land cover. Thus, deriving accurate land use information presupposes a strong correspondence or association between land use indicators and the target land cover variables as expressed in the satellite image. The high heterogeneous and fragmented nature of the landscape made the design of a classification scheme a challenging task. The 1983–1984 bush fires, in particular, may have affected the forest more than the savannah mosaics, and consequently influenced the interpretation and the designing of classification schemes by distorting land cover information. However, the use of Landsat TM data with relatively high spectral resolution, intensive ground-truthing of spectral patterns, the use of GPS georeferenced vegetation samples and aerial photographic information considerably improved the situation.

In developing the classification scheme, it was impracticable to differentiate between current actively farmed lands and other sparsely vegetated arable lands since these have dried up or burnt. All tree and shrub formations or mixtures of the two were referred to as woodland. To ensure a meaningful output for the change detection, four land use categories were used; a generalization which may have masked certain local processes:

- Close/dense woodland—savannah woodland or forest or trees and shrubs with close or almost closed canopy. In the more deciduous sections of the transition zone reserves and teak plantations constituted the main type of this land use/cover category
- Open woodland tree or shrub formations with moderate to widely open canopies with grass and bushes and annual crop farms. Where it occurs, the yam belt has similar spectral characteristics to this floristic formation. Much of this formation consists of mature woody fallow land
- Fallows/annual crops—dominantly herbaceous fallows of forbs and grass and annual crops with or without isolated trees and shrubs
- Bare lands/settlements—built-up areas, recently cleared farmlands or farms harvested of crops and left in bare or burnt state

Principal component analysis (PCA) was carried out to identify the most relevant bands and components with specific information values. The enhanced image was finally classified by a Maximum Likelihood Classifier Algorithm.

Verification procedures were designed to balance scientific rigor with practical limitations of time and the general limitations/challenges associated with the use of remote sensing techniques in the tropics and availability of appropriate historical test reference information. Point samples collected from a vegetation ground-truthing were used as test reference data. These were randomly sampled, photographed, characterized floristically and georeferenced with a Geographical Positioning System(GPS). Pixels used to train the Maximum Likelihood Algorithm were not used as test samples so that the reference data could be as independent or unbiased as possible. The test samples were used for a pixel-by-pixel comparison with the classified image, and accuracy computed using Kappa statistical technique. An overall accuracy of about 81.0% was finally accepted within the given constraints.

Land use/cover change analysis was carried out in a Geographical Information System (GIS) environment using IDRISI software. The change detection analysis was done by the post-classification technique since proportional changes, direction of change and interconversions among the land use/cover categories were important considerations. The choice was made with recognition of the limitation of transferring accumulated errors of two separate classifications to the change image produced.

Agricultural Modernization in the Brong Ahafo Transition Zone

While the Brong Ahafo transition zone is the major commercial food-producing zone in Ghana, it has one of the lowest population densities in spite of large movements of migrants into the district, which continues into the present. According to the 2000 population census, the Brong Ahafo region had a population density of 46 people per square kilometer, which is the third lowest in Ghana.[1] Population densities are unevenly distributed within the region, with a much higher population in the southerly forest districts and a thin population in the transition zone.[2] Land is still widely available in the transition zone, and can be acquired cheaply, so migrant farmers largely from the northern regions of Ghana continue a long-term migration and population distribution dynamic.

The northern transition zone is characterized by savanna woodland interspersed with high forest mosaics in gallery forests along stream banks and valleys. The dominant land tenure systems in the more sparsely populated areas towards the north tend to be based on communal land. In the southern areas on the boundaries of dry semideciduous forests land tends to be held by lineages which exercise control over fallow land and its allocation (Fig. 1). The northern transition zone is ethnically diverse. The dominant groups are the Bono (or Brong), Banda, and Mo.

[1] This compares with 130 in Ashanti, 109 in the Eastern Region, and 103 in the Upper East Region of Ghana.

[2] According to the 2000 Population Census, the transition zone districts of Kintampo and Wenchi had population densities of 21 and 22 people per square kilometer, respectively, while the high forest zone districts of Berekum and Dormaa have population densities of 88 and 109 people per square kilometer, close to the more densely populated regions.

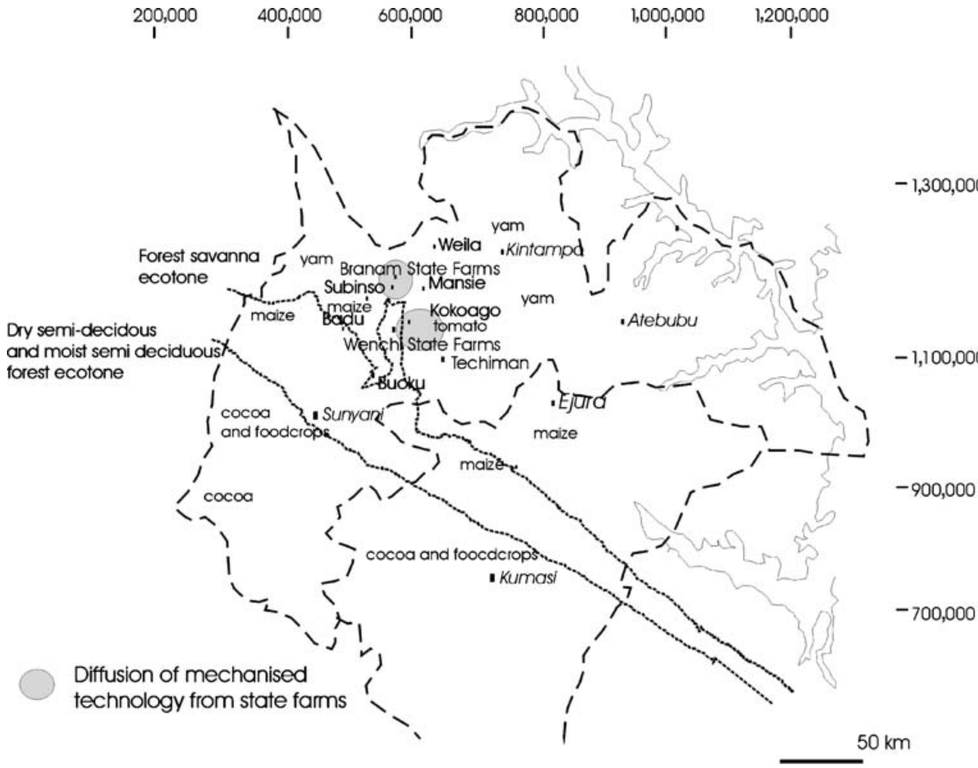


Fig. 1 Farming system and the mechanized farm belt in Brong Ahafo.

The transition zone of Brong Ahafo was identified as a zone of agricultural commercialization in the 1960s. Early forms of commercialization were based on the development of state farms, followed by state-sponsored projects that promoted the use of synthetic inputs, and large private-sector commercial estate farms. The development of state farms in the area led to the rapid concentration of a modern infrastructure, including mechanized ploughing services, synthetic input distribution depots, canning factories, irrigation infrastructures, and a road network facilitating the opening of markets. The choice of Brong Ahafo transition zone as a focus for agricultural commercialization was largely a result of the availability of land, which enabled the state to acquire large tracts of land for state farms without expropriating small farmers. The transition zone, with its open vegetation and small trees, was also a more suitable environment in which to practice agricultural mechanization than the high forest, with its large trees with huge root structures which could destroy tractor ploughs if not removed, and whose removal often promoted rapid soil erosion.

Agricultural mechanization had not figured in colonial agricultural policy until the late 1950s. Prior to this colonial agricultural policy had largely focused on cocoa, the leading export crop in the southern high forest zone and had neglected food crops. The lack of a comprehensive transport network outside the cocoa zone in the early colonial period hampered the development of large agricultural markets for food produce. The main crops cultivated in the transition zone of Brong Ahafo were yam, maize, sorghum, groundnut, cowpea, and bambara bean. Yam predominates in the northern transition zone, and maize in the areas bordering the semideciduous forest.

Agricultural Modernization and Mechanized Agriculture

Cocoa production and rapid urbanization in the postwar period in Ghana led to increasing importation of food, which in turn made food production an important policy issue. During the 1950s, the first experiments in mechanized agriculture took place in the Gonja Resettlement Programme to the north of the Brong Ahafo transition zone (Konings, 1986). While this project was a failure, mechanized agriculture was given increasing priority in the early postcolonial period, as an international structure of institutions and funding was created in developing countries for promoting agricultural modernization based around mechanization, new high yielding varieties, and synthetic inputs.

In 1962, state farms were established in Wenchi and Branam, on former Ministry of Agriculture experimental farms. At Wenchi the main crops grown were maize—250–300 acres—sorghum and yams. At the Branam State farms 2,000 acres were under maize, 700 under cotton, 200 acres under yam, and rice was also cultivated. Oil palms and teak were also planted at Wenchi, but were destroyed by bush fires. Cattle were reared on both state farms.[3]

Maize was initially not cultivated on a commercial basis for food but for seed. Experiments with increasing fertilizer application beyond a low level did not prove to be cost effective—one bag of NPK per acre yielded were around five to seven bags per acre.[4] No fertilizer was used on sorghum and yields of five bags an acre were achieved. At both state farms the land was stumped of its tree cover to allow for mechanized field preparation. Tractor use was still experimental. At Wenchi, British Massey Ferguson tractors were used. The Branam State Farms acquired Russian MTZ tractors and ploughs, but they proved to be so heavy that they often got stuck and also ploughed much too deeply for the shallow 4–6 in. top soils. Planting yams on mechanized ploughed ridges rather than on circular mounds made with hoes yielded so badly that the state farms replaced mechanization with hired labor to prepare indigenous yam mounds. Since the tree cover on the state farms had been removed laborers had to cut the essential staking material from the surrounding bush. Insufficient staking material, however, resulted in decline in the area under yam cultivation.[5]

With the overthrow of the Nkrumah-led CPP government in 1966, the state farms became a target of much criticism for being inefficient and poorly managed (Miracle and Seidman, 1968). Moves were made to privatize them but without necessarily changing the style of farming. During the 1970s, large-scale investments in private farms by capitalist farmers, state bureaucrats and agribusiness were promoted by government, alongside a revamping of state farms, and government projects (Konings, 1986). Around the Wenchi State Farms a National Reconstruction Corps project was created at Kokoago focusing on maize production, and an irrigation project at Subinja for vegetables. The infrastructure for agricultural modernization also included a tomato cannery at Wenchi and parastatal food marketing companies.

By the early 1970s an infrastructure for agricultural modernization was fully in place in Brong Ahafo. Input delivery services were concentrated around the state farms. Large private farms began to develop around the state farms, encouraged by the cheapness of land and availability of subsidized inputs distributed by government agencies. Large-scale farmers bought tractors of their own, and to offer ploughing services to local farmers. Many local farmers in communities surrounding the state farms began to adopt tractor ploughing and use subsidized fertilizers.

Stumping and ploughing were also seen as ways of staking claims to land. Under the communal system of land tenure any member of the community can cultivate any portion of land that is not being cultivated by others or has been abandoned. As population began to increase, proximity to state farms and government services was seen as desirable, and local farmers attempted to keep their plots under constant cultivation. In some cases, this was driven by interests in land speculation and anticipation of the future development of a land market resulting from the influx of wealthy investors in estate agriculture. Stumping of land, mechanized cultivation and use of synthetic inputs formed part of a process of social differentiation, in which those wealthy enough to make initial investments in land clearance for mechanized cultivation could acquire rights to large tracts of land. This displaced small farmers who found that fallow lands were increasingly being converted into ploughed lands.

The introduction of ploughing also destroys the topsoil. Topsoils are usually very thin in these transitional environments and ploughing usually turns the subsoil over the topsoil. The fertility of the soil was only maintained by continuous applications of synthetic fertilizer. Obeng (1973) argued that the soil series of the northern transition zone are unsuitable for mechanized arable cultivation, and that this can result in widespread sheet erosion.

The development of a modern agricultural infrastructure around the state farms resulted in the uptake of new technology in their immediate vicinities, but only within a limited radius. In a survey conducted in 1993, 44% of farmers at Subinso used fertilizer and 51% of farmers ploughed their lands with tractors (Amanor, 1993).[6] However, 10 km from Subinso, at Mansie, only 7% of farmers used fertilizers and 18% used tractor services. At Badu, a leading maize center, 20 km from the Wenchi state farms, no fertilizers or tractors were being used.

The Impact of Neoliberal Market Policies on Mechanized Cultivation

The removal of fertilizer subsidies in the 1980s led to a rapid increase in the price of fertilizer, not reflected in the price paid to farmers for crops cultivated with fertilizer. For instance, in 1981 the price of one bag of maize could buy

[3] This information is largely derived from interviews with employees at the state farm, and from small farmers in the vicinity.

[4] One bag of maize weighs 110 kg.

[5] The application of synthetic fertilizer to soils also had a detrimental effect on the quality of yams. Yams planted with synthetic fertilizers grow to very large sizes, but they develop poor taste and texture characteristics and have an unpleasant hairy appearance, which repels urban consumers.

[6] This compares with similar figures for use of inputs in farming systems near other state farms in Ghana in the same period. In a study of farmers near the Ejura State Farms in northern Ashanti, Tripp (1993) recorded that 66% of farmers used fertilizers and 58% of farmers used tractors in land preparation.

5.5 bags of fertilizer but dropped to 3.3. bags in 1986 (Hailu, 1990). Around the state farms, the large agricultural estates rapidly collapsed and small-scale production of maize with fertilizers declined. In the 2001 survey of Subinso only 11% of farmers were using fertilizers and only 22% were ploughing their land. While monocropped maize was dominant in Subinso in 1993, only 11% of farmers were cultivating monocropped maize in 2001 (Amanor *et al.*, 2002). Unable to cultivate maize successfully without fertilizers on soils impoverished by the practices of mechanized agriculture, Subinso farmers increasingly adopted crops that could grow on poor soils and by 2001 cassava emerged as the main crop. The failure of markets to account for the increasing cost of agricultural inputs can be explained by two factors. Firstly, other farming systems producing maize without synthetic inputs were able to expand their production to account for the shortfall from the mechanized farm zone. Secondly, food imports increased, as trade liberalization policies prevented the government from protecting domestic food production from international competition. During the 1980s, government resorted to importing maize in years in which it appeared there might be shortfalls. This served to offset price increases. Production was monitored by the Policy Planning Monitoring and Evaluation Division within the Ministry of Food and Agriculture, which made forecasts of annual production. In addition to importing maize, trade liberalization resulted in huge imports of cheap US rice. Since the 1990s rice consumption in urban markets has increased and displaced other staples as the cheapest available food.

Agricultural Modernization and Local Farming Systems

Agricultural modernization has had a limited impact on the uptake of the technologies away from the main centers of government agricultural services and state farms. However, the creation of a modern agricultural state sector has had unintended effects on adjacent farming systems. The creation of state farms encouraged the development of road networks necessary to link them into the national economy and create agricultural service centers. The state farms and large private estates that formed around them acted as a magnate for labor. The opening up of a road across the Black Volta to what became the Upper West Region facilitated the movement of migrants southwards. The road network also encouraged the development of food markets. The position of Brong Ahafo in the center of Ghana facilitated the rapid expansion of markets, as traders visited from all corners of Ghana, including the major urban markets in Accra, Kumasi and Tamale, and even from neighboring countries. By 1980, the day market of Techiman had grown into the largest wholesale food market in Ghana.

The availability of labor and crop markets encouraged farmers to expand their production by cultivating more land. Seasonal labor took advantage of the vicinity of the Brong Ahafo region to the Upper West region, the ease of transport, and the differing timings of the farming seasons. The first of two rainy seasons in the transition zone starts from about February to April, while the single rainy season in the Upper West starts in late April to May. From September to October, the intensive process of clearing the undergrowth and hoeing yam mounds begins in the transition zone and creates a major demand for hired labor. Groups of youth from the Upper West usually come south during this period, contracting themselves out as labor gangs. Many migrants from the Upper West also settled in the transition zone establishing migrant villages in unsettled areas, attracted by the availability of land and the better rainfall regimes. This movement of migrant farmers and seasonal labor and the opening of new markets encouraged the expansion of yam production and Brong Ahafo emerged as the major yam-producing zone in Ghana.

Maize Farming Under Bush Fallowing

Maize formed the major crop within areas practicing mechanized agriculture. It is also a major staple in areas beyond the zone of agricultural modernization, in particular to the south of the yam belt, on the fringes of the dry semideciduous forests where it is frequently intercropped with cassava, yam pepper, and vegetables. It is cultivated in a bush fallowing system. With the opening up of a market infrastructure and the migration of labor, many farmers expanded their areas of cultivation and were able to achieve comparable yields to those in the more northerly transition areas in which synthetic fertilizers and mechanization were being used. More intensive production was also achieved through intercopping, which maximized returns to labor invested in clearing a plot of land. Maize was harvested in the first year; cassava from between 6 months to 2 years; and the cultivation period could be further extended to over 3 years by introducing chilli pepper into the intercrop system. Most weeding activities are focus on the new plots in which maize is cultivated. Cassava is a tall plant that can compete with weeds, so after the first year the cassava plot is only selectively weeded. By the end of the second year, the tall pepper and cassava plants compete with the regenerating weeds, which offer the soil protection from the elements. By extending the period of cultivation, the land is also protected from bush fires and the regeneration of desirable tree species is facilitated (Amanor, 1996). Although higher yields could achieved for the later harvested crops by more rigorous weeding, the style of managing the land facilitates rapid regeneration of the bush, while weeding is focused on maize, the most important cash crop. This maximizes returns to labor and integrates cropping with regenerative processes. By the time the land is abandoned fallow regeneration is well established, which allows for shorter fallows. Contrary to scenarios of intensification of bush fallowing resulting in land degradation, these are examples where intensification of cultivation and more rapid recycling of land can result in sustained regeneration.

Yam Farming

Many experts predicted a decline in yam production as agricultural production became more intensive (Purseglove, 1978). This is because yams are bulky, do not store well, are vulnerable to pest and nematode attacks, and are difficult to adapt to modern input regimes. However, yam cultivation expanded during the 1970s and 1980s in Ghana and has become one of the most valuable crops, contributing more to the agricultural gross domestic product (AgGDP) than cocoa. In the early 1990s yams contributed about 16% of AgGDP, ranking second behind cassava 19%. Cocoa, the leading export crop, which receives over 45% of agricultural research funds, produced 13% of AgGDP, the same as maize, the food crop that receives most research attention from the Ministry of Food and Agriculture (Plan Consult, 1993).

This unforeseen commercialization of yam is based more on expanding acreages under cultivation through hired labor, than adoption of new intensive modern technologies to meet market demand. However, there are also elements of intensification within this increasing production, including shorter fallow periods, and the introduction of new high-yielding robust varieties of yams that have been bred by farmers, which are tolerant of shorter fallow periods and less fertile soils.

In the northern transition zone yam is produced in a system of bush fallowing with long fallows. Since the population in this area is low, land is widely available for management of long-term fallowing systems. The main constraint on production is access to labor. Yam has usually been combined with groundnut in a cropping system based on a gender division of labor. Men usually open up new land, cutting trees and creating mounds in which they plant yam. The yams are cultivated for 1 year after which the men open up new areas and the women cultivate groundnuts on the old plots. After the groundnuts are harvested, the plots are abandoned to regenerate and the women move to the next old farm.

According to farmers, in the early twentieth century, before large markets developed for yam, the dominant varieties of cultivated yam in the Brong Ahafo tranisition zone included *Dahoba*, *Lobre*, *Dongo*, *Sejo Siato*, and *Tarikoo*. These varieties are reputed to be heavy feeders, needing very rich soils in areas fallowed for about 20 years. Informants said that with the development of urban market demand for yam (around the 1940s) these varieties were displaced by *Tila*, *Lariboko*, and *Pona*, white yams that tolerate less fertile conditions. *Akaba*, a water yam with limited urban market appeal, also became popular among farmers for domestic consumption and in local rural markets in this period. During the 1990s, a number of new varieties came into vogue, including *Seidu Bile* (also known as *Matches*, since it can be planted from sets cut the size of a matchbox), *Asana*, and *Teacher Takyi*. These yams yield heavily, can be planted from smaller sets than the older yam, and are more tolerant of drier conditions and less fertile soils. However, these species have limited commercial potential, since consumers in the major urban markets still prefer *Pona* (in Accra) and *Tila* (in Kumasi). In the areas around Weila and Mansie, *Pona*, *Tila* and *Lariboko* no longer do well. Many farmers find it difficult to switch back to the old varieties because they cannot afford to purchase planting material of these more expensive yams. The changes they have introduced in their farming strategies also make it difficult to cultivate these varieties successfully. Many yam farmers now intercrop *Seidu Bile* with maize and cassava. Maize is becoming an important market crop sometimes replacing *Seidu Bile* as a cash crop. *Seidu Bile* is cultivated largely for domestic consumption.

Impact of Neoliberal Policies on Local Farming Systems

Neoliberal policies have resulted in a general crisis in farmgate prices, as local markets have to compete increasingly with the production of international agribusiness on national food markets (Buckland, 2004). In recent years, food markets in Ghana have been pressurized by the declining purchasing power of a large proportion of the urban population, the increasing importation of cheap food from international agribusiness, and the increasing cost of fuel. Increasingly food markets within Ghana are being dominated by a small number of traders who control transport and access to market places (Clarke, 1994). Urban and wholesale rural markets are often dominated by "market queens," associations of women traders who control prices and who often have important political connections.

Global pressures on the agrifood system often translates into tight production margins, as farmers are increasingly pressured to produce cheap food. Traders now range into neighboring countries to access cheap sources of foods. Thus, significant amounts of tomatoes originate from Burkina Faso and plantains from Côte d'Ivoire. The most significant effect has been in the decline of mechanized and high input maize production. This has resulted in the expansion of maize production in the boundary areas between the transition zone and dry semideciduous forest. However, the extent to which this system will continue to be sustainable as profit margins drop is uncertain. The impact of increasing commercialization on the yam farming belt has been complex and is the focus of analysis here.

Neoliberal Policies and the Yam Belt

In recent years yam production has become increasingly vulnerable to declining wholesale prices, unstable markets and production gluts. Many yam farmers complain that the prices offered by yam traders are low in comparison to the price of production. This has resulted in efforts to diversify into other crops, including maize and cassava. Thus, the increasing uptake of maize at Mansie not only reflects the decline of the mechanized synthetic input Branam-Subinso farm belt, but declining prices for yam and a general insecurity in farmgate prices. Farmers cannot freely market their produce on the main regional wholesale markets, but must sell to associations of traders at prices usually dictated by the large traders who bulk regional farm production and then sell it at a premium to the large wholesale traders from the urban markets. Only members of these market associations are allowed to sell yams within the market places. Rising costs of transport and competition from imported crops mean that successful wholesale traders need to deal in economies of scale. Traders do not go out to the villages to buy yams but force the farmers to transport yams to the main markets. Given the high cost of transport along feeder roads farmers are forced to accept the prices offered them, or incur the additional expense of transporting the yams back to their villages.

Mansie farmers use the market of Subinso. Before the introduction of structural adjustment policies, monocropped maize production was insignificant at Mansie. However, with the removal of subsidies, as Subinso farmers can no longer afford to produce maize with fertilizers, Mansie farmers have taken up maize farming to supply the demand at the Subinso market. In 2001, only 11% of Subinso farmers were still producing monocropped maize, while 17% of farmers in Mansie were now monocropping maize in a system of bush fallowing without use of synthetic inputs. However, this transforms the existing bush fallowing system, for instead of cultivating yam for 1 year, before handing on the old farm to women for groundnut cultivation, men are now extending cultivation, following yam by other crops. Men have also entered into groundnut and cassava cultivation.

Gender Division of Labor in the Yam Belt

This diversification of men into other crops has a profound effect on the gender division of labor and also on land use patterns. Women's access to farmland declines, as they can no longer cultivate the old yam farms to the extent they used to. Men now frequently divide their old farms, giving a portion to their wives. To maintain their farming livelihoods, women now have to hire labor to clear their own plots, or extend the number of years they crop the old yam farms of men. Women tend to have multiple small plots in which they extend cultivation from 1 to 2 years to about 4 to 5 years. These shifts may affect the length of time required for fallow regeneration because coppice has to be removed each year, so that by the end of the period of cultivation there are far fewer live stumps in the field than after the first cycle of clearing with yam.

At Weila, unlike Mansie, monocrop maize production has made little impact on the farming system, since it lies beyond the service areas of maize markets—only 3% of surveyed farm plots were under monocrop maize in 2001. At Weila 41% of women gained access to land through their spouses or in-laws, while only 27% did so at Mansie. At Weila 18% of women cultivated their plots for more than 2 years as compared to 29% at Mansie. Thus, the expansion of maize cultivation into the yam belt results in female farming becoming increasingly commodified as women can no longer rely on their family networks to gain access to cleared land. Whether this results in a change in the quality of land and the replacement of the thickly wooded environments favored by yam by more open environments remains to be seen.

Youth and Charcoal Production in the Yam Belt

The high densities of trees in the yam belt and cultural practices that promote the regeneration of trees suited to farming practices results in the domination of small trees that can survive cutting and fire. Trees in the transition zone are adapted to a fire-climax environment, and often have some fire resistance. These factors produce ideal qualities in the trees for sustained charcoal production, including slow burning qualities for good charcoal and the ability to regenerate rapidly when cut, so that made the northern transition zone has become the major charcoal producing area in Ghana for the expanding urban areas in the south, where 90% of the population depend upon charcoal for cooking fuel.

In the recent past charcoal production was largely carried out by specialized migrant producers who purchase rights from local chiefs to cut areas including in the fallow land of farmers. Conflicts often arose between charcoal burners and farmers, particularly when charcoal burners cut in fallow lands which farmers were allowing to regenerate for yam production. With the rise of concepts of environmental conservation during the 1980s, charcoal burning was often identified as a major cause of deforestation in narratives that ultimately derived from international policy notions of a woodfuel crisis (Leach and Mearns, 1988). Some district councils in the transition zone attempted to ban charcoal. Some farmers in the yam belt took advantage to point the blame for deforestation at charcoal burners in a bid to gain greater control over their fallow resources. This has resulted in the introduction of local byelaws in some areas that prevent the exploitation of green wood (live trees) for charcoal production. Since charcoal burners are then forced to acquire their wood from trees cut by farmers in farm clearance, this enabled farmers to gain control over their fallow and farm fuelwood resources, which they were able to exploit themselves or negotiate with charcoal burners.

Charcoal production is strenous and labor intensive and consequently an activity for the young and strong. This often leads to intergenerational conflicts as youths become increasingly financially independent and elders are unable to exploit charcoal resources or gain revenue from them. Chiefs and their councils of elders have become concerned about their inability to extract revenues from local youth engaged in charcoal burning, and have resorted to calling for bans on charcoal production claiming that it destroys the environment. However, in reality, a ban on charcoal production cannot be implemented as national policy, since the overwhelming majority of the urban population depends on charcoal for their cooking fuel.

While researchers have developed models for estimating the impact of fuelwood production on the environment, it is difficult to disentangle the impact of fuelwood resources from farming, since much fuelwood derives from farm clearing (Leach and Mearns, 1988; Cline-Cole, 1996). Farm clearance also destroys more trees than charcoal burning, since charcoal burning is based on the selective harvests of trees with good burning qualities. The high labor costs involved in charcoal production ensure that burners use quality species and trees with the required girth. If the areas of land farmed by youth decline as a result of the reallocation of their labor to charcoal burning, there is likely to be less cutting of trees rather than more. If they combine farming with charcoal burning, a significant proportion of the wood they exploit is likely to originate from the farm, or the investment of time in cutting wood is likely to result in a reduced scale of farm clearance. The value gained from charcoal also encourages young farmers to continue to cultivate yams (with their interdependence with small trees) rather than convert to maize and other crops that prefer open environments. Yam farming and charcoal burning are both dependent upon controlled regeneration through coppice regrowth. Thus, rhetoric about the impact of charcoal burning on the environment usually reflects political struggles and conflicts over the control of natural resources more than the actual ecological state of the environment.

Tree Plantations, New Investors, and Environmental Conservation

With the collapse of synthetic input agriculture and declining real wholesale food prices, aspiring commercial farmers have moved out of mechanized food production into tree plantation development. In the transition zone, the main crops being cultivated under plantations include cashew, mango, and teak. Tree plantations are considered as promising investments for export-oriented production in state developmental circles. The main constraints are in acquiring land, the initial outlay in seedlings, and in the case of timber and polewoods the problems in discounting capital for the long duration until the investment comes to fruition. The creation of plantations enables the investor to claim private ownership in much the same way as stumping and ploughing land did in the 1980s.

Plantation development concentrates land into the hands of large farmers with capital and social influence at the expense of bush fallowing cultivators. Since tree plantations are considered an activity that conserves the environment, there are also loans available for plantation development, and the Ghanaian government with the World Bank and other donors have initiated a project to support the production of locally grown timber for industry and export. This project will enable large farmers to access credits for farm expansion and the government will be able to extend credit programs to farmers, as subsidies were used in the past—once more building up patronage over a rural constituency of aspiring commercial farmers. A number of NGOs also have programs supporting the establishment of small plantations, which make loans and credits available to middle-income farmers and aspiring commercial farmers.

The Brong Ahafo transition zone has become a major focus for plantation development for the same reason it became a major focus for mechanized estate agriculture—abundance of land. The widespread occurrence of bush fires in this area is, however, a major risk. A concerted campaign has been launched in most districts against the use of fire in farming, and shifting cultivators are blamed for spreading fire and encouraging degradation. A major focus in environmental campaigns is to replace "outmoded" farming practices that are said to destroy the environment with modern agriculture, and to replace shifting agriculture with modern scientific "agroforestry" and plantations. The promotion of exotic monocultural timber plantations, such as teak, is likely, however, to *increase* the fire hazard within the transition zone. While plantations are promoted as an environmentally friendly, like mechanized agriculture they replace the natural environment with a monocrop. They disrupt the root mat within the soil and processes of fallow regeneration through coppice. Banishing bush burning will

Table I Proportional Land Use/Cover Changes in Branam State Farms—Subinso Area

	2001					
	Land use/cover	Close woodland	Open woodland	Fallow/annual farm	Bare land	Total
1984	Close woodland	0.0006	0.0097	0.0364	0.0031	0.0497
	Open woodland	0.0068	0.1374	0.2996	0.0105	0.4542
	Fallow/annual farm	0.0014	0.0855	0.3233	0.0310	0.4412
	Bare land	0.0000	0.0055	0.0369	0.0099	0.0523
	Total	0.0087	0.2382	0.6977	0.0553	1.0000

also disrupt the intricate early burning techniques and other strategies that have been adapted to the environment to minimize the impact of dry season bushfires. While bush fires are depicted as anthropogenic, they are frequently an intimate part of the transition zone ecology, and play an important role in defining the species compositions of environments that have been considerably modified by humans over a very long period.

In contrast with the main narratives that accompany modern environmentalism, there is considerable evidence that the activities of farmers in the transition zone do not lead to a downward spiral of degradation. Localized farming practices often encourage regeneration of the root and coppice mat in the soil and promote rapid regeneration of many species. However, appropriation of land by plantation owners and the uptake of plantation technology by a significant stratum of middle-income farmers could disrupt the land management strategies of small and poor farmers. Narratives about the destructiveness of bush burning and shifting cultivation serve to justify the allocation of large areas of land to plantation developers, which will disrupt the land available to farmers for systems of agriculture based on bush fallowing.

Farming Systems, Land Cover and Remote Sensing

This section uses remote sensing analysis to map out the multidirectional changes across different farming systems in relation to policy interventions, crop and varietal changes, and shifts in the factors of production and food markets.

Yam cultivation is usually associated with landscapes with high tree densities, whereas areas dominated by intensive cultivation, permanent cultivation, and tree stumping and ploughing, were associated with bare lands and grassland. Generally, where bush fallowing is practiced, there are mixtures of both low and high tree density cover mosaics occurring at different locations in different times (see Tables I, II, III, IV and V and Figs. 2, 3, 4, and 5).

In the mechanized farming zone around Branam-Subinso, there has been a rapid contraction in wooded areas. In 1984, 50% of the area was under close and open woodland. However, by 2001, less than 2% of the same area was under wooded land. From the results of the change analysis, 30% of all conversions or transformations of vegetation represented a conversion from open woodland to herbaceous fallow/annual cropland (see Table I). This represented about 45% of the total fallow/annual cropland that existed in 2001.

In contrast, in the yam belt around Mansie, about 70% of the area was under open woodland in 1984. In 2001, 50% of the area was still under open woodland. Of the total open woodland that occurred in the area, 73% was retained from 1984. However, 20% of the open woodland in 2001 consisted of grassland fallow in 1984 that had regenerated into woody vegetation (Figs. 2 and 3 and Table II).

The yam belt itself is also significantly differentiated. At Weila, in 1984, woody vegetation only constituted 30% of the sampled area, which was much lower than at Mansie. In 2001, however, there had been an increase and the

Table II Proportional Land Use/Cover Changes in the Weila Yam Belt

	2001					
	Land use/cover	Close woodland	Open woodland	Fallow/annual farm	Bare land	Total
1984	Close woodland	0.0034	0.0080	0.0085	0.0001	0.0199
	Open woodland	0.0299	0.1562	0.0924	0.0018	0.2802
	Fallow /annual farm	0.0474	2049	0.3602	0.0136	0.6261
	Bare land	0.0034	0117	0.0531	0.0036	0.0718
	Total	0.0842	3815	0.5151	0.0192	0.0000

Table III Proportional Land Use/Cover Changes in Mansie Yam Belt

	2001					
	Land use/cover	Close woodland	Open woodland	Fallow/annual farm	Bare land	Total
1984	Close woodland	0.0012	0.0153	0.0073	0.0000	0.0238
	Open woodland	0.0182	0.3648	0.3130	0.0018	0.6978
	Fallow/annual farm	0.0022	0.1061	0.1420	0.0038	0.2541
	Bare land	0.0000	0.0035	0.0092	0.0077	0.0204
	Total	0. 0217	0. 4924	0.4725	0.0134	1.0000

total woody vegetation was now comparable to Mansie (Tables II and III). It is difficult to explain the appreciable difference in the woody vegetation that existed in Mansie and Weila in 1984. It may have been the result of recent of bushfires, or of earlier histories of cultivation—Weila was the site of failed attempts to promote cotton cultivation in the 1960s.

The practice of preserving the root and soil mat and stumps in the yam belt encourages the regeneration of trees, allowing for gains in woody vegetation. This contrasts with the mechanized ploughing belt where, despite the abandonment of state farms and the decline of mechanized cultivation and synthetic inputs since the 1980s, regeneration of woody vegetation is slow. There is a significant preservation and recuperation of woody environments within the yam farming area. However, there are also some areas in Mansie where there is conversion from woodier fallows to grassy fallows between 1984 and 2001 (Figs. 2 and 3). This may be a product of certain types of farming and commercial pressures, such as the adoption of monocultural maize production as a follow-on crop to yam.

In the southern part of the Wenchi district, in areas that lie on the boundaries of dry semideciduous forests, similar differences can be found between intensive mechanized cultivation and bush fallowing systems. In Kokoago and the Wenchi State Farm area, more than 95% of the land was characterized by grassy fallows or annual crops and only 5% lay under fallow. By 2000, there had been an increase in woody vegetation, perhaps related to the development of teak plantations in the area. However, a large proportion of the land still lay under grassy fallows or annual farms. More than 95% of the grassy fallows that existed in 2000 had remained unchanged since 1984, indicating very little regeneration of woody vegetation (see Table IV). In contrast with the Branam State Farms area, farmers continued to use intensive mechanized technologies for maize and tomato cultivation, which results in the suppression of tree regeneration.

To the west of Wenchi, in the Badu area, farmers cultivate maize using bush fallowing technologies without synthetic inputs. In 1984, 85% of the land was covered with grassy fallow or annual crops, only 8% was open woodland. By 2000, 30% of the land had regenerated into open woodland, representing a dramatic increase. Some 83% of the open woodland that had regenerated in 2000 was transformed from grassy fallows and annual farms in 1984.

Farmers in the Badu area suggest that in recent years *Chromolaena odorata* (an exotic herbaceous shrub) has been colonizing fallow land in the area, replacing grass. This has resulted in the decline of bush fires, and has promoted regeneration of forest species. As indicated above, many farmers have developed techniques of extended cultivation, which promotes rapid fallow regeneration. Extended management results in fire being kept out, creating favorable conditions for woody regeneration. Although the trees are cleared when farmers return to farm the area, high densities of stumps, coppice and roots are preserved in the soil creating conditions for the continued regeneration of secondary forest species.

A significant area within the Badu area has also remained unchanged between the two dates, retaining a

Table IV Proportional Land Use/Cover Change in Wenchi-Kokoago Area

	2000					
	Land use/cover	Close woodland	Open woodland	Fallow/annual farm	Bare land	Total
1984	Close woodland	0.0003	0.0009	0.0005	0.0003	0.0020
	Open woodland	0.0007	0.0235	0.0196	0.0016	0.0454
	Fallow/annual farm	0.0058	0.0788	0.4582	0.1472	0.6901
	Bare land	0.0003	0.0066	0.1493	0.1064	0.2626
	Total	0.0070	0.1099	0.6276	0.2554	1.0000

Table V Proportional Land Use/Cover Change in Fallow Farmlands in the Badu Areas

	2000					
	Land use/cover	Close woodland	Open woodland	Fallow/annual farm	Bare land	Total
1984	Close woodland	0.0036	0.0061	0.0055	0.0008	0.0160
	Open woodland	0.0042	0.0402	0.0357	0.0056	0.0856
	Fallow/annual farm	0.0533	0.2500	0.4459	0.1045	0.8537
	Bare land	0.0016	0.0066	0236	0.0128	0.0447
	Total	0.0628	0.3029	0.5107	0.1236	1.0000

grassy fallow cover. This indicates another set of factors at play. The Badu area is characterized by mosaics of semideciduous woodland interspersed with natural mosaics dominated by elephant grass (*Andropogon* spp.). Many migrant farmers from the northern savannas have acquired land on these grass mosaics, where they use a savanna style of farming. It is also possible that intensive maize cultivation, coupled with land shortages and short fallows in some localities, could also result in an increasing grassy environment. The trajectories of change are often complex, involving different movements in the same area, which reflect differences in microecologies, and different adaptive strategies and socioeconomic circumstances.

The satellite data were of limited use in discerning plantations because they are young and small-scale at present, even if the harbinger of important future shifts in the differentiated agricultural landscape and social dynamics. Attempts to examine such developments in more established cashew plantation areas such as Sampa and Banda were thwarted by cloud cover in the images and difficulties of differentiating the plantations from shrubby vegetation. However, further remote sensing research in these areas should help in the development of indicators.

While the present classification system clearly picks out the differences between the mechanized farming belt and bush fallowing, it is less successful in differentiating between localized farming systems and practice. Although the resolution of Landsat cannot pick out different cropping systems, techniques can be found to differentiate the spectral characteristics of different types of farming sys-

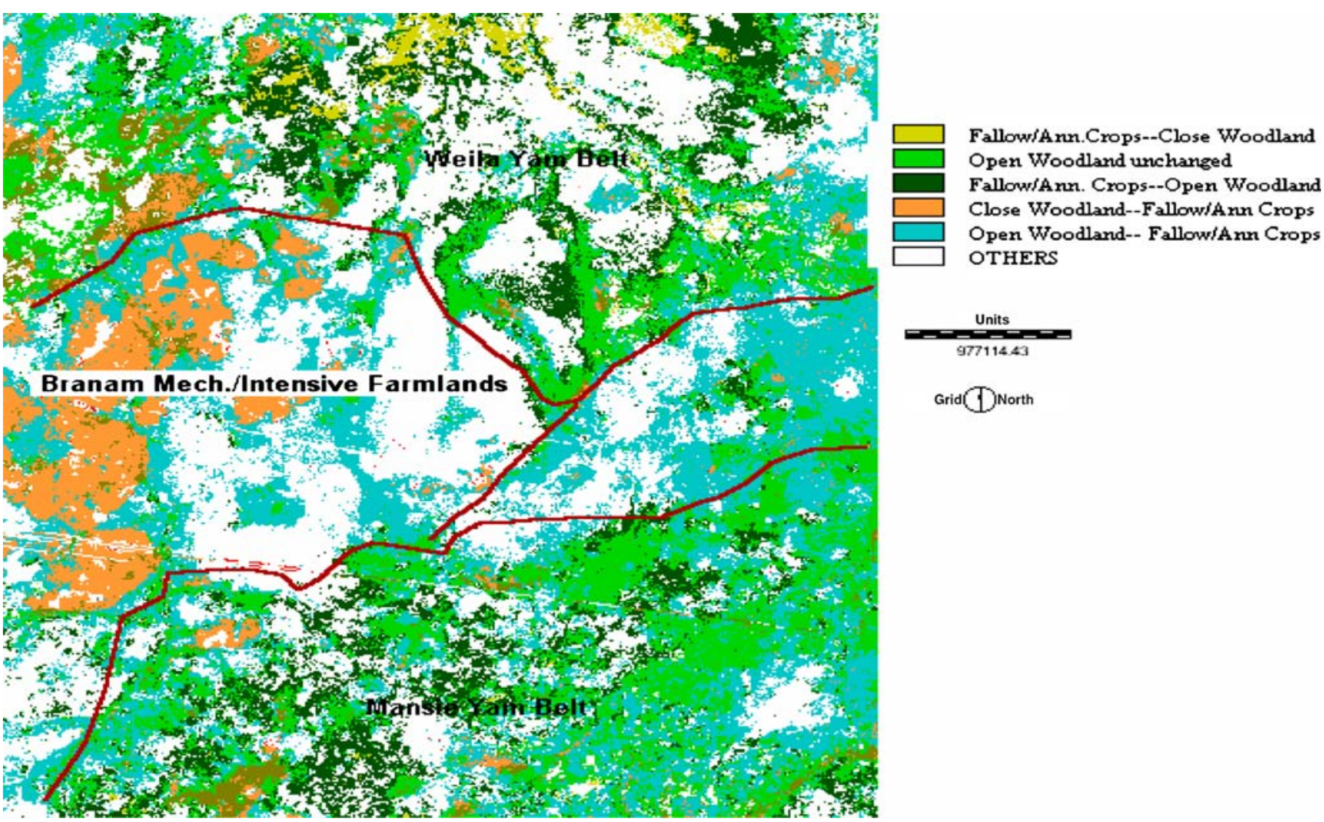


Fig. 2 Land use/cover change in the Branam, Weila and Mansie area (1984–2000).

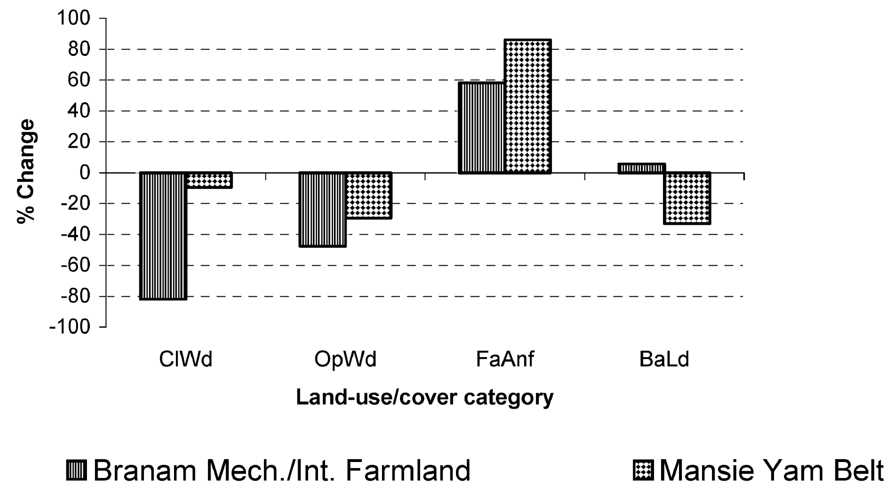


Fig. 3 Land use/cover change in the Branam and Mansie Area in 2001 as a percentage of what existed in 1984.

Clwd = Close woodland OpWD = Open woodland FaAnf = Fallow or annual farm BaLd= Bare land

tems. It should be possible to develop new systems of classification that differentiate between broad types of cropping systems, such as yam, with its association with trees, and annual crops planted in more open environments. It is also necessary to develop techniques to differentiate different stages of fallow regeneration, so that patterns of regeneration of cultivated plots back into woodland or their conversion into other types of vegetation can be discerned.

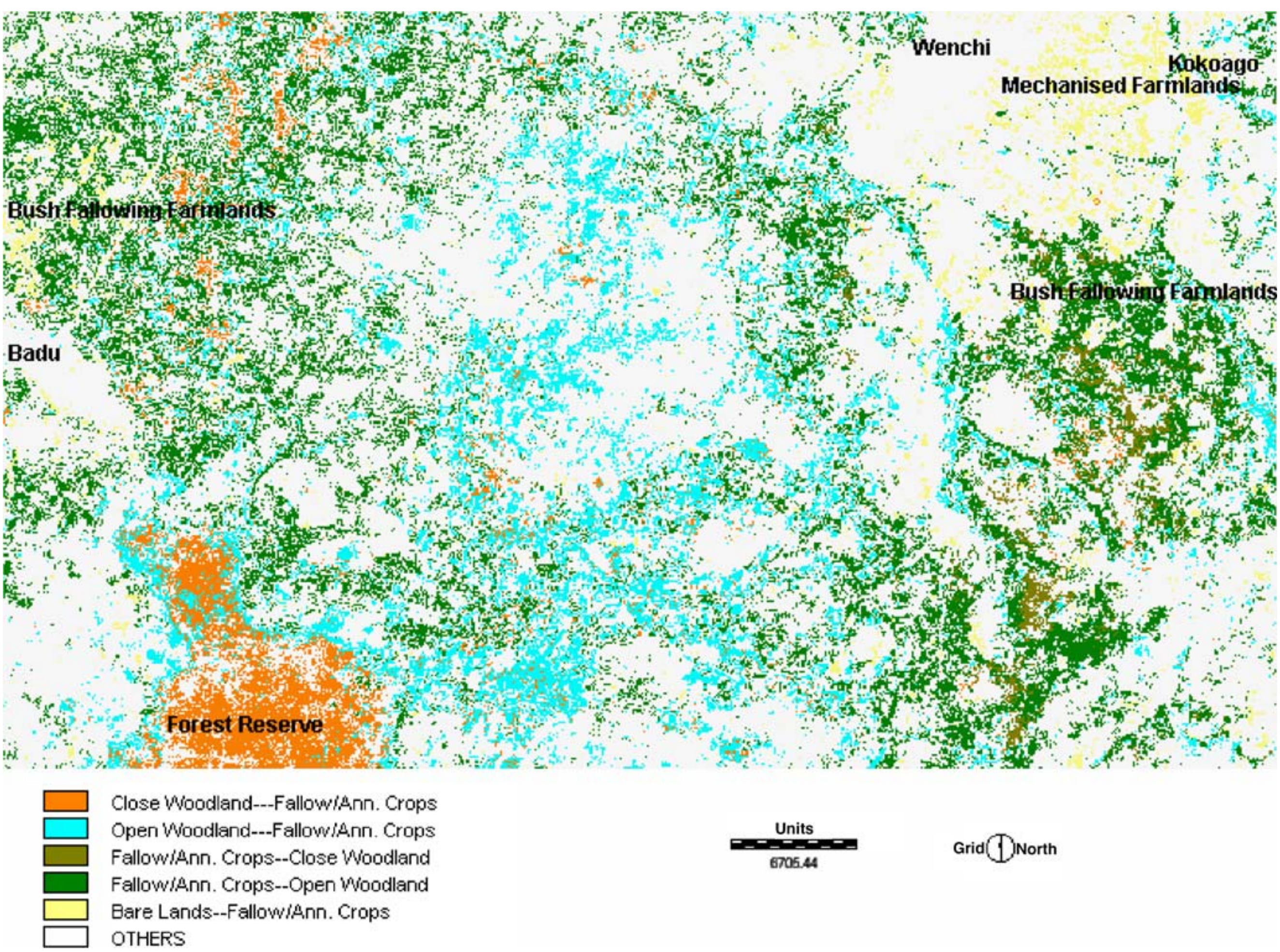
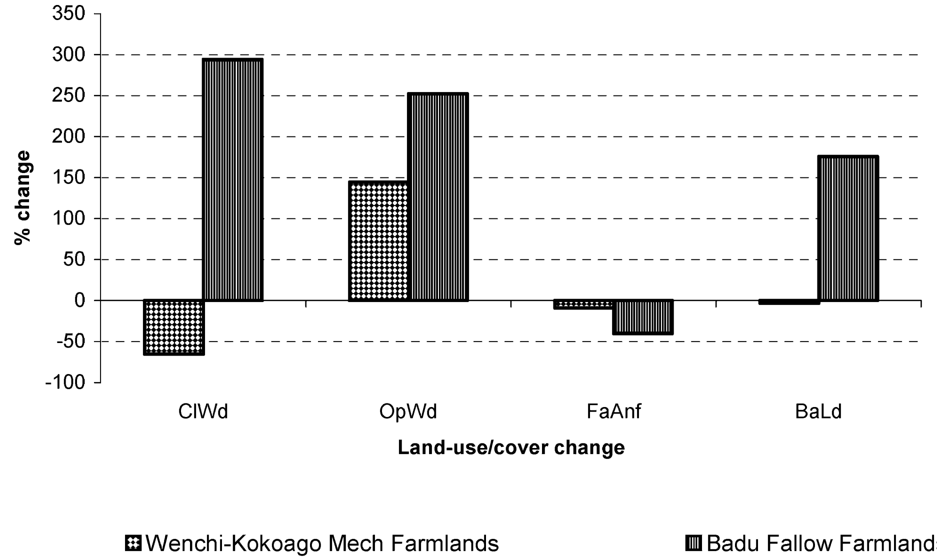


Fig. 4 Land use/cover change (1984–2000) in the Kokoago and Badu Area.

Fig. 5 Land use/cover change in the Wenchi-Kokoago and Badu areas in 2001 as a percentage of what existed in 1984.



Clwd = Close woodland OpWD = Open woodland FaAnf = Fallow or annual farm
BaLd= Bare land

This will require analysis of a larger number of time series of images to enable cycles of cultivation and regeneration and recycling of land to be observed.

The analysis of change is affected by the resolution and extent of data used in analysis (Saura and Millan, 2001; Lam and Quattrochi, 1992). Perceptions of change can vary with the scale of analysis, the definition of the units of analysis, and spatial aggregation (Kummer and Sham, 1994). The definition of appropriate spatial units needs to establish correspondence between biophysical, socioeconomic, and political factors. This needs to take into account the social institutions involved in policy and political administration, the modes of landscape transformation, and the scale of ecological processes. Methodologies for investigating land use and land cover change have rarely dealt with the spatial aspects of socioeconomic processes (Irwin and Geoghegan, 2001).

Conclusion

Collaboration between anthropological research within a regional economies perspective and remote sensing can be useful in providing a framework for analyzing the dynamics of localized patterns of change. These include changing boundaries of farming systems that result from commercial pressures and the development of markets, production technologies and transport infrastructures. Remote sensing can spectrally identify patterns of change described by social science and map out the temporal–spatial dimensions of these changes, as well as identify patterns of temporal–spatial change to be explained by social science analysis. In the present exercise, remote sensing has been useful in delimiting the extent of the state-sponsored mechanized and synthetic input agricultural belts in Brong Ahafo, their influences on the existing farming systems, and the contrasting impacts of bush fallowing and mechanized cultivation on the environments of the transition zone.

Environmental crisis narratives do not reflect the state of the environment within the transition zone as we see it from anthropological and remote sensing evidence. Their main role seems rather to justify external intervention in shaping farming practices (Leach and Mearns 1996), and redistributing land from those defined as environmental destroyers to practitioners of “sustainable agriculture.” This may result in a new coalition of elite farmers with links to global markets coming to prominence and displacing the existing peasantries.

This detailed study of agricultural change within the transition zone in Brong Ahafo has shown that there have been three main elements in agricultural modernization:

1. The development of technologies of mechanized agriculture with synthetic inputs
2. The opening up of an infrastructure of development reflected in transport, markets, extension and other agricultural services
3. The development of an administration and policy prescriptions with interfaces to global policy centers, markets, and different socioeconomic groups through networks and patronage

Of these, perhaps the least successful has been the technological interventions. Mechanized agriculture has been highly experimental and without precedence before the 1950s. The major challenge was to adapt technologies developed in very different temperate ecologies to the fragile soil base of the transition zone. Mechanized agriculture only continued to exist commercially through state support and subsidies. However, subsidies became so controversial that mechanized high input cultivation was effectively closed down in the 1980s. The expansion of the technical base of mechanized synthetic input agriculture is perhaps much more modest than is often portrayed in the literature on agricultural modernization and limited to small pockets. However, agricultural modernization also had indirect impacts on regional economies, resulting in the development of infrastructures of administration, transport, and markets, which have often facilitated the opening up of new frontier areas to markets and the expansion of local agricultural practice and innovation. This has resulted in forms of local agricultural development which incorporate both elements of intensification and extensification, involving new cropping systems, new varieties, expansion of area cropped through hired labor, and specialized production for specific markets. This often involves the development of hybrid farming systems, which combine elements of agriculture from diverse sources, but often retain specific forms of adaptation to agroecological conditions. Many of the systems that can be labelled under the rubric of shifting cultivation are not traditional static forms of agriculture. They have been transformed by responses to commercialization and commodification. While the yam belt retains the semblances of shifting agriculture and preservation of many small trees, it is becoming increasingly differentiated and subject to competition and conflicts, including:

- Between men and women over crop specialization, crop mixes, land allocation, and commodification of labor and crops
- Between youth and elders over alternative livelihoods based on charcoal and the attempts of elders to control land, natural resources, and labor
- Between bush fallow farmers and plantation developers over the appropriation of fallow land by plantation developers, use of fire, and other land management practices

All these developments signify considerable change. Many of the responses of farmers are also conditioned by policy dimensions, which can have positive, negative, and unintended impacts. The fortunes of mechanized agriculture have been partially determined by debates about the role of the state in production, the nature of state support services for agriculture, and the role of subsidies. Nevertheless, the infrastructure created for the functioning of state sponsored agricultural modernization may have had positive and unintended effects on local farming systems. The decline of state patronage in agriculture may have created new potential markets for local farming systems that have resisted use of synthetic inputs. However, the increasing liberalization of agricultural markets and food imports have also created complex pressures on pricing structures, production gluts, farmgate prices, and general security in regional economies. Increasingly, food markets are influenced by international agribusiness (Buckland, 2004; McMichael, 2000, Watts, 1994; Goodman and Redclift, 1991). Marketing and production infrastructures and administrative institutions are increasingly formulated for the penetration of global agribusiness investment and production, as seen in the nascent plantation sector.

There is a need to go beyond the rhetoric of agricultural modernization with its aims of displacing farming systems that do not conform to its logic. There is also a need to go beyond the defence of local farming systems by agricultural populism and the search for isolated success stories or examples of best practice. This can be achieved by developing research that attempts to understand the dynamics of food systems in regional economies. The challenge for research is to make sense of the spatial and temporal dimensions of changing landscapes and changing patterns of land use and adaptation, while understanding the ways in which political factors, commodification, and accumulation mediate both popular/cultural and science-based understandings of the environment, natural resources, and livelihoods at international, national, regional, and local levels.

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