GHANA
Strategy Support Program

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
IFPRI
Supported by the CGIAR

WORKING PAPER 43 | April 2016

Development of Agricultural Mechanization in Ghana: Network, Actors, and Institutions

A case study of Ejura-Sekyedumase district

Frances Cossar, Nazaire Houssou, and Collins Asante-Addo

April 2016

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF TEXT BOXES

ABSTRACT

This paper characterizes the network of tractor service providers in Ghana. Using the case of Ejura-Sekyedumase district, this research examines the implications of the adoption of mechanical technology in agriculture for farmers and institutions based on perspectives that go beyond the suppliers and users of mechanization services alone. The results suggest that, in addition to rising population density and favorable access to local and regional markets, the current pattern of use of tractors by farmers in Ejura district emerged from favorable historical and institutional factors. The current arrangement involving a network of private tractor owners providing tractor hire services to a broad set of farmers draws upon the legacy of an earlier institutional intervention and is sustained organizationally through kinship and other existing social relationships within and outside the district. Moreover, the expansion of tractor use has created a set of new roles and relationships within the network. Participation in the network is affected by various factors, including farmer's access to capital and knowledge, experience, and contacts. This privately operated network is significantly more efficient and provides small-scale farmers with considerably better access to plowing service than did previous government-managed systems. Further development of the tractor service sector is likely to improve the quality of mechanization offered to smallholder farmers, enhance bargaining power for farmers seeking such services, and reduce structural weaknesses within the network.

1. INTRODUCTION

A reemergence of public interventions in agricultural mechanization in Africa south of the Sahara has reignited policy debates over the role that governments can play in the adoption of mechanization in the sub-region. In Ghana, both government and the private sector for decades have been involved separately in the importation and supply of tractors to farmers. With the increasing use of mechanical power in the country, new forms of interactions are expected to emerge between farmers, the private sector, and government in the supply of mechanization services.

The interactions between mechanical technology in farming and the structure of Ghana's agriculture will have different implications for different participants in agriculture in the country. Access to a tractor provides benefits to the owner, but the benefits of tractor use spill over into their communities as owners provide plowing and other tractor services to farmers who may not be able to afford a tractor of their own. Several factors contribute to the patterns of local adoption of agricultural mechanization, including local institutional histories in an area; the evolution of farming systems, and economy-wide relationships (Boserup 1965; Ruthenberg 1980; Lewis 1996). Lewis (1996) describes a network of transactions linking the tractor owner and the people he employs to the farmer end-user through a number of technological roles. This network typically includes several intermediaries, such as brokers, mechanics, and others linked with the operation and maintenance of a tractor.

This paper characterizes the network of supply of agricultural mechanization services in the case of Ejura-Sekyedumase district in Ashanti region of central Ghana, analyzing the social and commercial relationships which emerge as tractors and other mechanical tools are introduced into the farming systems of rural communities. The paper examines the implications of the adoption in farming of mechanical technology for local individuals and institutions based on perspectives that go beyond the suppliers and users of mechanization services alone. This case study aims at improving our understanding of the factors affecting participation in the supply networks of agricultural mechanization services, access to the machinery, the cost of transactions in these networks, and the power relations among network participants.

The remainder of the paper is organized as follows. Section 2 presents the conceptual framework, whereas Section 3 set out the case study methodology. Section 4 examines the conditions that may have led to the adoption of mechanization in the district. Section 5 analyzes the relationships which have emerged between actors, including the roles of key players linked with the supply of and demand for mechanization services in the district. Section 6 provides our concluding remarks.

2. CONCEPTUAL FRAMEWORK

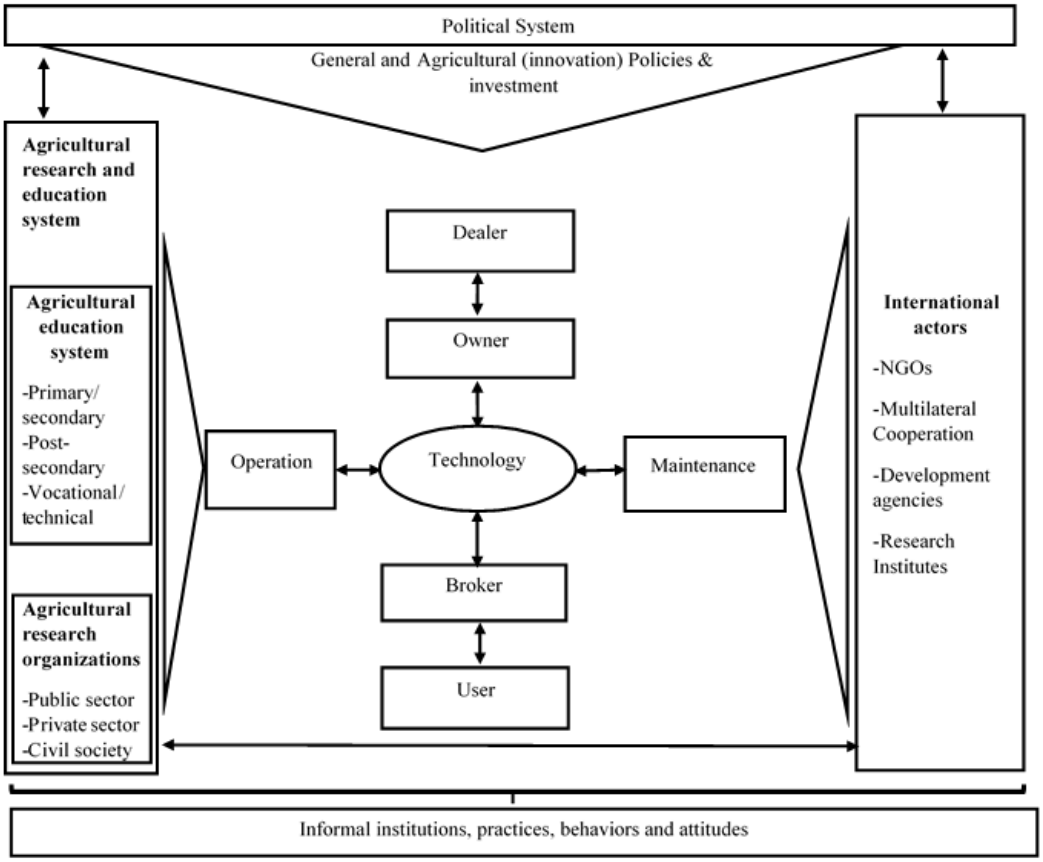
Field interviews in the Ejura-Sekyedumase district (referred to hereafter as Ejura) reveal the many roles associated with the use of tractors in farming and how these roles are linked by different types of transactions. To better understand the network of supply of agricultural mechanization services in the district, we adopted the "innovation systems" framework to analyze and disentangle these roles. Esparcia (2014) defines an innovation system as a "group of elements which, by themselves and via mutual interactions, have an effect on the introduction, the adoption, and the development of different types of innovation at a given spatial scale (local, regional, national, or international)." "Innovation" is any new or existing knowledge introduced into and used in an economically or socially-relevant process (OECD 1999). In our case study, the term means the adoption of a tractor in farming in Ejura district, which is an existing innovation used solely for economic purposes.

In applying the framework to our case study, we consider the adoption of agricultural mechanization (especially tractor use) as a social process situated within an array of networks involving various actors ranging from the dealer who sells the tractor to the owner or the tractor user. The owner, who is usually a farmer, can use the tractor on his or her farm only, rent it out to other farmers, or combine own use with hiring services. When an owner hires out the tractor, the fixed cost is spread and shared with tractor hirers, while an owner who uses the tractor only on his or her own farm bears all the financial costs and risks involved with tractor ownership alone. Because several farmers may rent a tractor from the same owner, these farmers are interconnected, thus forming a network based on formal or informal contractual relationships.

The owner-user relationship is the basis for professional and collaborative networks within which tractor-use diffusion and technology transfer occur. In addition, an owner may hire a driver or an assistant to operate the tractor. This can occur based on kinship or skills, such as driving experience, which guarantee entry into the network. Likewise, without the mechanics who maintain and repair tractors, the diffusion of the use of the machine would be seriously challenged. The hierarchal nature of the relationships between the dealer, owner, operator, mechanic, user, and, in some instances, brokers determines how the adoption of mechanization in agriculture in central Ghana through the use of tractors for farm operations proceeds.

Since the innovation of tractor use is not an isolated initiative, but forms a part of a wider national processes of economic and social development (Ward and Brown 2009), the framework also includes the conditions and institutions that may promote or hinder innovation (tractor use), such as public policies on innovation and agriculture, agricultural research and education systems, informal institutions, and the behaviors, practices, and attitudes which determine the way individuals and organizations act and interact (Spielman and Birner 2008). This network of actors, institutions, policy frameworks, and social norms making up the innovation system for an agricultural technology, such as agricultural mechanization, is portrayed conceptually in Figure 1.

Figure 1—General view of agricultural innovation system for technology



Source: Adapted from Lewis (1996) and Spielman and Birner (2008)

3. METHODOLOGY

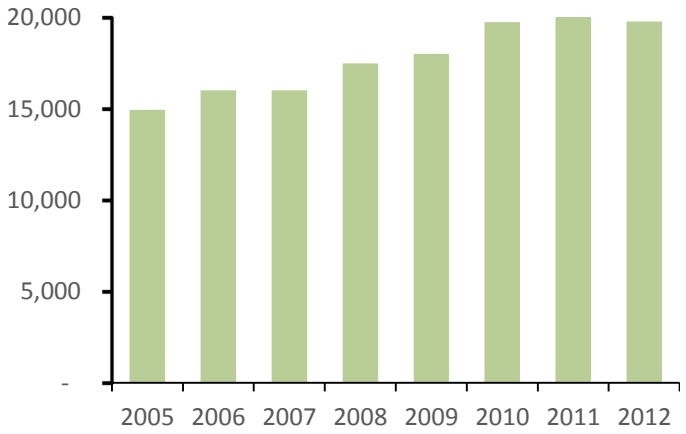
This case study was conducted in Ejura district which is located in the Ashanti Region of Ghana. We used a combination of qualitative interviews, literature review, and survey data to examine local farming systems and the institutional histories in the district and to identify the main actors and their respective roles in the supply of and demand for agricultural mechanization services. We conducted 16 interviews and two focus group discussions with farmers, tractor dealers, owners, operators, and other key stakeholders in the district in July 2013. Information gathered from these interviews was supplemented with existing studies on mechanization and data from a survey on tractor ownership conducted by IFPRI and the Savannah Agricultural Research Institute (SARI) between October and December 2013. This survey covered nearly all tractor owners in the district. (See Chapoto et al. 2014 for further details on the survey.)

Following the conceptual framework described earlier and Lewis (1996), we use the agricultural mechanization network as our unit of analysis in order to identify the actors in the network and their functional roles with respect to tractor use. However, our focus is on the inner cycle of the framework; that is the direct actors involved in the supply and use of tractors in the district, since our data captured only limited information on the influence of institutions and other conditions that may promote or hinder tractor use. The network approach is useful for the study of structural patterns of social relationships and for the identification and analysis of networks within and between organizations (Knoke and Yang 2007, 2008; Scott 1987). Lewis (1996) highlights that the network approach can demonstrate the limits of individual opportunity within networks without isolating people from the broader connections and structures of which they form a part.

4. AGRICULTURE IN EJURA-SEKYEDUMASE DISTRICT

Agriculture is the most important provider of employment in Ejura district (Government of Ghana 2014). Consequently, the district offers an excellent case to study in order to better understand the linkages and dynamics which have supported the development of a mechanization service market in the district. In 2012, there were 127 tractor owners in the district. With favorable agro-ecological conditions and a bi-modal rainfall pattern, Ejura district has become an important maize-growing area, with the crop accounting for 41 percent of cropped area in 2012[1]. The maize area in the district increased from 14,952 ha in 2005 to 19,800 ha in 2012 (Figure 2).

Figure 2—Area under maize production in Ejura-Sekyedumase district, 2005 to 2012, ha



Source: Statistics, Research and Information Directorate, MOFA 2013.

In part due to its agricultural potential, population density in the district has risen steadily. Ashanti is the most populous region of Ghana. The region contains over 20 percent of Ghana's population and has a population density of about 200 persons/km^2 (GSS 2012). Between 1984 and 2010, the population density in Ejura district increased from 58 persons/km^2 to 65 persons/km^2, with 50 percent of the district's residents living in urban areas (GSS 1984 2010) (Table 1). Urban population growth in the last 20 years has been considerable: Kumasi's population increased from 376,000 in 1984[2] to 2,035,000 in 2010[3].

Increasing population density has implications for the development of mechanization and agricultural intensification for two reasons. First, the growing local population in the district and the region provides an expanding urban market of net consumers of agricultural outputs. In addition to population growth, urbanization, especially around the regional capital of Kumasi, has increased the demand for agricultural products, whereas agricultural labor has become limited due to increasing local employment opportunities outside of agriculture. Only 44 percent of the workforce in the Ashanti region is engaged in agriculture, which is lower than most other regions in Ghana (Ghana, Ministry of Food and Agriculture 2011). Kumasi city is 95 km by tarmac road from Ejura-Sekyedumase district capital.

Second, population density growth will create pressure to intensify agricultural production. As discussed by Boserup (1965), Ruthenberg (1980), and other scholars, under increasing population density, farming systems move from forest and bush fallow to short fallow or annual cultivation with increasing use of modern inputs such as chemicals, mechanization, seeds, among others. For Ghana, evidence suggests that intensification of land use was underway by 1996 with over 33 percent of agricultural lands under annual cultivation (Diao et al. 2014). For the case of Ejura, Codjoe and Bilsborrow (2011) report that intensification of input use, such as fertilizer,

[1] Statistics, Research, and Information Directorate (MOFA). Total area includes rice, cassava, yam, cocoyam, plantain, groundnut, and cowpea.

[2] http://www.econ.brown.edu/faculty/henderson/ - See World Cities Database

[3] Millennium Cities Initiative

hired labor, and improved seeds, were more prevalent in the district than in districts in northern Ghana. In addition, the authors found that 52 percent of the 991 farmers they surveyed in the district reported having cultivated new lands in the previous five years, suggesting that both processes of intensification and land expansion were at play in the district.

Table 1—Regional population density, persons per sq. km

	1984	2000	2010
Greater Accra	396	789	823
Ashanti	122	151	164
Ejura-Sekyedumase district	*58*	*60*	*65*
Upper East	72	105	122
Volta	60	80	96
Western	47	80	57
Brong Ahafo	30	46	53
Upper West	24	32	30
Northern	16	25	34

Source: Ghana Population and Housing Census (GSS 1984, GSS 2000, & GSS 2010)

5. TOWARDS A CHARACTERIZATION OF THE AGRICULTURAL MECHANIZATION NETWORK IN EJURA-SEKYEDUMASE DISTRICT

This section discusses the context within which a tractor network has developed in Ejura district, particularly the institutional history of the area, the actors in the network, and their roles.

Institutional History and Technology Choice

The origin of the use of tractors in farming in the district can be traced back to the era of Ejura Farms, which was established in 1969 through a joint venture of the government of Ghana and an American investor. The company focused on large-scale maize, soybean, yam, and cassava production, developing over 14,000 acres of farmland on which was used mechanized production technology with up to 50 tractors and combine harvesters. Upgrading of the downstream supply chain for maize in the area was done through a large maize processing and storage facility, which is still used by some local farmers. Ejura Farms went into decline starting in the 1980s, and the company's farmlands were given to farmers and remaining workers. In 2010, about 20 tractors and other machines were auctioned off by Ejura Farms to private buyers.

The rise and fall of Ejura Farms generated considerable technology spillover effects in the district, including knowledge of modern mechanized production techniques and the development of support industries, such as tractor mechanics and tractor dealers. The experience of Ejura Farms demonstrated to farmers in the area the possibilities of using tractors and to entrepreneurs in the area the potential benefits of investing in tractors. In 2012, there were several tractor importers and dealers in the regional district capital, Kumasi, and seven tractor dealers in Ejura district alone. At the same time, the processing and marketing of maize also improved not just around Ejura Farms, but for all maize farmers in the area. Although these spillovers have not been quantified, the district is known for its specialization in maize production and use of modern technology in doing so. In 1983, a survey of 33 villages across the forest (31 villages) and savannah (2 villages) zones of Ashanti region found that machinery use was concentrated in those villages located in Ejura district (Hine et al. 1983). For example, Dromankuma village in Ejura district accounted for 65 percent of machinery used by survey farmers. Similarly, Blarel et al. (1992) commented that in the early-1990s many operations in Ejura were tractorized, unlike in other regions of Ghana.

Furthermore, knowledge spillovers continues today as most current tractor owners stated that they hired-in tractor services for several years before venturing into owning tractors. The 2013 IFPRI-SARI survey found that 88 percent of tractor owners in Ejura (127 tractor owners) previously had rented-in tractor services for up to

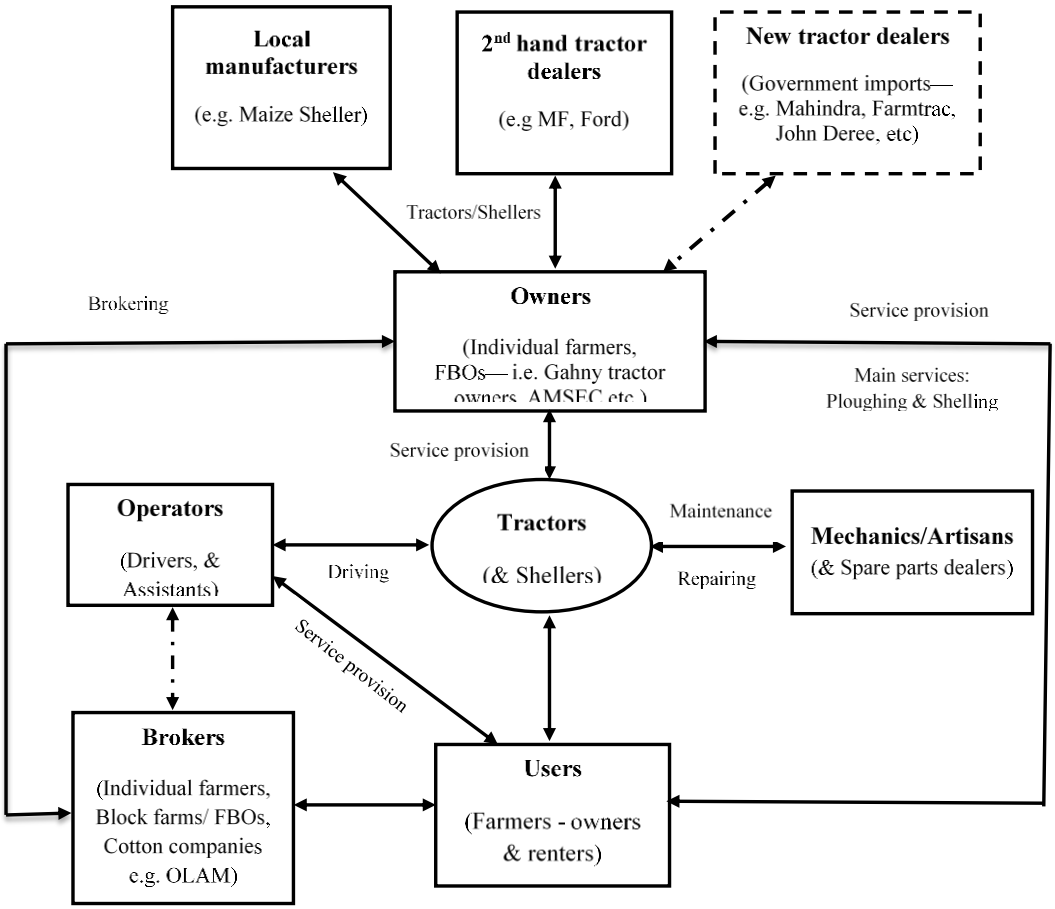
9 years before purchasing their own tractors (IFPRI-SARI 2013). Participation in the tractor service market enabled farmers to build their knowledge about tractors, their use, and their benefits before investing in the machines themselves.

The adoption and widespread use of tractors in the district would not have materialized if there were no need or markets for tractor operations in local farming systems. With the evolution of farming systems from subsistence toward commercial and semi-commercial production, labor needs have increased and labor costs have risen due to rural-urban migration and economy-wide labor constraints (Diao et al. 2014). Consequently, tractor-based mechanization has become a commercially attractive venture for owners who wish to plow on time and for users who find it cheaper to hire tractor services than to use manual plowing.

Actors in the Tractor Network

Tractor use for plowing (and shelling) in Ejura district is made up of a network involving dealers; owners, who are mainly farmers; operators; mechanics and artisans; and farmer end-users. Here we discuss the role of each actor and their relations using the network concept (Figure 3).

Figure 3—Conceptual diagram of the tractor service provision network in Ejura-Sekyedumase district



[Box = actors, Oval = equipment, Solid arrows = activities or strong ties, Dotted lines = weak ties]

Source: Ejura case study (2013)

TRACTOR DEALERS

Ejura has experienced significant growth in business activity in recent years. As a result of this development, there is a market for the supply of tractors. Tractor dealership in the district is dominated by the private sector, which imports largely used (second-hand) tractors. New tractors, on the other hand, are supplied by government through the Ministry of Food and Agriculture. Private tractor dealers in Ejura also draw customers from across the

northern regions of Ghana. Dealers in Ejura reported selling between 8 and 16 tractors per year. For farmers looking to invest in machinery, second-hand tractors are more affordable in terms of the capital required and the cost of maintenance. There is little formal credit available to assist farmers with their machinery purchases, although some private dealers sell on credit in some cases. In those cases, the documents specifying ownership is transferred to the purchaser only after the final payment is made for the tractor. Even when government-subsidized tractors are available, most farmers prefer to purchase used Massey Fergusson (MF) and Ford tractors. In one case, a farmer acquired a John Deere tractor through the Government, but sold it after two years in order to buy an MF tractor because spare parts for the tractor are more readily available. Most tractor dealers in the district are connected with people abroad (mostly relatives and friends) who are involved in obtaining and shipping these used tractors to Ghana.

In terms of their experience, tractor dealers often will have either previously operated a car shop or a tractor. For example, Mr. Mills, a tractor dealer, worked as a tractor operator (driver) for 25 years. Through this work, he discovered the market potential for the supply of tractors in the area. He then linked up with a friend abroad who shipped these tractors to Tema port in the Greater Accra region. For the transport of each tractor from Tema to Ejura, he pays 500 GHc. It usually takes about one month to bring the tractors to Ejura. He sells only second-hand MF tractors because, according to him, farmers prefer second-hand MF tractors over new tractors as they are cheaper and their spare parts are easily available. He can sells 8 or 9 tractors in a year, most just before the plowing season, with customers coming from Ejura and other regions of Ghana (Brong-Ahafo, Volta, and Northern). Once the tractors are sold, he sends funds to his friend overseas to obtain a new consignment. He does not sell implements or spare parts, but will obtain them for his customers upon request. He does not provide any credit – farmers have to pay 100 percent of the tractor price upfront. He indicates that new dealers are emerging as they observe how the local tractor market is booming.

TRACTOR OWNERS

Ejura district has among the higher number of tractors relative to other districts in the country, with the surge in tractor numbers occurring primarily since 2009. On an area basis, Ejura has the highest density of tractors of any district in Ghana (Table 2). The district is also among the most mechanized both in absolute terms and as a proportion of medium and large-scale farmers, i.e., 57 percent of medium and large-scale farmers own at least one tractor (IFPRI/SARI 2013). The increasing tractor numbers in Ejura has been accompanied by a rise in the number of tractor dealers and a significant increase in tractor ownership. The IFPRI-SARI survey data shows that 71 percent of tractors in Ejura were acquired since 2008. Most tractor owners in the district are migrant farmers who came from northern Ghana some decades ago, settling in Ejura.

Table 2—Tractor use in sampled districts in Ghana

District	Weighted percentage of farmers			Number of tractors	% of tractors owned by medium- and large-scale farmers
	Small (<12 ha)	Medium (12-60 ha)	Large (>60 ha)		
Gushiegu	85.4	13.2	1.5	178	38.0
Ejura-Sekyedumase	**90.1**	**9.6**	**0.3**	**172**	**57.5**
Yendi	94.5	5.0	0.5	180	49.2
Sissala East	88.9	10.7	0.4	85	35.1
Kintampo North	93.4	6.4	0.2	50	72.7
Bawku Municipal	98.1	1.8	0.0	13	55.6
Techiman	94.8	5.1	0.1	6	0.0
Kassena Nankana East	98.5	1.4	0.1	27	54.6

Source: USAID/ADVANCE census (2013), IFPRI/SARI survey data (2013).

Discussions with farming communities revealed that farmers decide to purchase a tractor when they want to expand their farm size. The decision to invest in a tractor depends both on the benefit to own farm production

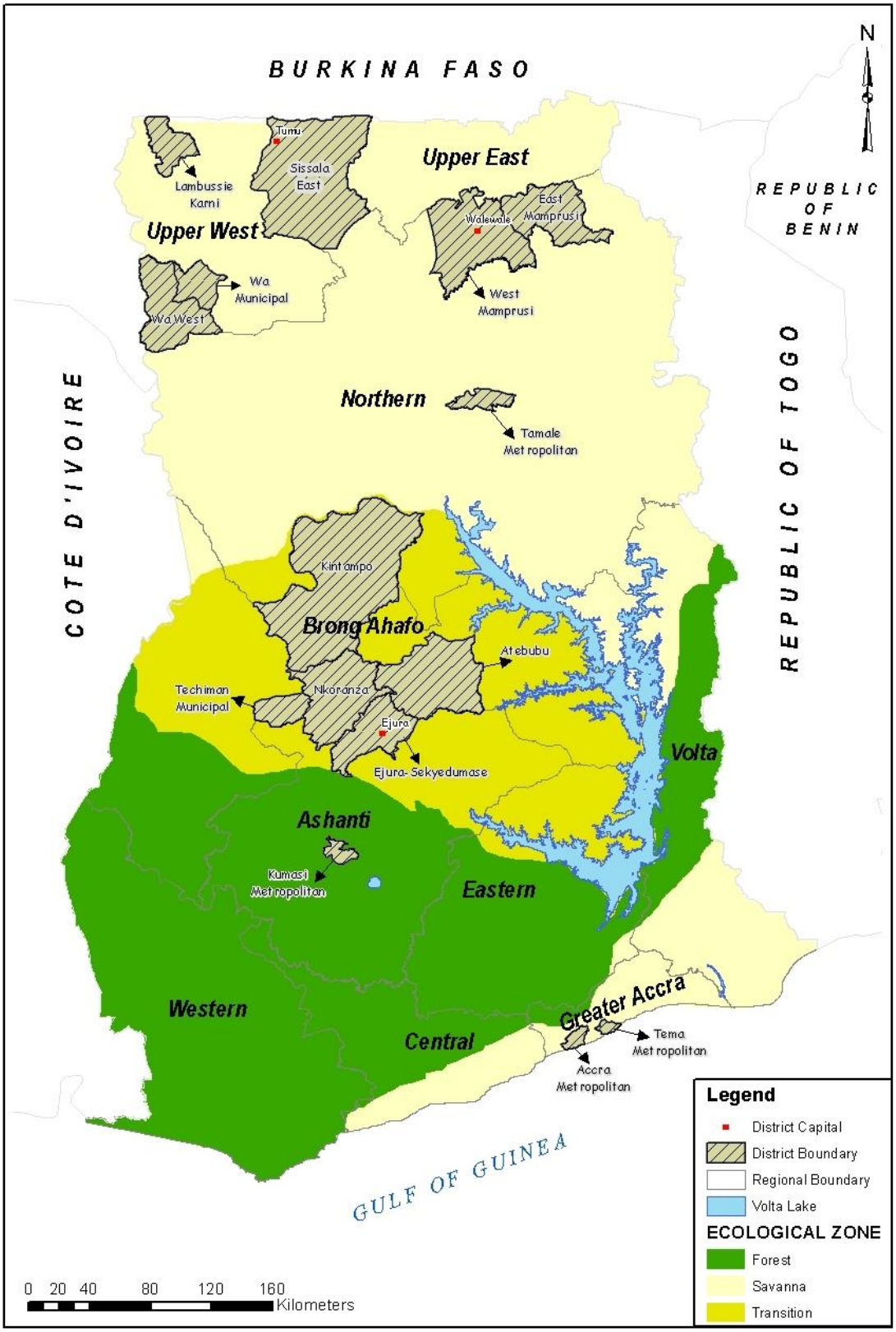
and the anticipated income from hiring-out tractor services to other farmers. According to tractor owners, a major advantage of ownership is eliminating the risk associated with waiting for tractor services. If plowing on one's own farm is done too late, planting is delayed and the risk of poor harvest increases. Plowing in Ejura takes place after the first rains in March or April for the major season and July or August for the minor season. Large and medium-scale farmers wishing to plow their lands on time invest in a tractor to overcome timeliness constraints, provided that they can afford it.

After preparing their fields, finding that they no longer need their tractor for operations on their own farm, farmers engaged in hiring-out tractor services to increase the utilization rates of the machines, to spread fixed costs, and to generate extra revenue. Houssou et al. (2014) show that 80 percent of tractor use come from hiring-out services. The revenue from tractor services is used to provide working capital for the tractor owners own farming and for other off-farm activities. Other farmers operate tractors as part of a portfolio of small business activities, such as carting of farm produces and inputs (seeds, fertilizer, water, laborers, etc.), and maize shelling.

Apart from the capital required to invest in a tractor, human capital assets present in an area, i.e., knowledge and experience, also facilitate individuals' access to the tractor service provision network (Lewis 1996). Our interviews indicate that tractor owners often previously worked as tractor operators, engine dealers, welders, or as owners of trucks for transportation. Putting this knowledge into practice in a new enterprise in operating a tractor, they are better placed to benefit from involvement in the tractor network. For example, one tractor owner indicated that he was a small-scale farmer, worked as a surveyor, and also ran a bus and a transport truck. Realizing that larger-scale farming was profitable, he decided to expand his farm to 50 acres. But, since it was difficult to access tractors to obtain plowing services on his farm during the peak season, he decided to buy a tractor. Through tractor ownership he became aware of the potential profitability of tractor service provision. He then bought additional tractors to offer plowing services to other farmers, in addition to providing transportation and maize shelling services.

The seasonal rainfall patterns across Ghana's agro-ecological zones permit seasonal migration of Ejura tractor owners to the northern areas of the country where there is only one cropping season in the year. Tractor owners based in Ejura provide plowing services for the major season locally, then regularly migrate up north to provide tractor services to farmers in the Northern, Upper East and Upper West regions before returning to Ejura for the minor season (Figure 4). Tractor service providers also migrate to neighboring countries, including Togo, Burkina Faso, and Benin, to offer plowing services to farmers there. This migration of tractor service providers is motivated by a quest to increase tractor utilization rates and to earn more income from the machines. Through plowing operations across the two rainfall zones, tractors can be active for six to eight months in the year. Tractor owners from Ejura started seasonally offering plowing services in northern Ghana 20 years ago. An owner reported that a tractor can plow between 100 and 150 acres in Ejura for the major season, between 150 and 250 acres in northern Ghana, and then return to Ejura to plow up to an additional 80 acres in the minor season. Tractor owners also indicated that plowing in northern Ghana is cheaper than in Ejura because they use less fuel to plow the lighter soils of the region – they estimate that they can plow 50 percent more acres from a tank of fuel in the north of Ghana compared to plowing in Ejura district.

Figure 4—Map of districts of origin and destinations for seasonal tractor hire service providers from Ejura-Sekyedumase and neighboring districts, Ghana



Source: GADM and HarvestChoice/International Food Policy Research Center (IFPRI), 2014.

During their journey to northern Ghana, tractors are usually loaded on trucks. Two to three tractor owners will together arrange for a truck to transport their tractors. A few tractor owners or operators also drive their tractors to northern Ghana. After arrival, tractor operators move around to different locations, following the rainfall

patterns. They stop and plow all the land of farmers seeking plowing services where there are rains, sometimes working in the night until they finish, before moving to another village or area. They stay in northern Ghana for 45 days or more, depending on the rainfall. In addition to owners and operators, mechanics, welders, and spare part dealers follow the tractors to northern Ghana. These actors are usually stationed in the district capitals with their motorbikes and working tools. Whenever a tractor breaks down, the mechanics and spare parts dealers are called upon (via cellphone) to assist. Box 1 summarizes the seasonal journey of two tractor owners from Ejura to northern Ghana and on to neighboring Togo and Benin.

Box 1—A journey of two migrant tractor owners from Ejura-Sekyedumase to northern Ghana, Togo, and Benin

Sadissou and his brother Yacoub were born into a farming family, so they stated that they had to be farmers and have to farm. For this reason, they bought tractors, rather than a car or a "trotro" (passenger bus), because a tractor is a working tool that will be more useful to them.

They began seasonally migrating to northern Ghana to provide tractor services in 2009. Yacoub lived in Libya for two years to work and raise financial capital. He came back to Ejura in 2006 and used the funds he had earned in Libya to buy a tractor. The two brothers plow for farmers in Ejura district before they annually migrate to northern Ghana. However, they return to Ejura in order to plow during the minor season as well.

Other places from where providers of seasonal tractor services to farmers in northern Ghana come from include Nkoranza, Techiman, Atebubu, and Kintampo districts, neighboring districts to Ejura. However, according to the two brothers, the majority of seasonal tractor services providers in northern Ghana come from Ejura. They noted that some tractor owners with shellers also go to northern Ghana to render shelling services to farmers during the harvest season. They stated that they cannot use their tractors on their farms alone since they need to earn more income to purchase agro-chemicals, other inputs, and to hire labor. Their tractors are used continuously for plowing for five months in the year – two to three months in northern Ghana and for two months in Ejura during both major and minor seasons, inclusive.

In 2013, the two brothers left Ejura for northern Ghana on 27 May, returning 16 July. On their way to northern Ghana, they spent two days at Walewale in West Mamprusi district (Northern Region), which is the station for tractor loading and off-loading en route to Upper East Region and the destination of those going to plow at the Cotton Company farms in Tumu in Sissala East district (Upper West Region). They then went to Lambussie district (Upper West Region), where they spent three weeks, before continuing to Togo and Benin, where they stayed for two months. From there, they came back to Walewale, where they worked for five days, before returning to Ejura.

While in northern Ghana and in Togo, Sadissou reported plowing 221 acres in total – 50 acres at Lambussie, 15 acres at Walewale and 156 acres in Togo. He does not remember the amount of acres he plowed in Ejura before going to northern Ghana. The brothers stated that plowing in northern Ghana is easier than in Ejura – in northern Ghana they normally uses 30 minutes and 1 gallon of fuel to plow an acre, while in Ejura they use 1.5 gallons of fuel per acre because the soil is heavier and requires more traction than in northern Ghana.

To transport their tractors to northern Ghana, they loaded them onto trucks, being charged 600 Cedis per tractor for transport to Walewale. The brothers started going to Togo and Benin two years ago. On crossing the border to Togo, they pay 30 Cedis at the Ghana border post and 100 Cedis at the Togo border post for the "Laissez-Passer" entry permit. They stayed in Togo for 2 months. Due to language barriers, they had to hire a translator or middle man, paying him 1,000 CFA (4 Cedis) for every hectare plowed. They charged the farmers 26,000 CFA per hectare plowed. Land in north Togo is also reported to be easier to plow than in Ejura. At the Benin border, they paid 3,000 CFA before crossing the border and an additional 3,000 CFA when coming back.

On their way back to Ejura, they transported their tractors on a truck going to Kumasi and alighted in Techiman and then drove their tractors to Ejura. They paid 200 Cedis from Walewale to Techiman for the transportation of each tractor. However, Yacoub reported that he sold his tractor on the way in Tamale and bought another one on his way back in Techiman.

TRACTOR USERS

Although tractor use is quite high in Ejura, most tractor users rely on tractor service providers, as the majority of the district's farming population do not own a tractor. The IFPRI/SARI survey indicates that in 2012, 84 percent of tractor users in the district hired tractor services. A similar pattern is reported by Chapoto and Ragasa (2013) who found that 39 of the 42 farmers who used mechanized plowing for land preparation in their five study villages in Ejura district did not own a tractor. Use intensity is also high. For example, Codjoe and Bilsborow (2011) report that farmers in Ejura used tractors for 12.7 hours per hectare per year against 3.2 hours per hectare per year in Kassena-Nankana district (Upper East region.) Tractor use is correlated with farm size. The IFPRI-SARI survey data show that farmers who own or make use of tractor services cultivate more than 4 ha on average, while non-users are typically found to cultivate smaller land areas of around 3 ha (Table 3).

Table 3—Estimated landholding by tractor use in Ejura-Sekyedumase district, ha

	Average	Standard error	Number
Own tractor	12.9	1.21	121
Rent-in tractor services	4.8	1.07	108
No tractor use	3.1	1.00	24

Source: IFPRI-SARI Medium and Large-Scale Farmers and Tractor Owner Survey.

According to Ejura farmers, access to a tractor offers the opportunity to compensate for labor shortages and perform timely farming operations. But, tractor users, both owners and non-owners, perceive that the supply of tractor services in the district is inadequate to meet demand for plowing during the peak season, indicating an under-developed service market. On the other hand, once the plowing season is over, most of the tractors become virtually idle, suggesting an incomplete mechanization of farming operations. As most tractor users rely on market services, tractor hiring transactions are either based on preexisting client relations or roadside negotiations. These can be influenced by complex planned or unplanned arrangements with distant tractor owners who can choose to honor an agreement or not (Lewis 1996), because demand is higher than supply in the district. Small-scale farmers, who form the majority of users, are often in a weak position to determine the availability of tractors and, thereafter, access those available, especially where there are limited tractor numbers. For example, farmers in Samari-Nkwanta community have to hire tractors from Ejura center, as there are no tractor owners in their community.

When a farmer manages to bring a tractor to a community, other farmers take advantage of the presence of the tractor and request services from the tractor operator. After serving the farmer who brought him to the community, a tractor owner may stay in a community for as long as three weeks to provide services to other farmers. Tractor-hiring farmers report having to approach more than one tractor owner before securing services to plow their field, sometimes missing the optimum time for planting before securing such services. The median number of days that service seekers reported waiting was four days (IFPRI/SARI Survey 2013). However, farmers indicate that mechanization services generally have improved in the district in recent years. The service charge for tractor plowing in the district was between 40 and 45 GHc per acre in 2012.

In addition to plowing, a rental market for maize shelling has emerged in the district. Old tractors with reduced plowing capability are exclusively used for maize shelling activities. Most tractor-mounted maize shellers are manufactured locally. The service charge for shelling is paid either in kind or in cash – in 2012, the charge was one bag of maize paid for every 10 bags shelled or 3.50 GHc per bag shelled.

TRACTOR OPERATORS/DRIVERS

Tractor operators, according to Lewis (1996), are the link between the tractor owner and the farmer customer or broker. Usually, the tractor owner will hire an operator who, in turn, hires an assistant to help him during the plowing and shelling seasons. But, in some cases, tractor owners operate their own tractors. Payment for drivers is usually a cash wage of 10 percent of revenue, which is often shared with an assistant hired by the operator. As in the case of Bangladesh, kinship plays a vital role in the tractor network (Lewis 1996). Many operators in Ejura are sons, brothers, nephews, or other relatives of tractor owners. The IFPRI/SARI survey (2013) found that about 50 percent of tractor operators are owners' sons or relatives.

Despite these kinship relationships, owners frequently expressed their frustration with the problem of underreporting by their operators of the volume of services provided to farmer customers. Tractor operators tend to over-use the tractors, which increases the cost of maintenance and repairs for the owners, while they keep any extra revenue earned. When owners send their tractors to remote areas to provide services, the supervision of the work done becomes a challenge. This is exacerbated by the fact that some farmers seek tractor services while operators are in the field, without the knowledge of the tractor owner (Daum 2014), thus creating grounds for underreporting to the tractor owner of the work done. In order to have some degree of control over the work

done, owners either travel with the operator, send a relative along with him, or visit the operator frequently during their stay in northern Ghana, especially in a case that the tractor operator is not a relative of the owner. Most of the tractor operators have low levels or no formal education. About 97 percent of the tractor operators learnt tractor driving informally from other tractor operators. According to Daum (2014), the majority of tractor owners and operators are not aware of the tractor driver training offered by Ejura Agricultural College. But, even those who are aware of this training course, find it too expensive or do not see any benefits the training might provide.

TRACTOR BROKERS

Brokers or agents arrange for the provision of tractor services to farmers from suppliers and are normally paid a percentage of the contract fee. They make hire services more efficient by minimizing between-job transport of the tractors (Chancellor 1986). The role of the broker is essential in breaking down the use of a lumpy technology (the tractor) into smaller units for profitable interaction with smallholder farmers (Lewis 1996).

Brokers or middlemen are rarely used in Ejura district as farmers usually contact tractor owners directly to seek services, probably due to high number of tractors in the district. However, a few individual farmers negotiate tractor hire services for other farmers through informal arrangements, especially in distant communities with few or no tractor owners, as is the case in some Asian countries (Maranan 1985; Chancellor 1986; Lewis 1996; Koike 2009). These farmers are usually small-scale farmers whose single holdings make service provision unattractive for a tractor owner or operator. Hence, they organize themselves with other farmers in order to make a trip to their community worthwhile for a tractor owner offering services. As they are not proper brokers, however, they do not take any share of the profits from the tractor owner/operator, in contrast to the situation in some Asian countries.

Within the scope of the Block Farm Program of government, which brings together farmers onto large tracts of lands, program managers also contract with tractor owners to offer paid service to participating farmers in the program. Equally important, some brokers or private companies from northern Ghana contact tractor owners through established networks or by traveling to Ejura to negotiate tractor services for their outgrowers. Usually these companies guarantee a minimum number of customers for each tractor owner and cover the tractor transportation costs to district where the tractor services are required. A tractor owner in Ejura reported that a cotton company contracted his fellows to plow for their out-growers in Upper West region at a service charge of 55 GHc per acre and covered fuel and transport cost to the region. After fulfilling these contracts, tractor operators/owners remain in northern Ghana of the country to provide services to other farmers before returning to Ejura at the end of the farming season.

TRACTOR MECHANICS AND ARTISANS

The market for tractor maintenance or repair services is dominated by informal businesses. These businesses are not registered and typically comprise a master mechanic with a few apprentices that do not earn any salary. When a tractor needs repairs, an initial consultation is made between the tractor owner/operator and the mechanic over the phone to determine the cause of the breakdown, the spare parts needed, and whether the tractor should be driven to the mechanic's shop or not. In most instances during the farming season, mechanics travel to the field to provide repair services. Virtually, no tractor part is manufactured locally. Most of the spare parts are imported from abroad. Spare parts are available in major cities, especially for Massey Ferguson tractors.[4] Mechanics may salvage parts from irreparable tractors to fix other tractors. Most of the tractor mechanics in Ghana have no formal education or training. Usually, they trained for about three years in the informal sector. A trained apprentice may remain working with his master for some time before setting up his or her own shop.

Just as for tractor dealerships, local manufacturing of tractor-mounted shellers is an expanding industry in Ejura and its environs. At the Suame Magazine industrial area near Kumasi, artisans manufacture a wide range

[4] Compared to spare parts for more newly imported tractor brands, such as John Deere, Mahindra, Farmtrac, etc.

of agricultural and non-agricultural equipment and attachments. Designs of tractor-mounted maize shellers imported from abroad have been reproduced by local artisans and successfully manufactured locally. This has increased the availability of mechanized shelling services in various locations across the country. These local artisans have acquired specialized skills for manufacturing, repairing, and maintaining maize shellers. Metal workers with whom we spoke in Ejura stated that they started producing the attachment in 2008. These local patterns of innovation play an essential role in sustaining the tractor network and the mechanization service market in Ejura.

6. CONCLUSIONS

The aim of this paper is to contribute to our understanding of the supply network of tractor plowing and other agricultural mechanization services and participating actors' relations, using the case of Ejura district in central Ghana. Under favorable agro-ecological conditions, a bi-modal rainfall pattern, and a high concentration of tractors, the district has witnessed a considerable increase in maize production in recent years, much of it mechanized.

The results suggest that, in addition to the traditional drivers of agricultural mechanization, such as rising population density and favorable access to local and regional markets, the current patterns of adoption of tractors in Ejura district occurred within an environment characterized by favorable historical and institutional factors. Tractor use has created a set of new roles and relationships within a network, entry to which is determined by a farmer's access to capital, knowledge, experience, contacts, and information. Access to relevant experience in Ejura district has been facilitated historically by technologies introduced through the former Ejura Farms enterprise in which relatively experienced mechanics and operators were released into the area after the enterprise went into decline. Furthermore, knowledge spillovers continue today, as most owners hire-in tractor services for several years before venturing into owning tractors.

The current arrangement made up of private tractor owners who provide tractor hire services draws upon the legacy of the previous institutional intervention and rely on formal organizational units based on kinship and existing relationships within and outside the district. For example, tractor operators in the district are usually employed along lines of trust, and often are sons, brothers, nephews, or other relatives of tractor owners. While brokers or middlemen play a minor role within the district, as farmers usually contact tractor owners directly to seek mechanization services due to the high number of tractors in the district, brokers can be important in procuring business for tractor owners in other districts or with groups of smaller farmers.

Participation in the market for the provision of tractor services has also allowed farmers to overcome the knowledge and information barrier about tractor technology and its benefits. Apart from the capital required, the human capital assets (i.e. knowledge and experience) also facilitate individuals' access to the network, as some tractor owners have worked as tractor operators, engine dealers, welders, and as owners of trucks for transportation before obtaining a tractor. This privately operated network provides a relatively efficient service that enables small-scale farmers to have good access to plowing services. Further development of the market is likely to improve the quality of mechanization services provided to smallholder farmers, to enhance bargaining power of famer customers, and to reduce structural weaknesses within the tractor network.

REFERENCES

Blarel, B., P. Hazell, F. Place, and J. Quiggin. 1992. "The Economics of Farm Fragmentation: Evidence from Ghana and Rwanda." *The World Bank Economic Review* 6 (2): 233-254.

Boserup, E. 1965. *The Conditions of Agricultural Growth: The Economics of Agrarian Change Under Population Pressure*. London, UK: George Allen & Unwin.

Chancellor, W.J. 1986. "Improving Access To and Use of Appropriate Agricultural Machinery by Small-Scale Farmers." Proceedings of the International Conference on Small Farm Equipment for Developing Countries: Past Experiences and Future Priorities, USAID & IRRI, 525-543.

Chapoto, A., and C. Ragasa. 2013. Survey Data on Rice and Maize Farmers, Washington, DC: International Food Policy Research Institute.

Chapoto, A., N. Houssou, A. Mabiso, and F. Cossar. 2014. *Medium and Large*-Scale *Farmers and Agricultural Mechanization in Ghana: Survey Results*. Washington, DC: International Food Policy Research Institute.

Codjoe, S.N.A., and R.E. Bilsborrow. 2011. "Population and Agriculture in the Dry and Derived Savannah Zones of Ghana." *Population and Environment* 33 (1): 80-107.

Daum, T. 2014. "Assessment of Policies and Institutions for Smallholder Mechanization in Ghana." MSc. Dissertation, University of Hohenheim, Germany.

Diao, X., F. Cossar, N. Houssou, and S. Kolavalli. 2014. "Mechanization in Ghana: Emerging Demand and the Search for Alternative Supply Models." *Food Policy* 48: 168-181.

Esparcia, J. 2014. "Innovation and Networks in Rural Areas. An Analysis from European Innovative Projects." *Journal of Rural Studies* 34: 1-14.

Ghana, Ministry of Food and Agriculture. 2011. *Agriculture in Ghana: Facts and Figures*. Accra, Ghana: Ministry of Food and Agriculture, Statistics, Research, and Information Directorate.

GSS (Ghana Statistical Services). 1984. *Population and Housing Census 1984*. Data. Accra: GSS.

GSS (Ghana Statistical Services). 2000. *Population and Housing Census 2000*. Data. Accra: GSS.

GSS (Ghana Statistical Services). 2010. *Population and Housing Census 2010*. Data. Accra: GSS.

GSS (Ghana Statistical Services). 2012. *Population and Housing Census 2010: Summary Report of Final Results*. Accra: GSS.

Government of Ghana. 2014. *Profile of Ejura-Sekyedumase District*.

HarvestChoice. 2014. "AEZ (16-class, 2009)." International Food Policy Research Institute, Washington, DC., and University of Minnesota, St. Paul, MN. Accessed August 30, 2014. http://harvestchoice.org/data/aez16_clas.

Hine, J.L., J D.N. Riverson, and E.A. Kwakye. 1983. *Accessibility and Agricultural Development in the Ashanti Region of Ghana.* Transport and Road Research Laboratory (TRRL) Supplementary Report 791. Crowthorne, Berkshire, England.

Houssou, N., X. Diao, and S. Kolavalli. 2014. *Can the Private Sector Lead Agricultural Mechanization in Ghana?* IFPRI Ghana Policy Note No. 4. Washington, DC: International Food Policy Research Institute.

IFPRI/SARI (International Food Policy Research Institute/Savannah Agricultural Research Institute). 2013. *Medium and Large-Scale Farmer and Tractor Owner Survey*. Ghana Strategy Support Program. Accra, Ghana.

Knoke, D., and S. Yang. 2007. *Social Network Analysis (Quantitative Applications in the Social Sciences)*. Los Angeles: Sage Publications.

_____. 2008. *Social Network Analysis*. Los Angeles: Sage Publications.

Koike, M. 2009. "Custom Hire Systems for Agricultural Machines in Southeast Asia: In a Rural Community in Thailand." *Engineering in Agriculture, Environment and Food* 2 (4): 144-149.

Lewis, D.J. 1996. "'Appropriating' Technology? Tractor Owners, Brokers, Artisans and Farmers in Rural Bangladesh." *Journal of International Development* 8 (1): 21-38.

Maranan, C.L. 1985. "Comparative Evaluation of Tractor and Carabao Use in Rice Land Preparation, Nueva Ecija, Philippines, 1980." *Philippine Journal of Development* 12 (1): 113-140.

Organization for Economic Cooperation and Development (OECD). 1999. *Managing National Innovation Systems*. Paris: OECD.

Ruthenberg, H. 1980. *Farming Systems in the Tropics,* 2nd edition. London, UK: Oxford University Press.

Scott, J. 1987. *Social Network Analysis: A Handbook*. London: Sage Publications.

Spielman, D.J., and R. Birner. 2008. *How Innovative Is Your Agriculture ? Using Innovation Indicators and Benchmarks to Strengthen National Agricultural Innovation Systems*. Agriculture and Rural Development Discussion Paper, 41. Washington, DC: The World Bank.

SRID (Statistics, Research and Information Directorate). 2013. *Agricultural Production Data. Accra*, Ghana: Ministry of Food and Agriculture.

USAID (United States Agency for International Development) and ADVANCE (Agricultural Development and Value Chain Enhancement). 2013. *Tractor Census of Northern Ghana*. Accra, Ghana.

Ward, N., and D.L. Brown. 2009. "Placing the Rural in Regional Development." *Regional Studies* 43 (10): 1237-1244.

World Bank. 2008. *Agricultural Innovation Systems: An Investment Sourcebook*. Washington, DC: The World Bank.

About the Authors

Frances Cossar is a Research Student in the Department of International Development, University of Oxford in the United Kingdom and formerly a Research Analyst in IFPRI's Development Strategy and Governance Division.
Nazaire Houssou is the Research Coordinator for IFPRI's Ghana Strategy Support Program in Accra.
Collins Asante-Addo is a Research Officer in IFPRI's Ghana Strategy Support Program in Accra.

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

2033 K Street, NW | Washington, DC 20006-1002 USA | T+1.202.862.5600 | F+1.202.457.4439 | Skype: ifprihomeoffice | ifpri@cgiar.org | www.ifpri.org

IFPRI-ACCRA

c/o International Water Management Institute (IWMI) | PMB CT 112, Cantonments, Accra, Ghana | CSIR Campus (Opposite Chinese Embassy) | Airport Residential Area | T: +233-(0)21-7807163333 | F: +233-(0)21-784752 | gsss.ifpri.info

This publication of the Ghana Strategy Support Program is made possible by the generous support of the American people through the United States Agency for International Development (USAID). It has not been independently peer reviewed. The contents are the responsibility of the author(s) and do not necessarily reflect the views of USAID, the United States Government, or the International Food Policy Research Institute.