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Dynamics of Transformation

Insights from an Exploratory Review of Rice Farming in the Kpong Irrigation Project

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ABSTRACT

Agriculture in African South of the Sahara (SSA) can be transformed if the right public support is provided at the initial stage, and it can sustain itself once the enabling environment is put in place. Successes are also specific to the location of projects. In Ghana, interesting insights are obtained from the successful Kpong Irrigation Project (KIP), contrasted with other major irrigation projects in the country. Through an exploratory review, we describe how a productive system evolved in KIP and how public support for critical aspects (accumulation of crop husbandry knowledge, selection and supply of profitable varieties, and mechanization of land preparation) might have created a productive environment that the private sector could enter and fill in the market for credit, processing, mechanization of harvesting, and other institutional voids that typically have constrained agricultural transformation in the rest of SSA. Slower progress in other projects also raises a number of questions. We conclude by summarizing those questions and some testable hypotheses for future research.

Keywords: agricultural transformation, profitability, crop husbandry knowledge, Ghana, public irrigation scheme, rice

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1. BACKGROUND

Agricultural transformation is regarded as key for reducing poverty and improving food security in Africa South of Sahara (SSA), but repeating the success of the Asian Green Revolution in SSA has been challenging. Many initiatives to transform agriculture in SSA have failed due to the area's constraints and lack of complementary conditions. It is therefore imperative to identify what critical factors the governments in SSA must provide and which constraints can be overcome once such critical conditions are in place.

Useful insights can be obtained by examining some successful examples for rice production in Ghana and how the constraints have or have not been overcome along rice value chains. Agricultural transformation can have a significant economic importance, particularly for crops like rice, which has the highest economic potential among major crops for overall agricultural growth and for generating the greatest producer benefits in many West African countries, including Ghana (Nin-Pratt et al. 2009). Ghana imports 60 percent of its rice (Breisinger et al. 2012), with increasing consumption being met by imported aromatic rice. As rice import bills grow, political incentives to develop the domestic rice sector increase.

Despite its demonstrated importance, the rice sector has not been transformed in much of SSA. Rice yield there has been low due to a number of limitations, including the following:

- depressed prices and distorted measurement of paddy due to oligopsony by traders (Kranjac-Berisavljevic, Blench, and Chapman 2003)
- low price premiums for appropriate rice processing; insufficient knowledge of packaging (CARD 2010)
- insufficient availability of general inputs due to a poorly developed private sector (IFDC 2008; CARD 2010)
- insufficient availability of certified seeds for consumer-oriented varieties (USAID 2009; CARD 2010)
- insufficient mechanization of land preparation, planting, and harvesting (CARD 2010)
- insufficient private-sector development for machine parts (USAID 2009)
- poor access to appropriate milling machines (Kranjac-Berisavljevic, Blench, and Chapman 2003)
- insufficient labor availability during the main cropping season (Somado, Guei, and Nguyen 2008), particularly for land leveling and bunding (USAID 2009)
- poor performance of public irrigation projects, including lack of facility maintenance and poor drainage (IFDC 2008)
- high cost of paddy from processors' perspectives due to insufficient supply
- weak extension services with poor knowledge of production practices for lowland/irrigated rice production (Somado, Guei, and Nguyen 2008; Kranjac-Berisavljevic, Blench, and Chapman 2003)
- lack of credit and high interest rates (IFDC 2008; CARD 2010)
- inadequate drying space, warehousing, and storage
- weak land tenure that discourages investment in irrigation and land improvements (USAID 2009).

Rice production in the area of the Kpong Irrigation Project (KIP) in Ghana, however, is highly productive, unlike that of conventional irrigation projects in SSA. It achieves an average yield of 5.5 tons per hectare (ha) (dry paddy), comparable to irrigated rice yield in Asian countries and much higher than in the rest of Ghana. Intensive use of crop husbandry knowledge for irrigated rice, of modern inputs (fertilizer, seeds, and chemicals), of labor, and of mechanization all lead to this high yield. With such a high productivity, farmers in KIP seem to face fewer of the constraints mentioned above: Relatively high farmgate prices of the varieties have overcome the profitability constraint despite the still oligopsonic nature of traders; the input accessibility constraint has been overcome by adequate private input dealers supplying fertilizer, pesticides, and herbicides; the certified seeds constraint has been partly overcome by on-site production of certified seeds and partly by external support for developing a seed certification system that may lower the cost of certified seeds, speed up their supply, and prevent adulteration of their quality; the research focus constraint has been overcome by direct attention to the selection of aromatic varieties; the mechanization constraint has been partly overcome by private land preparation services that use power tillers and by private investments into harvesting machines and milling facilities; the labor constraint has been overcome by high profitability, which permits higher wages; some of the institutional constraints have been overcome by farmers' self-coordination for canal maintenance; the knowledge constraint has been overcome by well-trained extension staff and a high extension-to-farmer ratio, as well as an intimate knowledge of good agricultural practices developed by farmers themselves over time; and finally, the credit constraint has been partly overcome by informal agents such as traders who extend credit for adoption of intensive practices. Overall, KIP has become one of the few successful public irrigation projects in SSA.

The success of KIP, however, has not been replicated in other irrigation projects, despite a number of similarities in varieties cultivated; production practices; and access to inputs, technologies, and water. Although the soil quality, land tenure system, and market access differ between KIP and other projects, it is still unclear whether these factors explain why other projects have not reached the yield level of KIP.

In the remaining section of this report, we take an exploratory look at irrigation systems as part of a potentially larger study to understand the dynamics of agricultural transformation. An overarching question is how the productive system in the KIP area has evolved, what role the state has played, how the private sector has responded, and how some of the common challenges in the SSA rice sector have been overcome in KIP. This study is based on information collected through various field visits and through discussions with the irrigation project management staff and local extension agents, farmers, traders, and other service providers, as well as a rapid survey of rice producers in the areas served by the Kpong, Tono, Vea, Bontanga, and Weta irrigation projects. In particular, we highlight (1) key farming practices; (2) how the knowledge and technologies have been brought in and accumulated in KIP; and (3) how high profitability might have induced the growth of other markets in KIP, including processing, credit, and farmers' coordination. We conclude the report by discussing several hypotheses and key questions for future research. For consistency, we describe all figures in US dollar using the conversion rate of $1 = 1.88 Ghana cedi (GHS), except certain figures which are fixed in GHS term (such as irrigation fees).

2. RICE PRODUCTION IN KPONG IRRIGATION PROJECT AND OTHER MAJOR IRRIGATION PROJECTS

Agronomic and Biophysical Potential of Aromatic Rice in KIP and Other Projects

The Kpong Irrigation Project (KIP) is located in a floodplain on the Lower Volta River. KIP comprises two sections for rice production consisting of 18 branch canals—the relatively newer Section A (1,000 ha) and the older but rehabilitated Section B (860 ha)—and 1,700 ha of irrigated commercial banana area (Figure 2.1 shows a map of the area). Section B was originally developed as part of an older irrigation project in the area.[1] Development of Section A and rehabilitation of Section B took place after 1997 (AfDB 2005) at a cost of US$40 million,[2] mostly in loans to be repaid over 50 years. The loans were extended by the African Development Bank (AfDB), consisting of loans from African Development Fund and grants from the Technical Assistance Fund and the Arab Bank for Economic Development, and reinforced by contributions from the Ghanaian government. By the end of 2005, a total of 1,636 ha had been developed (870 ha newly developed and 766 ha rehabilitated), bringing the total development cost under the AfDB project to around $25,000 per ha (/ha), which is higher than that of irrigation projects outside Africa (Inocencio et al. 2007). Currently, approximately 1,000 farmers are registered in Section A (1 ha per farmer) and 1,630 farmers are registered in Section B (0.53 ha per farmer).[3] The number of farmers registered has been growing, and area per farmer has been declining, although, as discussed below, a substantial share of farmers sublease their plots. Aromatic varieties of rice are commonly grown in the area, including Jasmine 85, Aromatic Short, Jet Three, and Togo Marshall.[4]

KIP is one of the 12 functional irrigation projects overseen by Ghana Irrigation Development Authority and Irrigation Company of Upper Region, among which the Weta, Tono, Vea, and Bontanga irrigation projects are major ones. The Tono project has 2,450 ha of developed land (Namara et al. 2011). It was initially aimed at supplying tomatoes to the nearby Pwalugu tomato factory and also contributing to Operation Feed Yourself (Ubink and Amanor 2008, 121). The project operates with about 3,250 farmers who primarily plant a Jasmine 85 variety of rice (Namara et al. 2011). The Vea project is smaller than the Tono project, having just 850 ha of developed land (Namara et al. 2011). The Bontanga project operates on 450 ha of developed land, 390 ha of which is used for rice production (Namara et al. 2011; authors' field work). Lastly, the Weta project has 880 ha under cultivation.

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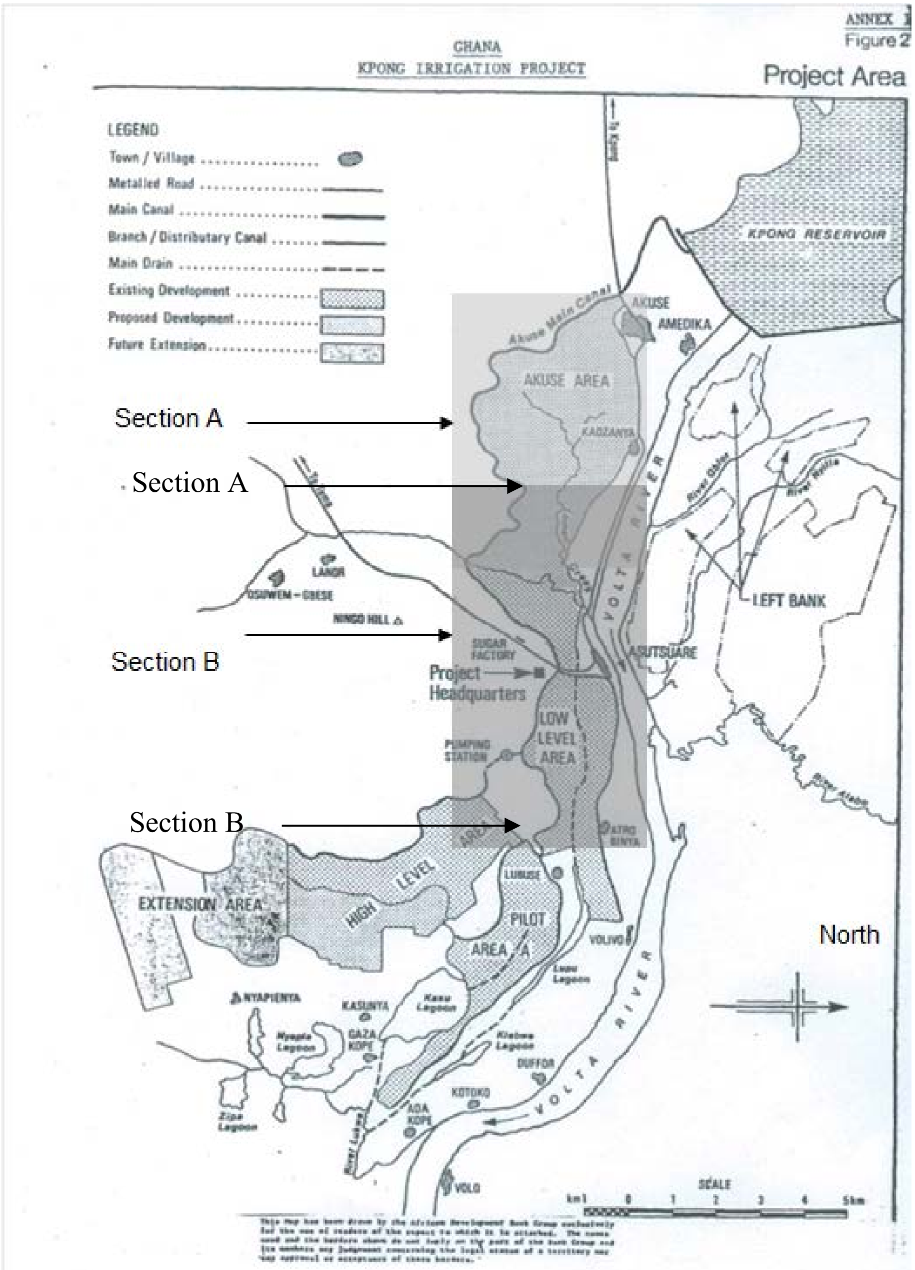
[1] Four irrigation projects along the Volta valley have been built at steplike intervals of 16 km (10 miles) below the great Akosombo Dam: the Kpong, Asutsuare, Aveyime, and Adidome projects, in that order (Hunter 1997). The Asutsuare Irrigation Project was developed in a floodplain of the Lower Volta River in 1967 as one of the first national irrigation projects with public support (Yamaguchi 1999; Kyei-Baffour and Ofori 2006; Namara et al. 2010). Section B of KIP was developed as part of Asutsuare Irrigation Project.

[2] All dollar amounts are in US dollars. This figure is based on the dollar exchange rate for a unit of account (UA) at the African Development Bank of 1 UA ≈ $1.5 (AfDB 2011).

[3] Based on the interaction with KIP staff.

[4] Aromatic varieties are classified as one type of Asian rice (*Oryza sativa* L.), separate from other types of Asian rice such as Indica or Japonica rice (Garris et al. 2005), and therefore all four aromatic varieties mentioned above are likely to be Asian varieties. Aroma is due to certain gene characters in these varieties. The genes responsible for producing aromatic rice are now patented and can be used to create an aroma in other, nonfragrant rice varieties ("Thai Scientists" 2005).

Figure 2.1—Map of Kpong Irrigation Project



Source: AfDB 2005.
Note: Top is toward west, north is on the right.

Agroclimatic potentials are similar between KIP and other projects for short-maturity Indica wetland rice under irrigated conditions (as shown in Table 2.1). Agroclimatically attainable yields[5] vary little across projects, with about 6.5 tons/ha attainable in all projects, assuming sufficient levels of inputs and appropriate varieties. This figure, however, ignores the soil fertility; greater inputs may be required in infertile areas.

[5] Agroclimatically attainable yields are calculated based on temperature and radiation regimes, taking into account temperature and moisture constraints; yield-reducing effects caused by pests, diseases, and weeds; and climate-related workability constraints (FAO and IIASA 2013).

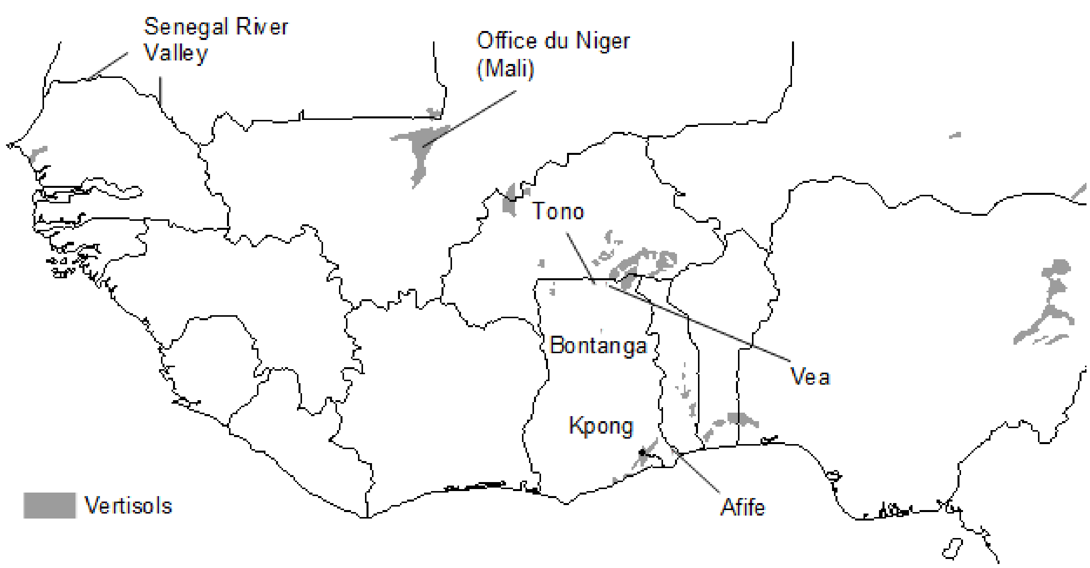
Table 2.1—Agroclimatically attainable yield (tons/ha) for irrigated Indica wetland rice with maturity of 105 days

	Kpong	Weta	Tono	Vea	Bontanga
Length of growing period	**240–269 days**	**210–239 days**	**150–179 days**	**150–179 days**	**180–209 days**
High input	6.1	6.3	6.5	6.5	6.4
Intermediate input	3.9	4.1	4.2	4.2	4.1
Low input	1.9	1.9	2.0	2.0	2.0

Source: FAO and IIASA 2013.

Dominant soil in the KIP area is Chromic Vertisols (FAO et al. 2012), an alluvial soil with a low water infiltration rate and high fertility, often appropriate for basin irrigation (Ahmad 1996; Troll 1965). Workability of vertisols is, however, low (Moorman and Breemen 1978) and equipments such as power tillers may be needed. Vertisols are found across various locations including parts of Burkina Faso, areas around Office du Niger in Mali, and also parts of northeastern Ghana (see Figure 2.2). Areas immediately surrounding the Bontanga, Tono, and Vea projects seem, however, more dominated by Lixisols (Oxisols under US Department of Agriculture soil taxonomy), although soils within the projects may vary. Unlike Vertisols, Lixisols have low levels of nutrients, low cation retention, and high erodibility. Consequently, production on these soils requires more frequent fertilizer applications, and tillage through heavy machinery can severely deteriorate the soil. It is recommended to rotate annual crops on Lixisols to maintain organic matter content in the soil (FAO 2006). Lixisols, unlike Vertisols, tend to have high levels of free iron that can cause iron toxicity when flooded, though with high phosphorus-fixing capacity (Balasubramanian et al. 2007). Lixisols are also generally difficult to puddle, and their potential for rice cultivation is low to moderate (Sanchez and Buol 1985). KIP therefore may be endowed with more fertile soils than are other irrigation areas, being located fully within the Vertisols area. Other crops in the KIP area, however, get yields that are relatively moderate in Ghana, including maize (1.2–1.7 tons/ha), groundnuts (0.6 tons/ha), and cassava (8.8 tons/ha) (SNC Lavalin International 2010).

Figure 2.2—Locations of Vertfisols in West Africa



Source: Authors' GIS file modified from FAO et al. 2012.

Aromatic rice, such as jasmine rice in Thailand (including the varieties Khao Dawk Mali 105 and KDML), has traditionally been low yielding and grown in an arid environment (Dawe, Moya, and Casiwan 2006; Rahman et al. 2009). It can, however, achieve 4.5–5 tons/ha under good management (Sarkarung, Somrith, and Chitrakorn 2000). Jasmine 85 might have good yield response traits inherited from IR 262 as its parent. Jasmine 85 is considered an early-maturing variety compared with other popular varieties in Ghana, including Bouake 189, Sikamo, and Wita 7 (Issaka, Buri, and Wakatsuki 2009).

Grain qualities like aroma can depend on the production environment, including soil type and fertility. Such factors potentially lead to observed differential prices, though the mechanisms are still unclear and left for future studies (Rohilla et al. 2000). Cool temperatures during the flowering and grain development stages can often improve aroma. KIP is slightly cooler than the north, particularly during the day, in the growing season. Aroma can be increased by complete puddling before transplanting, a well-leveled field, clayey soil, sufficient water supply, and timely harvesting after maturity (Rohilla et al. 2000). As is described below, many of these conditions seem to be present in KIP. Certain production practices, however, sometimes adversely affect aroma. Excessive nitrogen and urea could reduce aroma and cooking quality, while more potassium can improve aroma (Rohilla et al. 2000). Transplanting, as opposed to direct seeding, or less sunlight can also reduce aroma (Rohilla et al. 2000). Some of these conditions are also observed widely in KIP.

Key Rice Production Practices in KIP and Other Projects

In order to roughly characterize key rice production practices and performance in KIP and compare them with those in other major project areas, we interviewed 30 rice producers randomly within each of the Kpong, Weta, Tono, Vea, and Bontanga irrigation projects. Interviews were conducted between March and Aril 2013 with reference to the 2012 rainy season. However, a few farmers grew rice without irrigation in the 2012 rainy season; for those farmers, we asked about the 2012 dry season. This way, we obtained information strictly for irrigated conditions because our focus is to compare the performance of different areas under irrigated conditions. Interviewees were randomly sampled from the list of registered rice growers obtained from each project. Table 2.2 summarizes the results.

Table 2.2—Key rice production characteristics across irrigation projects, 2012

	Kpong	Weta (Afife)	Tono	Vea	Bontanga
Sample size[a]	30	29	29	32	30
Average yield (tons / ha)	**5.5** [5.0, 6.1]	**3** [2.3, 3.7]	**3.3** [2.8, 3.7]	**1.3** [0.7, 1.9]	**2.6** [2.2, 3.1]
Fertilizer use (product, kg / ha)	**600** [519, 680]	**515** [468, 563]	**401** [325, 478]	**262** [182, 342]	**347** [288, 405]
Nitrogen (kg / ha)	**120** [105, 136]	**127** [113, 140]	**71** [59, 84]	**49** [32, 65]	**67** [54, 81]
Phosphorus (kg / ha)	**58** [48, 68]	**38** [34, 41]	**39** [30, 47]	**24** [16, 31]	**32** [26, 37]
Potassium (kg / ha)	**58** [48, 68]	**38** [34, 41]	**39** [30, 47]	**24** [16, 31]	**32** [26, 37]
Output / nutrients[b]	**46**	**24**	**46**	**27**	**38**
% of area with transplanting	**76** [59, 93]	**3** [0, 8]	**96** [89, 100]	**100**	**2** [0, 5]
Average years of transplanting experience (years)	**7** [5, 9]	**3** [1, 5]	**13** [11, 16]	**11** [9,14]	
% of area using power tillers	**100**	**23** [3, 44]	**23** [6, 41]	**3** [0, 8]	**2** [0, 5]
Average years of power tiller use experience (years)	**10** [8, 11]	**9** [6, 12]	**8** [5, 11]	**1**	**2** [0, 4]
% of rice area using rotovation or tractor plow	**0**	**33** [6, 59]	**67** [44, 89]	**0**	**88** [73, 100]

Table 2.2—Continued

	Kpong	Weta (Afife)	Tono	Vea	Bontanga
Sample size[a]	30	29	29	32	30
% of area using combine harvesters	**48** [31, 64]	**33** [12, 53]	**13** [0, 29]	**0**	**20** [2, 38]
% of farmers getting formal seeds (KIP, ICOUR, MoFA, or similar)	**57** [35, 79]	**8** [0, 20]	**86** [72, 100]	Almost 0	**0**
Sample sizea	**30**	**29**	**29**	**32**	**30**
% of rice growers growing Jasmine 85	**41** [21, 62]	**0**	**95** [84, 100]	**18** [0, 39]	**31** [12, 49]
Other major varieties grown	Jet Three, Aromatic Short	Togo Marshall		Agric (3-, 4-month)	Kpasogu
% of rice area getting enough irrigation water when needed	**83** [66, 100]	**87** [73, 100]	**82** [65, 98]	**37** [17, 58]	**68** [49, 87]
% of rice growers taking out credit	**57** [35, 79]	**64** [44, 85]	**15** [2, 28]	**24** [1, 46]	**9** [0, 23]
- credit from wife/sister, traders, or market women (among credit takers)	**52** [30, 74]	**24** [5, 44]	**2** [0, 6]	**18** [0, 41]	**9** [0, 23]
- credit from formal institutions (AgDB, rural bank, or similar) (among credit takers)	**5** [0, 13]	**37** [16, 58]	**13** [0, 26]	**6** [0, 14]	**0**
Average credit amount among all rice areas (US$/ha)[c]	**459** [217, 701]	**265** [36, 494]	**45** [0, 106]	**13** [0, 28]	**4** [0, 11]
Leasing					
% of rice area cultivated under subleasing	**33** [14, 52]	**0**	**1** [0, 4]	**11** [0, 24]	**0**
% of registered farmers leasing out	**23** [8, 39]		**6** [0, 17]	**13** [0, 26]	
Common leasing term	By season				
Average years of leasing history among lessors	**5** [3, 7]				
Average operational size (ha)					
- among all rice growers	**0.8** [0.5, 1.1]	**0.8** [0.6, 1.0]	**0.8** [0.6, 1.1]	**0.4** [0.3, 0.4]	**0.6** [0.5, 0.7]
- among sublessees	**1.5** [1.1, 1.9]		**1.5** [0.8, 2.1]	**0.4** [0.2, 0.6]	
- among nonlessees	**0.6** [0.3, 0.8]		**0.8** [0.5, 1.0]	**0.4** [0.3, 0.5]	
Average price (weighted by sales quantity, dry paddy, US cents/kg)[c]	**47** [46, 48]	**48** [47, 50]	**34** [31, 37]	**28** [23, 33]	**36** [34, 37]
Average price of Jasmine 85 (US cents/kg)[c]	**47** [45, 48]		**34** [31, 37]	**28** [23, 32]	**35** [34, 37]
Gross revenue (US$/ha)[c]	**2574**	**1452**	**1123**	**360**	**927**

Source: Authors' field surveys in 2012.

Notes: KIP = Kpong Irrigation Project; ICOUR = Irrigation Company of Upper Region; MoFA = Ministry of Food and Agriculture; AgDB = Agricultural Development Bank of Ghana.

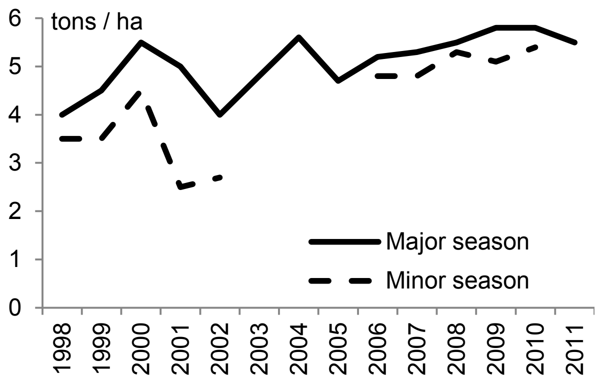
[a] Includes only irrigated rice. Rainfed rice in rainy season is excluded. Figures in brackets are 95 percent confidence interval. Figures are adjusted by sample weights accordingly, so that average figures for the project levels are consistently calculated.

[b] Output/nutrients = production/nitrogen. Nitrogen, phosphorus, and potassium are calculated based on the assumptions that NPK (nitrogen, phosphorus, and potassium fertilizer) is 15-15-15, urea is 46 percent nitrogen, and SA (sulfate of ammonia) is 21 percent nitrogen.

[c] Exchange rate: US$1 = 1.88 Ghana cedis (GHS).

Average yield (dry paddy) in KIP in the 2012 rainy season was almost certainly above 5 tons/ha (Table 2.2). Yield was slightly higher in the major production season (April through September) than in minor season (August through January), as shown in Figure 2.3. Yield used to be slightly lower, around 4 tons/ha before 2005 (AfDB 2005). Current production intensity in KIP is around 170 percent, much higher than the 102 percent reported in 1998 (AfDB 2005). Yield in KIP is significantly higher than yield in all the other four projects, which range between 1 and 4 tons/ha (see Table 2.2). This high yield in KIP is an exception among Ghanaian rice irrigation projects. Yield in KIP seems to have been persistently higher than in other projects like Afife and Bontanga for a long time, since some studies from the 1990s indicate similar differences (Amoatin and Acheampong 1997).

Figure 2.3—Yield trends in Kpong Irrigation Project since 1998



Source: Information obtained from KIP Project Office.

KIP yield is comparable to that of some major canal-irrigated projects in Indonesia (5 tons/ha) and considerably higher than yields in Nepal (4 tons/ha) or India (2.3–3.5 tons/ha) (Mushtaq et al. 2009; Gujja et al. 2007). This level of yield is observed in only a few locations across SSA, including Office du Niger in Mali (Aw and Diemer 2005), Senegal River Valley projects (Nakano et al. 2013), Mwea Irrigation project in Kenya (Njagi, Mano, and Otsuka 2013). KIP yield could be even higher, taking into account the loss due to the manual harvesting still done on 50 percent of the area in the project (Tinsley 2009).[6] Yield seems relatively stable given the high level of control of water, pests, and weeds, although flooding, poor drainage, and poor infrastructure lead to some yield risks.

Rice yields in each project are generally associated with fertilizer use (see Table 2.2). Access to seeds from formal institutions, extensive use of a power tiller, mechanized land preparation, extensive leasing, and higher paddy price also seem to be associated with higher yield. Fertilizer use in KIP is high; generally more than 500 kilograms (kg) of fertilizer, or 120 kg of nitrogen, is used per ha, with combinations of NPK (nitrogen, phosphorus, and potassium) 15-15-15, urea 46 percent, and SA (sulfate of ammonia) 21 percent. Fertilizer use in Tono, Vea, and Bontanga are lower than in KIP and similar to levels described by Al-Hassan (2008, Table 5). More NPK fertilizer is used per ha in KIP than in irrigated rice systems in some Asian countries, including China (256 kg on average), Vietnam (173 kg), Indonesia (167 kg), and India (95 kg) (Zeigler and Mohanty 2010).

KIP farmers typically replace seeds every year, recycling them only from the major season to the minor season. Seed is replaced more frequently in KIP than in other regions in Ghana, indicating more intensive use of improved seeds. The seeding rate in KIP under transplanting is around 75 kg/ha, which is comparable to rates in irrigated transplanting systems in some Asian countries like the Philippines (IRRI 2009). Access to certified seeds may affect the yield difference. While more than half of farmers in the south obtain seed from formal institutions, very few do so in Weta. Similarly, while most farmers in Tono obtain seed from formal institutions, almost none in Vea and Bontanga do so. Yield differences are clearly associated with such patterns.

[6] Based on this rough calculation, the high yield is also economically significant. With an average yield of 5.5 tons/ha (generating about $4,500/ha of revenue) and production costs of about $1,500/ ha, these farmers make around $3,000/ ha. From two production seasons per year, they make about $5,000–$6,000/ha per year. With an average holding of 0.5 ha and household size of six in the area, this is equivalent to about $500 per capita per year.

In KIP, power tillers are almost universally used for land preparation such as tilling and crossing. As described below, it takes roughly 50–100 power tillers of 15 hp to prepare approximately 2,000 ha, realizing a level of mechanization of 0.375–0.75 horsepower/ha, which is comparable to the level in many Asian countries. Harvesting activity has also been increasingly mechanized. As of 2012, almost half of the KIP area is harvested by machine. Use of power tillers and harvesting machines is less common in other irrigation projects.

Rice production in KIP is also labor intensive. Around 110–140 man-days of labor is used per ha (see Table 2.3), even though land preparation is mostly mechanized. Much labor is used for transplanting (11–14 man-days/ha), manual weeding (13–17), bird scaring (25–38), harvesting (11–13), threshing (24–25), and drying (11–12). KIP-area wages are also often higher than typical wages in Ghana and wages for similar activities in neighboring countries.[7] In KIP, farmers seem to intensively use knowledge of crop husbandry practices, such as nursery preparation (including the use of ashes from burned husks to start nursery plants),[8] transplanting (the number of seedlings per hill and spacing), the quantity and timing of input applications, and water depths.

Table 2.3—Labor inputs for different crop husbandry practices in Kpong Irrigation Project

Activity	Labor: Man-days/hectare	Labor: Man-hours/hectare
Nursery preparation	***3***	***14***
Nursery bed preparation	1	6.5
Sowing on nursery bed	1	6.3
Watering	1	0.5
Spraying	***1***	***0.5***
Field preparation	***4–11.5***	***28–77***
Land clearing (weeding)		
Bunding—labor	4	28
Manual tilling (if any)		
Manual leveling (if any)	0–7.5	0–49
Transplanting	***11–13***	***88–104***[a]
Gap filling	***5***	***28***
Fertilizer application—labor	***3–6***	***5–9***
Basal	1–2	1.5–3
Top dressing	1–2	1.5–3
3rd application	1–2	1.5–3
Herbicide spraying	***1***	***4***
Weeding (hand picking)	***13–17***	***104–136***
Bird scaring	***25–38***	***200–304***[a]
Harvesting—processing	***36–50***	***407–438***
Harvesting and cutting	11–13	77–91
Threshing and winnowing	24–25	264–275
Drying and bagging	11–12	66–72[a]
Total	***112–146***	***897–1,135***

Source: Authors' calculations based on interviews with farmers and KIP staff.

Note: [a] Assuming eight hours' work per day for transplanting, bird scaring, drying, and bagging.

The KIP and Weta projects enjoy a 30 percent higher farmgate price of paddy than those in Tono and Bontanga. Milling quality of Jasmine 85 paddy seems better in Kpong than in Tono. Transportation cost explains only part of the price difference. Kumasi traders pay 30–40 percent more for Togo Marshall in Weta than for Jasmine 85 in Tono, which seems a much larger differential than would be simply due to the difference in distance. Empirical studies indicate that rice markets in Ghana are fairly well integrated

[7] For example, in Nigeria, transplanting sometimes takes 20 man-days per ha but total cost is still lower than in KIP (Jamala, Shehu, and Garba 2011).

[8] Planting rice seeds on ash that is layered on top of the soil makes it easier to uproot seedlings without damaging the roots. Ash is obtained for free from burned husks, collected after rice is milled. Only the transportation cost ($2) is paid for ash.

(Cudjoe et al. 2010). Economies of scale do not explain the price difference either. Kumasi traders are estimated to have purchased at least a few hundred tons of paddy in the 2012 rainy season from the Tono project, although less than they purchased from Weta or KIP, as shown in Table 2.4. Competing demand for other crops may also explain the low intensity in area for northern projects. In the north, irrigated rice farming is done more in the dry season, while in the rainy season farmers are more focused on upland farming of maize, groundnut, millet, and sorghum. Vegetable production is also common under irrigation.

Table 2.4—Estimated quantity of paddy sold per season (in ’000 tons)

	From Kpong	From Weta	From Tono[b]
Total	**9.5**	**2.5**	**2.9**
	[7.6, 11.4]	[1.9, 3.1]	[2.5, 3.2]
To Kumasi	**1.6**	**2.1**	**1.0**
	[0.03, 3.1]	[1.7, 2.6]	[0.3, 1.7]

Source: Authors’ field surveys in 2012 combined with rice area.
Notes: Figures in brackets are 95% confidence interval. Figures are adjusted by sample weights accordingly.
[b] In Tono, sales quantity was not obtained, so the figure is the total harvest of rice by producers who sold to Kumasi traders.

Milled rice in KIP attracts higher prices than in other locations as well. As of June 2012, ungraded milled rice was $51/50kg (or $1/kg), and graded milled rice was $59/50 kg ($1.2/kg). In contrast, the farmgate prices of local dry paddy and local milled rice in southern Ghana are typically $0.3 and $0.5/kg (calculated from USAID 2009, Annex A), albeit with yearly variations. The wholesale prices of foreign rice may be between $0.6 and $1.6/kg (Food Security Ghana 2012). KIP milled rice therefore attracts almost twice the price of other local milled rice, comparable to the price of imported rice. A significant proportion of rice in KIP is sold as ungraded rice, and few millers seem to have a grading machine. Milling is undertaken in small plants, some of which do not grade or de-stone, since demand for ungraded rice is considerable, although farmers indicate that larger-scale milling facilities could bring a further premium. Some ungraded rice is sold to schools in Kumasi. Similarly, much rice is sold as mixed instead of pure varieties, indicating that large enough markets exist for ungraded, mixed-variety rice from KIP. Price risks in the open market do not seem serious, except some seasonal variations of 10–20 percent, with the lowest prices in April through June and the highest in November through January.

Subleasing of plots, though usually not allowed in public irrigation projects, is common in KIP (see Table 2.2).[9] Of registered KIP farmers, 10–40 percent lease out their plots, and 15–50 percent of rice area is cultivated under subleasing (ranges are large due to a small sample). Sublessees in KIP operate at twice the scale (1.5 ha) of nonlessees (0.6 ha). Subleasing is also observed in Tono and Vea but to a much more limited extent, and some of the plots in these areas may be leased for production of crops other than rice. KIP started allowing such subleasing a few years ago. A vibrant market has been emerging for tenancy in the area. Most sublessees in KIP are not registered with the project and are relatively new to rice farming in the area. Their yield is, however, almost as good as that of nonlessees. With the subleasing option, skilled farmers with better capital may be cultivating substantial plots in KIP that would otherwise give a lower yield. With high profitability in the area, the subleasing market may be competitive enough to reduce the moral hazard of having lessees in land management. The most common leasing term is by season rather than year or multiple years (see Table 2.2). Lessors are reasonably certain that lands will not be taken from them.

[9] In Ghanaian irrigation systems, land is acquired by the government with compensation and then allocated to farmers guided by Ghanaian Irrigation Development Authority (GIDA) law (the Irrigation Development Authority Regulation of 1987, L.I.1350) and managed by a land allocation committee. According to our interviews with KIP staff, the committee typically consists of two representatives of the assembly in the project area; two representatives of the traditional council in the project area; two representatives of the farmer association; a representative of GIDA; a representative of the KIP as secretary (the project manager); and the political head of the project location, in this case the district chief executive, as chairman. Applicants are allocated land with preference going to those who are displaced and living in nearby communities, as well as some farmers showing strong interest and skills in rice farming. KIP staff reported there are about 20 communities in the nearby area.

In projects other than KIP, the subleasing option is limited either by the project or due to the traditional land-allocation decision mechanism. Around the Tono region, earth priests, chiefs, and state agencies have historically been influential in land allocation (Ubink and Amanor 2008). Village committees seem to play an influential role in land allocation within irrigation projects as well.

Overall, although inputs, labor, and machinery are intensively used, rice cultivation in KIP is profitable thanks to high yield and high farmgate price. Table 2.5 delineates the production budget per ha per season, based on information from KIP Project Office in 2012 and supplementary fieldwork. Typically, KIP rice production yields $2,400/ha of gross revenue at the production costs of $1,500–$1,600/ha. KIP is exceptional in its high productivity among major irrigation projects, which seems mostly enabled by intensive use of fertilizer, power tillers, subleasing of plots, certified seeds from formal sources, easy access to informal credit, and higher paddy price. All other factors seem to explain little regarding the different productivity. Water access is generally good and the irrigation fee is similar among projects.

Table 2.5—Production budget per hectare, per season (transplanting method) in Kpong Irrigation Project

	Figures from KIP Project office				Figures from KIP Project office updated with fieldwork			
	Qty	Unit cost (GHS)	Total cost		Qty	Unit cost (GHS)	Total cost	
			GHS	US$			GHS	US$
Seed	75 kg	1.48	111	59	75 kg	1.48	111	59
Land preparation	1 ha	-	300	159	1 ha	-	300	159
Fertilizer/agrochemicals	-	-	491	260	-	-	577	306
NPK	8 bags	31	248	131	8 bags	31	248	131
Urea	1 bag	30	30	16	1 bag	30	30	16
Sulfan/SA	3 bags	26	78	41	3 bags	26	78	41
Herbicides/weedicides	10 liters	10	100	53	10 liters	10	100	53
Fungicides	2 kg	10	20	11	2 kg	10	20	11
Insecticides	1 liter	15	15	8	1 liter	15	15	8
Harvesting materials	-	-	-	-	-	-	86	46
Labor cost per ha	-	-	2,050	1,086	-	-	1,805	956
Transplanting	-	-	300	159	-	-	300	159
Gap filling	-	-	-	-	-	-	175	93
Bund repair	-	-	50	26	-	-	50	26
Nursery preparation/care	-	-	40	21	-	-	40	21
Hand picking/weeding	-	-	300	159	-	-	300	159
Rouging	-	-	0	0	-	-	0	0
Spraying	-	-	150	79	-	-	150	79
Fertilizer application	-	-	60	32	-	-	60	32
Bird scaring	-	-	150	79	-	-	150	79
Harvesting/postharvest	-	-	1,000	530	-	-	-	-
Harvesting	-	-	-	-	-	-	280	148
Threshing	-	-	-	-	-	-	300	159
Irrigation service charge		1 ha/season	60	32	-	-	60	32
Total cost	-	-	3,012	1,596	-	-	2,853	1,511
Price per 90 kg bag	-	-	74	39	-	-	74	39
Price per kg	-	-	0.82	0.44	-	-	0.82	0.44
Gross revenue (with yield = 5.5 tons/ha)	-	-	4,522	2,396	-	-	4,522	2,396
Net revenue	-	-	1,510	800	-	-	1,669	884

Source: Authors' calculations based on information obtained from KIP Project office and informal interactions with farmers during the field visits.

Notes: NPK = Nitrogen, phosphorus, and potassium fertilizer; SA = Sulfate of ammonia; ha – hectare; kg = kilogram
Exchange rate is US$1 = 1.88 GHS.

3. SOURCES OF KNOWLEDGE, INPUTS, AND TECHNOLOGIES

High productivity in Kpong Irrigation Project (KIP) is generally associated with intensive use of knowledge, inputs, and technologies. Here we briefly summarize the sources of these factors.

Crop Husbandry Knowledge

Modern rice production in SSA requires specific knowledge-intensive farming activities (Kijima, Ito, and Otsuka 2012), such as nursery preparation, transplanting, line planting, spacing, and bunding. Many KIP farmers seem to understand the benefits of modern crop husbandry practices and therefore apply them. Such knowledge in the KIP area appears to have been gained from various sources.

External Sources of Knowledge

In the KIP rice area, much knowledge seems to have been provided by eight KIP extension staff members (three provided by the Ministry of Food and Agriculture (MoFA) and five employed by KIP), Korean individuals and a Korean school (Bok Nam Kim's Agricultural School and Farms Limited), and Japanese and Thai institutions (see Appendixes A and B for more detailed descriptions of the activities by Korean and Thai institutions). Many extension staff members have received training in Japan, China, Egypt, and the Philippines on hybrid rice seed, rice processing, or irrigation and drainage.

The most influential source of transplanting knowledge in the area appears to be a Korean expert called Dr. Ann, who had been the head of the Asutsuare Irrigation Project in the area during the 1980s and moved to KIP in 1992. Similarly, beginning in 1988, the Japan International Cooperation Agency (JICA) implemented a technical cooperation project in Ashaiman, located one hour south of Kpong. Between 1988 and 1992, the JICA project launched the Irrigation Development Center (JICA RI 2006). The later project (the Small-Scale Irrigated Agriculture Promotion Project) started in 1997 and produced the guidebook on crop husbandry that is currently used by the KIP extension staff for reference (GIDA and JICA 2004). KIP disseminates this information to farmers using demonstration plots. Farmers we interviewed seemed to understand the benefits and practice some of them, including the spacing for transplanting and nursery preparations.

Internal Sources of Knowledge

Not all the accumulation of knowledge may be attributable to the external sources. Some farmers, particularly in Section B, have been growing irrigated rice since the 1970s by pumping water directly from the Volta River. These farmers have taught themselves some crop husbandry practices with minimal or no external training. Extension visits to this section seem relatively uncommon, except demonstration of new chemicals and their application. Only a few practices, such as transplanting, seem to have been brought externally to these farmers, who appear to have started transplanting gradually from the 1980s through 2000.

Some knowledge might also have been obtained from other regions, since transplanting seems to have had been adopted, though still uncommonly, in Ghana in the 1980s. For example, in the Ashanti region, about 40 percent of farmers were growing GRUG 7 (an irrigated rice variety released in 1986) in the late 1980s, and half of them were using transplanting or bunding (Dankyi, Anchirinah, and Apau 1996). Some KIP farmers might have gained knowledge of these practices through informal interactions.

Seed

In order to respond to the rising demand for aromatic rice, the Ghana Rice Inter-professional Body (GRIB) commissioned a study of rice varieties grown in Ghana, which was carried out in the middle of the first decade of this century by a team led by Ghanaian expert Dr. Oteng. According to MoFA staff members interviewed, the study first selected 14 varieties, including both aromatic and nonaromatic varieties. From these, Jasmine 85, Aromatic Short, and Togo Marshall were selected and given to KIP for seed multiplication and certification.

Jasmine 85 was originally brought from the United States to Ghana, although the exact timing is unknown. It is the "first US long-grain cultivar possessing the aromatic flavor and cooking quality of the highly prized fragrant rice from Thailand" (Marchetti et al. 1998). Developed to satisfy the needs of southeast Asian immigrants for such rice in the United States, it was adapted from the varieties grown in northeast Thailand, developed at the International Rice Research Institute (IRRI), tested at the US Department of Agriculture–Agricultural Research Service state program at Beaumont, Texas, and released for production in the United States in 1989 as Jasmine 85 (Marchetti et al. 1998).[10]

One of the currently grown varieties, Jet Three, was brought from Benin to the Volta region and then to the KIP area, not through the aforementioned GRIB study but informally by one young farmer in 2009, who was originally from Asutsuare. Jet Three generally performs well, although it is sensitive to dryness and tends to break up easily at an inappropriate moisture level. It is unclear whether these varieties have been introduced through the formal seed program, since public institutions in Ghana and the West Africa Rice Development Association (WARDA) may not be breeding many aromatic lines of varieties like these (Tinsley 2009).

Currently grown aromatic varieties in KIP are not the first Asian varieties in the area.[11] Thai varieties such as Thailand 440, JB 90, and Zongo, which appear to have been brought in by the government from Thailand, were widely grown in Section B in the 1970s. According to some on-farm trial records and informal communication with farmers, many of the previously grown varieties, although broadcast and grown without many power tillers (but with tractors), could potentially realize yields similar to those of current aromatic varieties; some other records, however, suggest that the yield was modest when the varieties were grown by farmers (AfDB 2005).[12] These varieties disappeared more than 20 years ago, and no farmers kept the seed. Although they were not aromatic, they were palatable and popular among farmers, although they were difficult to thresh. Many farmers there still think that if there were aromatic varieties of Thailand 440 and JB 90, they would grow them. Other varieties grown in the past include Bouaké 189, RC 34, RC 54, RC 48, WITA 9, WITA 8, Otofio, Togo Marshall, and Marshall from Ashaiman.[13]

[10] Jasmine 85 was later promoted in larger scale in Ghana under the Emergency Rice Initiative Project, launched in 2009 after the rice price spike in 2008 (Buah et al. 2011).

[11] Various Asian varieties had already been grown under the Asutsuare project, including IR 442, IR 42 (Olufowote, Pankani, and Das Gupta 1985), and GR 18 (IR 3273-P339-2). IR 442 was released in 1975 and was popular among farmers. In 1983, the Asutsuare project had 410 ha (Olufowote, Pankani, and Das Gupta 1985), out of which 202 ha was under GR 18. GR 18 seemed to have been introduced for a rainfed lowland. The area is also close to the agricultural research station of the University of Ghana, which had been in charge of screening varieties for irrigated ecology (Kranjac-Berisavljevic, Blench, and Chapman 2003). Some of the first Asian varieties, now called Mande, were introduced by IRRI through Kpong Agricultural Research Station in the early 1960s (Kranjac-Berisavljevic, Blench, and Chapman 2003). The Asutsuare area thus seems to have had much exposure to Asian varieties of rice prior to KIP. Some of the earlier Asian varieties, such as IR 42 and IR 3273-P339-2, appear to have been very popular for irrigated cultivation in the Asutsuare area (Olufowote, Pankani, and Das Gupta 1985). WARDA encouraged their spread by on-farm trials from 1979 to 1983. In 1983, 202 of 410 ha at the Asutsuare Irrigation Project site as well as the Weta project (830 ha) were planted primarily in IR 3273-P339-2. IR 442, released in 1975 and yielding on par with IR 3273-P339-2, also remained popular with some farmers. No certified IR 42 seed was available and about 1,000 tons was imported from the Philippines with the assistance of the United States Agency for International Development and the United Nations Development Programme (Olufowote, Pankani, and Das Gupta 1985). These varieties usually obtained 5 tons/ha, based on on-farm trials (FAO 2002).

[12] In Asutsuare, some varieties realized close to 8 tons per ha in on-farm trials, although the yield could be below 4 tons per ha on farmers' plots (WARDA 1982, Table 20).

[13] Bouaké 189 is an Indonesian variety introduced through an IRRI international nursery (WARDA 1999). WITA 8 and 9 were bred by WARDA and the International Institute of Tropical Agriculture, both with tolerance against yellow mottle virus (WARDA 2002). RCs are likely to be Philippine Seed Board varieties, developed by either IRRI or the Philippine Rice Research Institute. RC 34, RC 54, and RC 48 were developed in 1995, 1997, and 1995, respectively (PRRI 1997). RC 48 is a salt-tolerant variety (AfDB 2005).

KIP, and recently the Thai project, have also provided seed-producing farmers with training on seed production. There are currently about 10 certified seed growers in KIP. Because the Ghana Irrigation Development Authority (GIDA) has the mandate to produce certified rice seed in Ghana, KIP farmers have better access to certified rice seeds than farmers in other areas. Seeds are inspected by MoFA staff and tested.[14] Seeds grown during the previous season can be used as certified seeds as quickly as in the next season. KIP seed production seems to be financed without external support and is likely to be commercially viable, although JICA initially provided technical support for testing and certification procedures. Seed supplied by KIP is, however, typically 50 tons per season, and meets only a fraction of demand (see Table 2.2). Many KIP farmers, who typically replace seeds at the beginning of the major season each year, obtain them from relatives or other farmers instead of KIP.

Fertilizer and Chemicals

The source of soil nutrients is largely external. KIP sells some fertilizer to farmers for cash from its warehouse, but most farmers buy directly from dealers. The government initiated a 40 percent fertilizer subsidy in 2008. Subsidized fertilizer seems to become available at a specific time each year, possibly affected by when subsidized prices are determined,[15] when vouchers (passbooks in 2012) are distributed, and also the physical supply of fertilizer.[16] While farmers seem somewhat responsive to such timing, in most cases, fertilizer does reach farmers at the subsidized price eventually, as is indicated by the intensive uses commonly observed. In addition, according to KIP staff, fertilizer use was already high prior to 2008.

Most chemicals for production (selective and nonselective herbicide, insecticide, pesticide, and fungicide) and seed chemicals appear to be easily accessible in the KIP area. Information about new chemicals is often disseminated through demonstration by chemical importers as well as through input dealers and KIP staff. Labor for applying fertilizer and chemicals seems mostly provided by families.

Mechanization

Most of the major machinery and parts are provided from external sources, except the minimum repair and maintenance service and parts provided or fabricated by local blacksmiths and repairers. Most power tillers and harvesting machines have been brought with a subsidy, but the mechanization services have been mostly provided by private service providers.

Power Tillers

Power tillers used in the area are typically combined with rotary tillers, which facilitate taking short turns on the field. There are about 50–100 power tillers in the KIP area. A rough breakdown of existing power tillers by brand shows 40 percent Shakti (Indian); 40 percent Kubota (Japanese); and 20 percent Dongfei (Chinese), Daedong (Korean), and Yammar (Japanese). Most power tillers seem to have been supplied over time by the government at subsidized prices. Shaktis were provided in the 1980s and in 2008. In around 2000, the government brought in close to 100 Yammar power tillers, of which several were allocated to the KIP area. In 2006, the government brought in 400 Kubota power tillers, of which 70 came to the KIP area. Between 200 and 500 Daedong power tillers were initially brought into Ghana by the Afko Company (a Korean fisheries company in Ghana) in the 1980s, and some of them are likely to have remained in the KIP area. Power tiller owners are often rice farmers, who use them for their own plots as well as for other plots for a fee.

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[14] The germination rate accepted by KIP is 86 percent.

[15] In 2012, for example, MoFA announced the subsidized fertilizer price in June (Ghana, MoFA 2012).

[16] The Ghanaian government does not seem to be involved with the direct distribution of fertilizer (Banful 2009), unlike in some countries, such as Nigeria, where the government's direct involvement often delays fertilizer distribution. However, the current fertilizer subsidy is relatively new in Ghana, having just started in 2008. Private distribution networks may be underdeveloped given the size of demand at the subsidized price, possibly causing a delay in fertilizer delivery.

Widely seen brands in full operation are Shakti and Dongfei. Their spare parts, such as engines, are generally available in Tema, and relatively easy to get. Power tillers with Shakti bodies and with engines manufactured by another Chinese company, Chang Fa (sold at $430 and typically lasting two years), are particularly common. Most Shakti power tillers (sometimes together with a 15 hp generator, water pump, and car washing machine) cost about $2,000 after the 50 percent subsidy, although the prices might have risen sharply recently. Other more popular brands like Yammar, Kubota, and Daedong (lighter and suitable on muddy plots because they do not sink) are not seen, not because of their prices (Kubota is $1,600 after subsidy, cheaper than Shakti) but because their spare parts are unavailable. Shakti power tiller owners learn about the availability of spare parts, including Chang Fa engines, when they buy them at the store in Tema or Accra. Some Daedong power tiller owners use personal connections to obtain spare parts from abroad. Most power tillers have been purchased without bank financing.

Tilling service is provided mostly by these private owner–operators. Shakti power tillers can till 1–2 ha (2.5 ha if crossing) in a day, consuming 3 gallons of fuel, with 0.5 gallons consumed traveling to the farm. The tilling service is typically $130–160 per ha, but it has been rising at the rate of $25–30 per year in the last 3–4 years, mostly due to the scarcity of machines.[17] Each power tiller owner typically serves 20–40 ha per season (40–60 ha per year), mostly tilling 1 ha per day, 5 days per week in May and June. Transportation service by power tiller is limited to owners' personal use and rarely provided for other farmers. Maintenance cost of a power tiller is around $600 per season, mostly for gears in the rotary, belts, chains, and iron tires. There are around 10 repairers in the area, charging typically $30 per repair. The maintenance cost is relatively high compared with the subsidized machine cost. Such a distorted price relationship may encourage farmers to use power tillers as disposable tools. Ages of these power tillers vary considerably in the area, ranging from more than 20 years to only 1–2 years. Under good maintenance, a typical power tiller can last for more than 4–5 years if used on moist paddy (Ademiluyi, Oladele, and Wakatsuki 2009). Power tiller owners typically have a few operators per power tiller working for them. Peak seasonal demand exceeds the supply of power tiller service. Timely service is often difficult to get, with waiting time reaching up to a month. Owners pay about $20–30 per ha to operators for tilling, while farmers requesting tilling service will pay operators $10 per ha for food and drinking water.

Some operational knowledge has been provided externally by GIDA, the Korean Agricultural School, and JICA volunteers. One operator learned about 8–10 years ago from JICA that since the front wheel is heavy, it is important to turn it to the side that is not yet tilled. Usually, however, owners and operators of power tillers gain operational skills through observing neighbors and practicing.

Harvesting Machines

Mechanized harvesting service has been increasingly provided in the KIP area by private investors. By 2012, seven combine harvesters had been brought in by private investors and three by MoFA. One combine can harvest 1 ha in a few hours, while manual harvest will take seven people and two days. Service by combine harvester is provided by KIP at $120 per ha, which is likely similar to what the private service providers charge. Common brands of harvesters and prices are a Thai brand ($85,000, nonsubsidized), the Japanese Yammar brand ($55,000 subsidized price), and the Foton brand ($35,000 subsidized price). Most buyers of combine harvesters obtained them through subsidy.

Irrigation Facilities, Land, and Roads

Irrigation facilities, road infrastructure, and land have been either provided or rehabilitated by KIP, unlike in private irrigation facilities constructed by communities seen in other parts of West Africa. In Sections A and B combined, a total of four night storage reservoirs, 26.5 km of main and branch canals, 200 km of laterals, 29.6 kilometer (km) of drains, and 8.4 km of grass waterway were constructed, and 22.5 km of

[17] This seems quite high compared with the tractor plow service on the other side of the Volta River, which is about $45 per ha (SNC Lavalin International 2010), indicating the higher returns from tilling in our study area.

canals and 10.2 km of drains in Section B were rehabilitated before 2005 (AfDB 2005). In addition, KIP constructed 18.1 km of primary roads (AfDB 2005). While water was directly pumped from the Volta River in the old Asutsuare Project that was in Section B, current use of pumping seems rare in Section B. The construction of canals might have significantly expanded the areas irrigable in Section B. Water is provided to farmers through canals and laterals generally on time, except during peak demand period, when delayed credit release by the Agricultural Development Bank of Ghana (AgDB) causes a delay in water service. The water service charge (levy) has been fixed at 120 GHS ($64) per year, paid in dry paddy. The charge was lower, at 70 GHS ($37), until 2007, and it was 45 GHS ($24) around 2001. The recovery rate has been about 40–50 percent in recent years.

KIP has 100 maintenance staff members to maintain the irrigation facility. Some sections of canal have been choked up with weeds, causing flooding and disabling water control in about 150–200 ha. Generally, however, management has not constrained yield in KIP. Farmers in some sections organize themselves and clean the canal, mobilizing 20–30 people for two weeks during the off-season, perhaps motivated by high profitability.

KIP newly excavated land in Section A while it rehabilitated land in Section B. The lands in Section A were allocated in 2001 at the rate of 2 acres (0.8 ha) per family. This size is considered the smallest viable unit. The level of initial land clearing by KIP might have affected farmers' leveling costs and efforts. Even with the power tiller, leveling becomes costly if the land surface is too rough at the beginning. More problems of this type are observed in Section B.

In section B, where irrigated agriculture has been practiced for a long time, there is a long history of conflict over land allocations. During a period when GIDA was not exercising control, farmers from a nearby community allocated the land to themselves. GIDA eventually legitimized the allocations by making the farmers sign agreements. These agreements are supposed to be renegotiated every five years, but the renegotiations have not systematically taken place.

Other Resources

Credit

Credit in the KIP area is provided by either AgDB or money lenders, many of whom are women traders. On average, $459 per ha of credit (up to 30 percent of production cost) is taken out in the KIP area, the majority of it provided by money lenders, family members, traders, millers, and input dealers (see Table 2.2). Lending in smaller amounts is also common. One miller with a capacity of 10 tons per day supports about 50 farmers by lending them $30–50 or some inputs like fertilizer, or both. One of the input dealers supports 5 farmers in a similar way.

Formal credit is also provided but in much smaller quantity. Under the African Development Fund, $4 million was provided to AgDB from 1997 to 2001 to establish a revolving credit fund. Currently about 300 farmers, out of 2,600 farmers in the project, receive these loans at interest rates of 20–30 percent, with a payback rate of 80–90 percent. AgDB bases farmers' loan requirements on a crop budget submitted by KIP each year. No collateral is required if the loan is given to a solidarity group consisting of at least 5 farmers, although a deposit of 10 percent is required to cover any default of a group member. These groups are formed by farmers themselves, sometimes irrespective of their canal sections. When borrowing from AgDB, farmers must pay KIP all of their paddy, from which the bank deducts the loan payment. The return of the balance of the paddy to farmers is often delayed by up to a year, creating additional costs from the borrower's perspective.

Labor

Labor in the KIP area comes from both within and outside the project area. Labor is usually provided as a group and requested through the group leaders. Labor demand has been rising, with rice and banana production combined employing 1,700 men and women, and the cost has been rising as well. As was mentioned above, daily wages in the area are often high enough to bring workers from outside the KIP villages, who used to be engaged in charcoal burning or petty trading at lower wages.

Milling

Milling in the KIP area is mostly done by private agents who have invested in milling facilities and land, even though the land for a medium-size milling facility could cost as much as $8,000. Some millers travel to other regions for extra paddy. Several milling facilities in the area can produce more than 10 tons of milled rice per day. Some milling services are also provided by input dealers. Only one milling facility owned by KIP is public, with a capacity of 2.5 tons/day. Typical capital expenses are the milling machine ($4,400), de-stoner ($3,200), grading machine ($2,800), elevators ($1,100, typically supplied by RST Company from India), and electricity ($400 /month in a 15-ton milling facility). Repair services seem generally available from RST when needed. The electricity supply in the area is sometimes irregular, but the milling facilities seem to operate actively.

Markets

Markets in KIP area are mostly private, though KIP provides a guaranteed market for some farmers.[18] Nearly all credit repayment, whether to banks, processors, traders, or KIP for irrigation charges, is made in kind. Those who borrow interest-free from traders or processors are expected to sell their produce at about $30 per bag less than the prevailing market price. There are seven traders who handle 75 tons of milled rice per week for several weeks during peak season. Assuming 10 weeks for the peak season, this works out to 5,000 tons out of the total 7,000 tons of milled rice from the area (2,000 ha times 5 tons/ha times a factor of 2/3 for converting paddy to milled rice). Traders use a mill house as their storage space.

Drying and Storage Space

Drying and storage space in the KIP area are provided by the project; there are three warehouses for harvested dry paddy, the largest of which has a capacity of 160 tons. There are also several drying spaces constructed by the project. Currently, about 15 mills also offer drying space for farmers who make use of their milling facilities. Most other farmers use tarpaulins for drying paddy.

Institutional Support

Institutional support in the KIP area is provided by the cooperative, which consists of all farmers registered with KIP. The cooperative negotiates chemical prices with input dealers. In 2011, the chemical price was reduced from 7 GHS ($3.7) to 6 GHS ($3.2)/liter of glyphosate and from 14 GHS ($7.4) to 12 GHS ($6.4)/liter for the insecticide Desban.

[18] At the beginning of each production season, KIP sets the buying price for the harvest.

4. CONCLUDING HYPOTHESES AND RESEARCH QUESTIONS

Although more empirical work is needed to test various hypotheses, current rice production performance in the Kpong Irrigation Project (KIP) and its evolutionary history has potentially wider implications for agricultural transformation in Africa. While irrigation could be transformative, its potential has rarely been realized in Africa, often due to poor design and management of public irrigation systems. While private, small-scale irrigation works in certain countries, it is mostly confined to small-scale production of horticultural crops. Irrigation performance in KIP, however, seems to be different from that in the majority of public irrigation projects in Africa, realizing high yields and employing intensive cultivation and machines. KIP farmers have also adopted labor-intensive crop husbandry, with labor input per ha, aside from land preparation, which is mostly mechanized, being about 110–140 man-days/ha for farmers using transplanting. Key hypotheses are that high profitability has been made possible by infrastructure (especially irrigation) and technology (including varieties and crop husbandry practices).

Public investment has played a key role. Investments in upgrading KIP to be able to offer water control have provided the basis for the effective practice of irrigated agriculture. Extension services offered by the irrigation system are effective, with well-trained extension agents who have manuals to fall back on. Knowledge spillovers from a number of projects and programs that operate in and near the system are reported. Knowledge of good husbandry practices also has been developed through long practice of rice cultivation in the region. The varieties bring high yields and attractive prices in the market. The system's efforts to supply certified seeds have been critically important to ensuring the use of appropriate genetic material.

Private services have developed to cater to this profitable farming community. The KIP project began with the involvement of the Agricultural Development Bank of Ghana (AgDB), whose role has diminished over time because of insufficient repayment rates. But nearly all of the farmers are able to apply recommended levels of external inputs from their own savings or funds borrowed from traders in addition to the AgDB. The traders who supply to small-scale processors extend considerable credit. The process was accurately captured by an extension agent who said, "Rice farming is so profitable here, money lenders have come in."

A number of small-scale milling companies have emerged. They offer platforms for drying paddy as well. The three companies that KIP developed are no longer sufficient to dry all the paddy produced in the system. Similarly, a number of private suppliers of mechanization services have emerged for land preparation and harvesting. They may be benefiting to various degrees from the government's mechanization program, in which machines are sold to individuals at a discount.

A number of opportunities are still unexploited. Whether inadequate supply of machines is the result of credit constraints or viability needs to be examined. Milling also could be improved with larger-scale mills, using better technologies. Coordination problems are perhaps hindering investments in more efficient milling facilities. The developments in this system are more atomistic rather than emerging from systemwide planning and coordination. Farmers are not as well organized as in other systems, and recovery of the irrigation service fee is poor. Overall, however, the system that has evolved is both productive and profitable.

Assessment of current situations helps us understand why the observed intensive and productive system is possible. However, it is unclear how the current level has been reached in Kpong and what components of this localized agricultural transformation can be applied for a wider-scale transformation in Ghana. The production system in the area is likely to have evolved over time through a sequence of adoptions of improved technologies and crop husbandry practices, knowledge accumulation, and skill formation. Understanding such a sequence is crucial in scaling up for a similar transformation of agriculture elsewhere. In addition, high yield in Kpong is driven by farmers' intensively using inputs and technologies, while similar varieties, inputs, and technologies have not induced farmers to do the same in other projects. Why is this the case? How were many of the constraints overcome in the early stages, when high profitability had not yet been established? We conclude by listing several key questions that should be addressed in future studies.

Question 1: Was more public support provided to KIP than to other projects?

A significant amount of support has gone into the KIP area, starting from the initial irrigation development project in Section B in the 1960s, including infrastructure development (land leveling, canal and road construction), training of extension staff and preparation of extension manuals, establishment of an on-site seed production and certification system, and subsidized provision of machinery (power tillers and combine harvesters). All of these have been provided by the Ghanaian government as well as various donors. Have other projects received similar public support?

Question 2: Is the price difference important?

Varieties in the KIP area attract higher prices than the same varieties in other locations. The difference in transportation costs is unlikely to explain this price difference. Is the quality different, and is it due to the production practices?

Question 3: Does the sequence of technology adoptions in KIP explain the high yield?

Interactions with farmers indicate that without power tillers, farmers may broadcast rather than transplant, because power tiller rotovation and crossing loosens the soil so that they are able to use their bare hands to transplant. It is not possible to transplant if a power tiller has not been used to prepare the land. Alternatively, several production practices and technologies have been adopted simultaneously. Particularly in Section B, prior to the introduction of transplanting in the 1980s, different Thai varieties were grown using tractors instead of power tillers, and rice was irrigated by pumping water from the river instead of relying on gravity. It is also possible that the knowledge of transplanting might have induced more demand for power tillers. What was the key sequence of technology adoption in KIP that was successful? Would a similar sequence have worked in other projects?

Question 4: How did external injection of knowledge contribute to knowledge accumulation, and how much was farmers' own learning? Does high profitability provide farmers with more incentive to learn the technology?

The area has received much external knowledge infusion on crop husbandry practices. Many of the extension staff in the area have also received training abroad. Some evidence indicates that extension is key for boosting lowland rice production in Africa, through the adoption of appropriate production practices including bunding, leveling, and row planting (Kijima, Ito, and Otsuka 2012). As was mentioned above, however, some farmers in Section B seem to have learned optimal fertilizer application timing over time through trial and error. It seems Sections A and B have been exposed to different levels of extension services and a different cultivation history, and contrasting them may give us some information. Similarly, the high profitability of the technology might have induced farmers to acquire knowledge, which might have sped up knowledge transfer and raised the returns on public support of extension.

Question 5: How important has been the fertilizer subsidy that started in 2008?

As was mentioned above, fertilizer use for some farmers had already been high prior to the introduction of the fertilizer subsidy and did not change substantially after its introduction. Some other farmers in the area, however, seem to delay their planting as they wait for subsidized fertilizer. If the former is primarily the case, the subsidy might have had little impact on fertilizer use, indicating that high profitability and availability of fertilizer alone can increase famers' fertilizer use. On the other hand, the latter is the case if demand for fertilizer is price elastic, and in that case the subsidy is likely to have increased fertilizer use by rice farmers in the area.

Question 6: How much can soil fertility explain the yield variations, production practices, and prices?

Some KIP extension staff members attribute higher yield in the KIP area compared with that in the north to a difference in soil quality. Vertisols in the KIP area are known to be fertile and suitable for basin irrigation. Office du Niger, which realizes a similar 5 tons/ha of yield, is also located in a Vertisols area (see Figure 2.2). Vertisols seem to be a plausible reason for the high yield in KIP. However, questions remain. Why was the rice yield formerly lower in KIP? Why haven't other Vertisols areas in northern Ghana been explored for rice production? More globally, why is the rice yield in India still relatively low, even though Vertisols are prevalent there (FAO et al. 2012)? Soil fertility only partly explains high yield in KIP.

Question 7: Are labor wages in KIP higher than in other regions? If so, is it because of the higher labor productivity? Where do these laborers come from?

Rice production in the area is labor intensive despite the mechanization of land preparation and some of the harvesting. Demand for various manual work seems to be met by labor not only from within the project area but also from nearby villages outside the project area. Do more skillful workers come to the KIP area because of higher returns?

Question 8: Is land tenure important?

Subleasing in KIP is a relatively unique phenomenon among SSA public irrigation projects. Does the project's allowing subleasing raise the yield significantly? Or does high profitability induce the emergence of an active subleasing market, where competition among skilled and capital-endowed sublessees raises productivity and reduces moral hazard?

Question 9: Is domestic research and development on rice varieties still important?

Essentially imported varieties like Jasmine 85 have been successful in KIP but not in other irrigation projects. Transferring internationally bred varieties, such as International Rice Research Institute (IRRI) varieties, has been difficult in Africa, except in Sahel regions such as Senegal and Mali or northern Nigeria, whose agroecological environment is closer to that of Asia than more tropical regions (Dalton and Guei 2003). In Asia, national and subnational research played as important a role as IRRI did in breeding varieties well suited to the local production environment (Hossaini et al. 2003; Hayami and Yamada 1998). In many West African countries such as Nigeria and Ghana, nationally and subnationally bred varieties are scarce. Does this mean domestic research and development is still essential in Ghana to breed better varieties for other irrigation projects and, more broadly, to support agricultural transformation on a greater scale?

Question 10: Is there agricultural transformation in KIP and is it sustainable?

High productivity in KIP so far has been supported by intensive input use, but the levels of total factor productivity as well as labor productivity are unknown. Still, mechanization is growing, wages are getting high, and the private sector is evolving. Production in KIP may be approaching the point of transformation. Also, irrigation was one of the key components in agricultural transformation in Asia (Timmer 1988). Agricultural transformation, however, often depends on the linkage with a growing nonfarm economy (Delgado, Hopkins, and Kelly 1998; Barrett, Carter, and Timmer 2010). In Asian countries such as Japan and Thailand, local innovation and manufacturing of motors and simple power tillers coincided with the Green Revolution (Francks 1979; Wattanutchariya 1983). Is there a nonfarm economy growing in the KIP area or a nearby area, other than the service sector that involves trading, financing, and mechanized operation? If not, will that lack affect the sustainability of current growth in KIP?

APPENDIX A: KOREAN PROJECT IN THE AREA

- Bok Nam Kim's Agricultural School and Farms Limited
- Met farm manager (Mr. Kwak Tae Yeon)
- Founder is Bok Nam Kim, currently handled by his wife
- Korean, works through Ministry of Food and Agriculture (MoFA)
- Has a milling plant
- Has 9.844 ha, 12 plots since 1999 (according to Kpong Irrigation Project [KIP] staff members) in Section C1. The farm manager told us it's actually 20 ha for rice and 17 ha for maize, piggery, Tilapia, and vegetable farm.
- Buys seed from KIP
- Korean school—one-month short course on rice production. Trains extension staff, researchers from around the country. It is free, with meals. Due to bed capacity, only 40 can be accepted at once. Usually people from MoFA, research institutes, and youth leadership, but also people from Nigeria and Gabon attend. Farmers in KIP area also select 5–10 farmers to attend. Curriculum is solely on rice farming, from land preparation to harvest. It basically teaches rice seed selection, nursery, transplanting, herbicide use, fertilizer use, harvest, and milling. The lecturers are Ghanaians, including Dr. Oteng.
- The project was started in 1982, and school started in 1985. Since then, 1,200 students have graduated from the course.
- The course manual may be obtained from MoFA. Lecturers bring their training manual when they come, so the school does not have manual.
- The course also teaches how to use power tiller for plowing, for 3 hours per week, for a total of 15 hours in 5 weeks.
- Owns
  - transplanter—brought in in 2002—can transplant 2 ha in a day
  - two harvesters bought in 1985, another in 1996
  - two power tillers
  - mill
- The director of the school (or maybe the fisheries company Afko) brought in 200–500 power tillers in 1988 (in relation to Seoul Olympics). These power tillers were either donated to somewhere or sold locally. Apart from that one-time supply, there has been no supply of power tillers.

Some Contents from Korean School

One farmer, the chief's nephew, attended Korean school.

- Land preparation:
  - Water depth to be 1 inch before tilling; in reality this is not practiced because land is rarely leveled.
  - Use a 2x3 board hooked to the power tiller for leveling. This was practiced in the farm and farmers say it was good. He did know this before. But since then he has practiced this because he does own a power tiller.
- Transplanting:
  - Use finger to measure the gap; in practice farmers do not do this because they have to pay workers extra to encourage such practices.

- Keep 0.5 inch of water when transplanting, so that seeds germinate faster. This is again inapplicable, because the land is not level.
  - Close transplanting will only aid upright growth of plant.
- Weed control—two weeks after the transplanting, spray the weedicide. This will kill weeds before they overgrow, and minimize the need for hand picking later. About 50 percent of farmers in Section B do this.
- Application of fertilizer:
  - Put water to about 1 inch when you apply fertilizer.
  - Basal fertilizer application before transplanting.
  - Another application after 3 weeks, and another after 5 weeks.
- Pests (stem borer) within the joint:
  - Use pesticides to control insects. You should mix pesticides with fertilizer and apply. The pesticides the school uses are Furadan and Durban.
- Nets for bird scaring
- Postharvest—use sickle instead of cutlass; not practiced because it takes longer to harvest.

APPENDIX B: THAI PROJECT IN THE AREA

- Thai Ghana Holding Ltd.
- Established under Thai–Ghanaian partnership. It started the business in 2011.
- Focus on
  - quality paddy (training on certified seed production)
  - quality production
  - land preparation
  - water management
  - fertilizer
- Variety is Jasmine 100 (considered purer than Jasmine 85). Also in the future, project will introduce Super Rice from China with yield of 12 tons/ha.
- Business goal is to invest in the area, since organizers think the soil is good enough to achieve a yield of 9.5 tons/ha (same as in Thailand). In 2011, using 9 bags of fertilizer, they obtained 9 tons/ha.
- Also trying to accept students to learn the technology (have not done yet—this is new project)
- Capital is $800,000.
- Project has 74 ha of plots, contracted from Kpong Irrigation Project. The area had been abandoned for long time after sugarcane production stopped. The project leaders think the soil has not been depleted and is very good. The rent is 120 GHS ($64)/ha.
- Has five permanent Ghana staff and five Thai staff, with many casual workers, to cultivate 74 ha
- Has Thai machinery (Kaset Phattana brand, meaning "agricultural development" in Thai):
  - One combine harvester (260 hp)—can harvest 6 ha/eight-hour day
  - One power tiller
  - One rotovator—4 ha/day
  - One tractor
- Offers services to farmers:
  - Tilling at 400 GHS ($213) per ha
  - Combine services at 450 GHS ($239)/ha
- Wants to improve production practice so farmers
  - will not do slash-and-burn (has been done in this particular section);
  - use water more intensively—for example, using water to kill weeds instead of chemicals (as is practiced in Thailand), filling the plot with water for two weeks and letting weeds die before rotovating; and
  - drain water at panicle stage but reintroduce water after a week, in order to control straw growth, because if the water stays on the plot, the straw will overgrow and the stems can easily be floored.appendix

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