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Dynamics of Transformation: Insights from Rice Farming in Kpong Irrigation System (KIS)

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INTRODUCTION

Rice plays an important role and has potential in the development strategy for many West African countries, including Ghana. Among major crops, rice has the highest potential for overall agricultural growth and for generating the greatest producer benefits for many West African countries (Nin-Pratt et al. 2009).

But Africa is a net importer of rice, accounting for 32 percent of global rice imports in 2006 (Somado et al. 2008). Ghana imports 60 percent of its rice (Breisinger et al. 2012). Imports of aromatic rice, which is preferred by consumers in Ghana, has boosted consumption. Because rice import bills are growing in West Africa, a good deal of political incentive exists to develop the domestic rice sector. Developing competitive domestic rice production sector is thus a politically feasible strategy with a potentially large payoff.

Despite its relatively long history of production and efforts to increase production, the domestic rice sector in Ghana has remained stagnant, characterized by low input intensity and yields. Much recent production growth has come from area expansion from rainfed systems into more marginal land, rather than yield growth (Somado et al. 2008). However, rice producers at the Kpong Irrigation System (KIS) produce an average of 5.5 t/ha of dry paddy through intensive use of knowledge (crop husbandry), modern inputs, and mechanization.¹ The production system that has emerged is both productive and profitable. Yields are slightly higher in the major production season than in the minor season. Yields have risen recently, compared to the pre-2005 period of 4.6 t/ha in the major season and 3.4 t/ha in the minor season (AfDB 2005).

This note reports on an exploratory look at the system as part of a potentially larger study to understand the dynamics of transformation. Questions emerging are:

- How has such a profitable rice production system evolved?

- What role have state interventions played?
- How has the private sector responded?
- How were the challenges overcome?

This brief is based on information collected through three visits to the system in June, September, and October 2012, as well as through discussions with management staff, extension agents, farmers, traders, and other service providers.

In particular, we highlight:

- Key farming practices in the area
- How the key endowments in the area (crop husbandry knowledge, improved seeds of profitable varieties, fertilizer, and power tillers) have been brought in and accumulated
- How such high profitability might have induced the growth of other markets, including processing, credit and farmer coordination

KIS DEVELOPMENT

KIS comprises of two sections—a newly developed Section A and a rehabilitated Section B—totaling about 2000 ha in a floodplain on the Lower Volta River (Yamaguchi 1999), along which several other irrigation projects have existed since the 1960s. The project was launched in 1997 in the western part of its predecessor, the Asutsu are Irrigation Project. KIS was implemented at a cost of US\$ 40 million, mostly in loans to be repaid over 50 years. The loan agreement was completed in 2004. The loans, which were extended by the African Development Bank (AfDB) and the Arab Bank for Economic Development (BAEDA), were reinforced by contributions from the Ghanaian Government. By the end of 2005, total of 1,636 ha had been developed (870 ha newly developed and 766 ha rehabilitated), bringing the total development cost per ha to be around US\$ 25,000. Irrigation has nearly doubled cropping intensity at Kpong from 102 percent in 1998 to 193 percent in 2002 (AfDB 2005).

These rice yields are higher than obtained in other irrigation systems and comparable to irrigated rice yields in Asia. Rice yields in some major rice production areas under public irrigation

¹The yields, information on which is collected by extension agents branch by branch and substantiated by farmers, in the area ranges between 4.5 to 7–8 t/ha, with an average of 5.5 tons.

in Ghana range from 2.5 to 4 t/ha (Namara et al. 2011). The national average of irrigated rice in Ghana is 4.5 t/ha (USAID 2009). KIS yields are even slightly larger than yields in some major canal-irrigated schemes in Indonesia (5 t/ha) and considerably higher than yields in Nepal (4 t/ha) or India (2.3–3.5 t/ha) (Mush-taq et al. 2009; Gujja et al. 2007). Taking into account losses from manual harvesting, the actual yield in the area could be even higher. Tinsley (2009) estimated the losses to be around 20 percent. The yields have been relatively stable despite many problems faced in the system, such as flooding caused by excess rain and poor drainage, which renders plots inaccessible to farmers in areas with poor infrastructure and exposure the crop to birds.²

VARIETIES

The three major varieties grown in the area are all aromatic: Jasmine 85, Aromatic Short and Jet Three.³ Unlike the usual practice among farmers in Ghana, a significant portion of the rice farmers in the project replace these seeds every year, only recycling them from major season to minor season. The seeding rate under transplanting is around 75 kg/ha, comparable to irrigated transplanting system in some Asian countries like the Philippines (IRRI 2009).

The varieties came from different sources. Jasmine 85, Aromatic Short and another variety called Togo Marshall were selected and cleaned by a Ghanaian expert (Dr. Oteng) after the Ghana Rice Inter-Professional Body (GRIB) commissioned a study of rice varieties grown in Ghana in order to respond to the rising demand for aromatic rice. The seeds were given to KIS sometime during 2000s for seed multiplication and certification.⁴ Jasmine 85 is likely to have been brought from the US, where it was developed from an International Rice Research Institute (IRRI) variety to satisfy the needs of southeast Asian immigrants. It was released for production in the US in 1989 (Marchetti et al. 1998). Other varieties are likely to have been brought informally into Ghana from neighboring countries.

Such flow of aromatic varieties was preceded also by a somewhat long history of flow into the area of Asian varieties developed by IRRI, the West Africa Rice Development Association (WARDA, now known as the Africa Rice Center), the Interna-

tional Institute for Tropical Agriculture (IITA) and the Philippines Rice Research Institute, some of which had tolerance for yellow mottle virus and salinity. The inflow of these varieties dates back to the 1970s, and some were widely adopted by farmers in the area. The area is also close to the Agricultural Research Station of the University of Ghana, which had been responsible for screening varieties for irrigated ecology and varietal selection of aromatic varieties in Ghana.⁵ Some of the first Asian varieties, now called *Mande*, were introduced from IRRI through Kpong Agricultural Research Station in the early 1960s (Kranjac-Berisavljevic et al. 2003). The yields of these varieties are unclear. Some on-farm trial records and informal communication with farmers indicate that many of the previously grown varieties, though broadcast and grown without many power tillers (but with tractors), could potentially realize similar yields of current aromatic varieties, although some other records suggest that the yield was modest when grown by farmers. The project report by the African Development Bank (AfDB 2005) also suggests that the performance of previous varieties was rather poor.

The varieties currently grown offer higher prices in the local market compared with prices for varieties grown in other systems. Both dried paddy and milled rice (either graded or ungraded) in the area attract high prices:

- Dry paddy: GHC75 per 95kg (GHC 0.79 per 1kg)
- Ungraded milled rice: GHC95 per 50kg (GHC 1.9 per 1kg)
- Graded milled rice: GHC110 per 50kg (GHC 2.2 per 1kg)

These prices are twice the cost of local rice in southern Ghana albeit some yearly variations, comparable to wholesale prices of foreign rice (USAID 2009).⁶ If the current varieties are non-perfumed, their dry paddy price may drop from GHC75 per 90 kg to GHC65. A significant proportion of rice is sold as ungraded rice to customers like schools, and few millers seem to have grading machines. Similarly, a significant share of rice is sold as mixed varieties instead of pure varieties. These observations indicate that there are large and profitable markets for ungraded, mixed variety rice from the KIS area.

HUSBANDRY PRACTICES

Modern rice production in Sub-Saharan Africa is regarded as knowledge-intensive because of the specificity of required farming activities such as nursery preparation, transplanting, line planting, spacing, and bunding (Kijima et al. 2012). Many farmers in the area seem to understand the benefits of modern crop husbandry practices, although some good practices such as transplanting, maintaining proper water depth, and using sickles

²The high rice yield in the area, however, may not be solely attributable to the dominant alluvial soil in the area, which is often considered generally fertile. For example, the yields of other crops in the area are relatively close to average for Ghana, including maize (1.2–1.7 t/ha), groundnuts (0.6 t/ha), and cassava (8.8 t/ha) (SNC Lavalin International 2010c), although maize yields for some farmers in the area can go up to 2.6 t/ha using 100–200kg/ha of fertilizer.

³Aromatic varieties are classified as one type of Asian rice (*Oryza sativa* L.), separate from other types of Asian rice such as *Indica* or *Japonica* (Garris et al. 2004), and therefore all three aromatic varieties are likely to be Asian varieties.

⁴Personal communication with MoFA staff.

⁵www.ug.edu.gh/index1.php?linkid=912§ionid=1239&page=3

⁶<http://foodsecurityghana.com/2012/01/20/food-security-ghana-2012-part-ii-food-balance-sheet-and-serious-question-marks/>

instead of cutlasses have not been widely adopted because of some constraints faced by farmers. However, the extension agents report that in the 2012 major season more than 90 percent of the area was transplanted.

TABLE 1—LABOR INPUTS PER HECTARE FOR DIFFERENT CROP HUSBANDRY PRACTICES

	Labor /person/ day/ha	Labor/ person/ hour/ ha
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
3 rd 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	46–50	407–438
Harvesting & cutting	11–13	77–91
Threshing & winnowing	24–25	264–275
Drying & bagging	11–12	66–72 ^a
Total	112 ~ 146	897 - 1135

Source: Authors' calculations based on the interactions with farmers and KIS staff.

Note: ^aAssuming 8 hours work per day for transplanting, bird scaring, drying, and bagging; and 6 hours for drying and bagging.

Such knowledge seems to have been provided by various external and internal sources. External sources include a farm managed by Koreans and a school established to train farmers in rice farming, several Japan International Cooperation Agency (JICA) projects, and eight KIS extension staff (three from MoFA and five employed by KIS). A Korean expert called Dr Ann, who had been the head of the Asutsu Irrigation Project in the area (Section B) during the 1980s, contributed to the initial adoption of transplanting. Farmers believe that transplanting raises the yield by 30 percent and substantially reduces seeding rate. Similarly, JICA had implemented from 1988 a technical cooperation project in Ashaiman, which is one hour south of Kpong. The project also launched the Irrigation Development Center in 1991. The later project, the Small Scale Irrigated Agriculture Promotion Project (SSIAPP), which began in 1997, produced the guidebook on crop husbandry, which is currently used by the KIS extension staff for reference (GIDA and JICA 2004). KIS disseminates this

information to farmers using demonstration plots. From field observations, farmers appeared to understand the benefits and conducted some of the practices described in the manual, including spacing for transplanting and nursery preparations.

Some knowledge has been developed by farmers themselves. Some farmers in Section B have been growing irrigated rice since 1972, pumping water directly from the Volta River. They claim they have taught themselves much about crop husbandry, such as fertilizer application timing with minimal or no external training. Extension visits to this section are infrequent, except when demonstrations of new chemicals and their applications are needed. Knowledge of postharvest techniques, drying of rice, and milling has been transferred from supervisors to workers. Only a few practices, such as transplanting, seem to have been introduced from outside to these Section B farmers. These farmers state that they started transplanting gradually from the 1980s.

Table 1 gives detail of labor inputs per hectare for different crop husbandry practices. Table 2 delineates the costs associated with production budget per season.

SEEDS

KIS produces certified seeds through about 10 seed growers in the area. Seeds grown during the previous season can be used as certified seeds as quickly as in the next season, after inspection by MoFA staff and going through the certification process. Seed production is financed without external support and is commercially viable. JICA provides technical support for the institutional aspect of certified seed production, such as testing and certification procedures. KIS can supply 50 tonnes per season, meeting only a fraction of demand. Many farmers, who typically replace seeds at the beginning of major season each year, obtain them from relatives or other farmers instead of KIS. The quality of KIS seed is generally good, partly because KIS is able to trace poor quality seed to particular growers, although some farmers still prefer to produce their own seeds.

FERTILIZERS AND CHEMICALS

The predominant soil in the area is a Chromic Vertisol in the FAG/UNESCO soil classification (FAO 1994). It is a type of alluvial soil with low water infiltration rate and high fertility, often appropriate for basin irrigation (Ahmad 1996, Troll 1965). The Kpong area is rural and about an hour from a town with more than 20,000 population.

Source of soil nutrients is largely external, given the heavy use of inorganic fertilizer and little use of manure or other internal materials. In the past 5 years, the Government has been providing fertilizer at the 40 percent subsidized price. Subsidized fertilizer becomes available at a specific time each year. The tim-

ing is affected by various factors such as when subsidized prices are determined, when vouchers (passbooks in 2012) are dis-

chemical importers through input dealers and KIS staff. Labor for applying fertilizer and chemicals is mostly family labor.

TABLE 2—PRODUCTION BUDGET PER SEASON (TRANSPLANTING METHOD)

	KIS 2012				KIS 2012 (and field work)			
	Qty	Unit cost (GHC)	Total cost		Qty	Unit cost (GHC)	Total cost	
			GHC	USD			GHC	USD
Seed (transplanting)	75kg	1.48	111	59	75kg	1.48	111	59
Land preparation	1 ha	-	300	159	1 ha	-	300	159
Fertilizer and agro-chemicals	-	-	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	2kg	10	20	11	2kg	10	20	11
Insecticides	1 liter	15	15	8	1 liter	15	15	8
Harvesting materials	-	-	-	-	-	-	86	46
Labor cost per ha	-	-	2050	1086	-	-	1805	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	-	-	1000	530	-	-	-	-
Harvesting	-	-	-	-	-	-	280	148
Threshing	-	-	-	-	-	-	300	159
Irrigation service charge	1 ha/season	-	60	32	-	-	60	32
Total cost	-	-	3012	1596	-	-	2853	1511
Price per 90kg bag	-	-	74	39	-	-	74	39
Price per kg	-	-	0.82	0.44	-	-	0.82	0.44
Gross revenue (with yield = 5.5 t/ha)	-	-	4522	2396	-	-	4522	2396
Net revenue	-	-	1510	800	-	-	1669	884

Source: Authors' calculations based on KIS (2012) and informal interactions with farmers during the field visits.

Note: Exchange rate is US\$1 = GHC1.88.

tributed by extension agents to farmers, and physical supply of fertilizer.^{7,8} Although delays occur, in most cases fertilizer reaches farmers at the subsidized price eventually, as is indicated by its intensive use.

A large number of private companies have emerged to supply chemicals to farmers. Most chemicals for production (selective and nonselective herbicide, insecticide, pesticide, fungicide) and seed chemicals are easily accessible. Information about new chemicals is often disseminated through demonstrations by

⁷ In 2012, MOFA announced subsidized fertilizer price in June (<http://mofa.gov.gh/site/?p=10057>).

⁸ The Ghanaian government is not involved with the direct distribution of fertilizer in Ghana, unlike neighboring countries like Nigeria where bureaucratic delays in fertilizer distribution are reported (Banful 2009). However, since the current fertilizer subsidy is relatively new in Ghana, starting only in 2008, private distribution networks are still underdeveloped.

MECHANIZATION

Power tillers are almost universally used for land preparation such as tilling and crossing (puddling). Roughly 50–100 15hp tillers are used for approximately 2,000 ha, realizing the level of mechanization in terms of horsepower per hectare as 0.375–0.750 hp/ha, which is comparable to many Asian countries. Labor is also intensively used for transplanting, weeding, and bird scaring. Despite the high yield, harvesting, threshing and drying are done by manual labor. But mechanization is increasing. At the end of October, there were seven combines harvesting major season rice.

Most power tillers in the area were supplied over time through the Government subsidy, consisting of a mix of brands such as Shakti, Yamar, Kubota, and Daedong (by Afko Company, a Korean fisheries company). Chinese Dongfei power tillers are increasingly available as well. Owners of power tillers are often rice farmers themselves, who use them for their own plots as well as hiring them to others. Spare parts of Shakti and Dong-

fei brands are generally available domestically. Power tillers with Shakti bodies come with engines manufactured by another Chinese company, Chang Fa, are sold at GHC800 and typically last 2 years. These are particularly common. Shakti power tillers (sometimes together with 15-hp generator, water pump, and car washing machine) cost about GHC3,700 after the 50 percent subsidy, although the prices have recently risen sharply. Most power tillers are purchased without financing from the bank.

Most Shakti power tillers can till 1–2 ha (2.5 ha if crossing) in a single day, consuming 3 gallons (11 liters) of fuel. Tilling service typically costs GHC250–300 per hectare, and has been rising at the rate of GHC50 per year over the last 3–4 years due to the scarcity of machinery given their high marginal returns. Because of the shortage of power tillers, waiting time can reach up to 1 month. Transportation service by power tiller is limited to owners' personal use, and rarely provided for other farmers. Maintenance cost of one power tiller is around GHC1,000 per season,

mostly for gears in the rotary, belts, chains, and tire iron. There are around 10 repair facilities in the area, typically charging GHC50. Because the maintenance cost is relatively high compared with the subsidized machine cost, the distorted prices may encourage farmers to use power tillers as disposable tools. The ages of these power tillers vary considerably, ranging from more than 20 years to only 1–2 years. Under the good maintenance, the power tiller can last for more than 4–5 years if used on moist paddy (Ademiluyi et al. 2009).

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

Farmers still do not have adequate access to machines. Discussions with them suggest that all their operations are delayed by lack of access to machines. And costs of certain operations using labor far exceed the costs of hiring the machines to undertake the same operations. Harvesting with combines, for example, costs GHC450 per hectare. Using labor, on the other hand, it costs in excess of GHC650:

- GHC280 for cutting the plans
- GHC300 for thrashing using a box
- GHC42 for hiring three boxes at GHC7 per day for 2 days
- GHC30 for transporting them
- GHC40 a day for two laborers at GHC20 a day to clean the produce and pick stalks left in the field

IRRIGATION

Water is provided to farmers through canals and laterals which farmers can access anytime on request. Timely availability of water was not reported to be a major constraint, except when the delayed release of credit by the Agriculture Development Bank (AgDB) forces many farmers to demand water at the same time. While water was directly pumped directly from the Volta River in the old Asutsuare Project in Section B, current use of pumping there is very rare. The construction of canals has significantly expanded the irrigable areas in Section B.

Water service charge (levy) has been fixed at GHC120 per year, paid in dry paddy. The charge was lower at GHC70 until 2007, and GHC45 in 2001. The recovery rate has been about 40–50 percent in recent years.

KIS maintains the irrigation facility with 100 maintenance staff. Section A is better maintained than Section B, which has been choked with weed, causing substantial flooding of the plots and making water control extremely difficult and leaving 150–

200 ha waterlogged and unusable. Farmers in some sections organize themselves to clean the canal, mobilizing 20–30 people for 2 weeks during off-season, indicating that high profitability incentivizes farmers to maintain the system themselves.

CREDIT

Farmers obtain credit from AgDB or money lenders, many of whom are women traders. Many farmers generally have sufficient cash and only require minimum credit. External support of about US\$4 million to AgDB came under the ADF from 1997 to 2001 with the aim of establishing a credit revolving fund. Currently, about 300 farmers, out of 2,600 farmers in the scheme, receive loans from AgDB at interest rates of 20–30 percent. No collateral is required if the loan is given to a solidarity group consisting of at least five farmers, which are formed by farmers themselves, sometimes independent of their canal sections, although 10 percent of the deposit is required to cover the default of some group members. When borrowing from AgDB, farmers must pay back all paddy from which the bank deducts the balance. The returning of balance paddy to farmers is often delayed up to 1 year, creating additional costs from the borrower's perspective.

Most other farmers rely on informal moneylenders such as traders, millers, and input dealers. The amount lent to farmers varies, but many farmers manage to borrow amounts that cannot be covered by their own cash. Lending in smaller amounts is also common. One miller, with a capacity of 10t/day, supports about 50 farmers by lending them GHC50–100, or inputs like fertilizer, or both. One of the input dealers supports five farmers.

LABOR

Labor is provided not only from within the project area, but also from nearby villages outside the project area. Labor is usually provided as a group. Labor shortage, aggravated by competition from banana production which absorbs 1,700 men and women, has raised the cost of these manual works. Major activities demanding labor include (in terms of labor cost):

- Transplanting (GHC300–400/ha)
- Gap filling (GHC200/ha)
- Weeding by handpicking (GHC100–600/ha)
- Harvesting and threshing (GHC300/ha)

Other minor work includes bunding and drying of paddy. The daily wages in the area are often high enough to attract workers from outside the villages who were previously engaged in charcoal burning and petty trading at low wages. Apart from using machines to prepare the fields, labor input per hectare may range from 112 to 146 person-days per hectare, accounting for 60 percent of the costs.

MILLING

Milling is mostly done by private millers who invest in milling facilities and land, even though the land for milling facilities could cost as much as GHC15,000. Some millers travel to other regions to supplement the paddy shortage. Several milling facilities in the area can handle more than 10 tonnes of milled rice per day. Some milling services are also provided by input dealers. The only public milling facility owned by KIS has a capacity of 2.5t/day. Typical capital values are:

- Milling machine (GHC8,200 GHC)
- De-stoner (GHC6,000 GHC)
- Grading machine (GHC5,200 GHC)
- Elevators (GHC2,000 GHC), typically supplied by RST company in India
- Electricity (GHC800 per month in one 15-tonne milling facility)

Repair services are generally available from RST when needed. The electricity supply in the area is sometimes irregular, but the milling facilities operate actively.

Milling is undertaken in small plants, some of which do not grade or de-stone, as demand for ungraded rice is considerable. Farmers know that they could get higher prices for their produce if large-scale milling facilities were available.

MARKET

Although farmers sell to private agents, nearly all of the credit repayment, whether to banks, processors, traders, or KIS for irrigation charges, is made in kind. KIS sets the price at which it will buy before the beginning of each season. Those who borrow interest-free from traders or processors are expected to sell their produce at about GHC50 per bag less than the prevailing market price. Seven traders handle 75t of milled rice per week for several weeks during peak seasons. If these seven traders handle this quantity for 10 weeks during peak season, they can cover 5,000t of a total 7,000t of milled rice from the area. The traders use their mill houses as storage space.

DRYING AND STORAGE SPACE

Initially, KIS provided three warehouses with a capacity of 160t where drying spaces were also provided. Currently, about 15 mills offer drying space for farmers who make use of their milling facilities.

TENANCY

There is a long history of conflict over land allocations, particularly in Section B where irrigated agriculture has been practiced for a long time. In Ghanaian irrigation systems, land is acquired by the government and then allocated to farmers guided by GIDA

law 1350 and managed by a land allocation committee. Applicants are allocated land with preference going to those who are displaced and living in nearby communities.

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. In Section B, on the other hand, during a period when GIDA was not exercising control, farmers from a nearby community allocated the lands to themselves. GIDA eventually legitimized the allocations by making them sign agreements. These agreements need to be renegotiated every 5 years, but they have not been in the system. Within the area, subletting of land is commonly done at a rent cost of GHC 500/ha/year. The land is owned by KIS and leased to farmers. KIS possibly has a mechanism to secure the land tenure of farmers in the area.

Contrary to GIDA rules, which state that lands left unutilized should be reallocated after a year, in this system farmers have been left with their plots so long as they pay their irrigation charges. But irrigation payment is also irregular; recovery is only about 40 percent. However, lands are fully utilized. A vibrant market has emerged for tenancy. Farmers lease 1ha of land for a year in return for seven bags of rice (630kg). They are reasonably certain that lands will not be taken from them. However, KIS staff complain that a significant portion of the farmers who have been allocated lands do not cultivate them, and therefore irrigation recovery is also weak because the tenants have no relationship with the system. Lands are also further consolidated for cultivation. A significant portion of the rice growers are cultivating more than 2 acres leased from other farmers.

KEY FINDINGS/HYPOTHESES

A number of factors have contributed to the development of a productive rice-growing system, which is being held together by profitability. Profitability comes from infrastructure (especially irrigation) and technology (including varieties and husbandry practices).

Public investment has played a key role. Investments in upgrading KIS to be able to offer water control have provided the base for the effective practice of irrigated agriculture. Extension services offered by the irrigation system are effective. The extension agents in the system are also well-trained and 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. The project began with the involvement of a bank, the

role of which has diminished over time because of poor repayment. But nearly all of the farmers are able to apply recommended levels of external inputs from their own savings or funds borrowed from traders. 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 KIS developed are no longer adequate to dry all the paddy produced in the system. Similarly, a number of private suppliers of mechanization services have emerged. They may be benefiting to various degrees from the MoFA mechanization program in which machines are sold to individuals at a discount. Supply remains inadequate. Threshing boxes are available for hire.

A number of opportunities are still unexploited. Farmers could use additional combine harvesters which could potentially increase productivity by 20 percent by some estimates. 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.

System managers complain of farmers not being as well-organized as in other systems and recovery of irrigation service fees is poor. The developments in this system are more atomistic rather than emerging from system-wide planning and coordination. Although the producers could do better, the system that has evolved is both productive and profitable.

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