**ACDI/VOCA**
**Farmer-to-Farmer Program**

# Increasing Rice Productivity for the Kpong Irrigation Project, Akusa – Asutsuare, Ghana


**Consultant Report:**
**Richard (Dick) Tinsley**
**Professor Emeritus, Colorado State University**
**Volunteer – Rice Production**


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## List of Acronyms

| | |
|---|---|
| ACDI/VOCA | Agricultural Cooperative Development International/ Volunteers in Overseas Cooperative Assistance |
| AfDB | African Development Bank |
| CIMMYT | International Center for Maize and Wheat Improvement (Spanish Acronym) |
| FtF | Farmer to Farmer Program |
| IARC | International Agricultural Research Center |
| IITA | International Institute for Tropical Agriculture |
| IRRI | International Rice Research Institute |
| JICA | Japan International Cooperation Agency |
| KIP | Kpong Irrigation Project |
| UK | United Kingdom |
| USAID | United States Agency for International Development |
| WARDA | West Africa Rice Development Association |

## Executive Summary

The Kpong Irrigation Project is a 3000 ha government owned rice based irrigation project built in the late 1990s with AfDB funding. Now after nearly 10 years of operation it is doing reasonable well. It appears to have sustainable yield across the scheme of six to seven tons per hectare. These are near optimal for a low altitude humid tropical climate. The desire to increase this to 10 t/ha may not be realistic as this yields are more associate with the sub-tropics and temperate zone where rice is confined to summer time with long day of up to 16 hours of sunshine, instead of the 12 hour limit for the tropics.

As with most public sector smallholder irrigation schemes the biggest problem is maintenance of the system. In this case there may be a special and urgent need to seek a renovation loan from the AfDB to compensate for some unexpected slumping of the main canal by herds of cattle entering the canal for drinking at a point not anticipated in the original design. There is some urgency in seeking this assistance as it normally takes at least two years for project to be realized once the initial project identification documents are submitted. By that time it is possible for some of the land at the end of the canals to go out of command and have to be abandoned. There is also a need to evaluate how to maintain the primary and secondary canals free of weeds and sediments with limited fund. As with most other smallholder schemes, it has been difficult getting water use payments from all the farmers, and nearly impossible to enforce non-payments.

Another problem perhaps is trying to facilitate an appreciation that value added might come more from providing traders with full bag of clean grain so the traders can pay them full value, and not deduct for an anticipated percent of trash in the form of stones and mud clods that have to be removed before milling, or too much chaff and empty spikelets. that needs to be winnowed. The deductions are an estimate of both the percent trash and the cost of removing it, and could total 10 or 15 percent of the value of the bag of rice.

Other than that, the production is doing well with open access to any inputs and a mechanization program based on the Asian rice power tiller for land preparation and transport. This is good as it is consistent with most of the smallholder rice areas of Asia. It might be possible to increase the production by increasing the mechanization of the harvest to reduce the crop conversion time and increase the crop intensity from two crops per year to five crops in two years. This would involve following the Asian example of using mechanical threshers and possible small combines that can easily work in fields of a half hectare or less.

The project does have a credit program but it only involves a small minority of the beneficiaries, and thus may not be very effective, or even really needed.

# Increasing Rice Productivity for the Kpong Irrigation Project, Akuse – Asutsuare, Ghana

**R.L. Tinsley, Professor Emeritus**
**Colorado State University**

## Introduction

The consultancy was done at the request of the Kpong Irrigation Project (KIP) as part of USAID's Farmer to Farmer (FtF) program managed by ACDI/VOCA. The objective was to evaluate possible means of increasing the rice output of the irrigation scheme. The consultancy took place during the last half of October when most of the fieldwork was harvesting, threshing and drying the first crop, followed by preparation for the second crop and continued through some early direct seeding of the second crop.

In Ghana rice is an important staple crop, but not the primary staple crop. The other staple crops are cassava as garri, plantains, yams and maize. However, rice production is mostly confined to the limited irrigated areas which rice can be produced. Thus, there is an overall shortage of rice in the country and Ghana imports large amounts mostly from Thailand, the world's largest exported or rice. It also imports substantial quantities from Viet Nam, the world's second largest exporter, but typically of a lower quality and cheaper price because of excessive broken. However, people in Ghana appear to prefer the imported Thai Jasmine rice even to locally produced perfumed rice, even though there is little visible difference in the quality.

The Kpong Irrigation Scheme is a 3000 ha irrigation scheme owned and operated by the Government of Ghana. It is located about two hours north east of Accra, the capital near the towns of Akuse and Asutsuare. It was constructed with African Development Bank (AfDB) funding in the late 1990s. It derives water from Volta River via the Kpong Reservoir which is primarily a relatively low head hydroelectric generation and storage facility. However, what is unusual is the takeoff for the irrigation scheme is separate from the power house (Fig. 1). Usually the power generation get priority and the irrigation canals take off below the power station. The discharge into the scheme is 7.2 $m^3$/sec. continuously year round. This is sufficient to allow two 120 day rice crops per year. It provides 2.4 l/sec/ha, which should be divided as 1/3rd for evapotranspiration, 1/3rd for deep percolation and 1/3rd for conveyance losses, which would be the same designed water allocation as was

*Fig 1. Inlet structure to the Irrigation scheme with the electric power plant in the distant background.*

done for Madibira in Tanzania, a sister scheme. The system was designed by Hunting Technical Services in UK. Twelve hundred hectares of the scheme are slightly higher and cannot be served by gravity. Therefore the water has to be pumped about two meters to reach this area. This land has been provided to a French company for commercial banana production under drip irrigation. The bananas are directly export to France and Europe.

The government subsidizes the scheme’s operation by seconding the management staff and covering their salaries outside the annual rent and water use fees charged the farmers that are retained in the scheme to defray the operating costs. This involves some 120 employees of the scheme, including professional officers, managers, extension officers, clerical staff and support personnel.

The land is officially allocated to the farmer beneficiaries in one hectare allocations. These beneficiaries are obliged to be members of the farmers’ cooperative that is mostly involved in managing credit through the local branch of the Agriculture Development Bank.

By what might be interesting coincidence the scheme appears to be very similar to one the consultant was involved with as the long term agronomy advisor for 2.5 years in Madibira, Tanzania. This was also a 3000 ha rice based irrigation scheme, funded by the African Development Bank, constructed in the late 1990s, designed by Hunting Technical Services, with one hectare allocations to the beneficiaries, and 2.5 l/sec/ha of water. However, Madibira was a run-of -the-river diversion as the plans for a storage structure were dropped for lack of funding. It was also 1100 m in elevation which resulted in sufficiently cooler temperatures that slowed the rice growth by 60 days. Thus, Madibira had the potential for only one rice crop per year.

## Rice Production - Overview

Overall the rice production looks very good. The yields are estimated at between six and seven tons per hectare. That is good for lowland humid tropics. More typically anything above five tons per hectare is considered better than average, perhaps that needs to be adjusted upward by a ton per hectare. All the rice appears to be short statured potentially high yielding varieties with open access to any desired inputs such as fertilizer and plant protection materials. The recommended rates of N are 120 kg/ha divided between a basal mixed application plus a N topdressing. The rice grown is mostly “perfumed” which appears the local name for aromatic. It looks like this is based on Thai Jasmine, the international standard for rice. Even the packages of imported Thai Jasmine refer to it as perfumed. Mechanization of at least crop establishment and transport seems reasonable based on the Asian rice power tiller, the purchase of which is assisted by the government with the support of Asian bilateral assistance programs, such as Japan and South Korea. Water management is ok as there is plenty of water to divert through the scheme with an easy return flow back to the river, where the excess water can easily be allocated to downstream users. However, the future has some serious concerns.

## Specific Issues

### Yield Levels

As mentioned above the yields are between six and seven tons per hectare with a desire to raise this to 10 t/ha. While there may be some isolated yields of this level within the scheme, it may be unrealistic for overall production across the scheme. The reason being Ghana has a pure hot humid lowland tropical climate, with only 12 hours of daylight each day, and warm nights that encourage respiration losses. Virtually all the areas with average yields in the 10 t/ha range or above are sub-tropical and temperate areas with 16 or more hours of summer daylight. This would include the USA, both, California and the Gulf of Mexico rice growing areas, Australia and much of southern Europe. These are also the areas that produce mostly Japonica rice. The highest yield are normally in Egypt with is sub-tropical desert climate. As a sub-tropical desert it has $16^{+}$ hours of cloudless daylight in the summer followed by tremendous back radiation at night so that the temperatures drop below 20º C, a temperature below which respiration for rice begins to slow down, thus preserving the photosynthetic accumulation during the day. By far the most ideal climatic conditions for maximizing rice yields but very difficult to match elsewhere including the humid lowland tropics of Ghana. All these sub-tropical and temperate areas have cool winters that prohibit rice production and restrict rice production to one summer crop per year, compared to the two crops now produced in the scheme, and provide the scheme with an overall annual rice production advantage.

### Improved Varieties

Like most African countries the public sector variety improvement, seed multiplication, and distribution is so underfunded to be virtually financially stalled. That is the program is in place with some qualified staff, but insufficient operating funds to effectively carry out a program. Thus the actual variety improvement work is handled by the International Agriculture Research Centers (IARCs) for which the West Africa Rice Development Association (WARDA) has the mandate for assisting Ghana. It works fairly closely with the International Rice Research Institute (IRRI) in the Philippines and the International Institute for Tropical Agriculture (IITA) in Nigeria. However, WARDA has had difficulty over the past decade finding a secure home. Each time it relocates national security conditions deteriorate, and it has to relocate again. The result is that the Ghana national rice varietal development program has not received any new genetic material in over 10 years. Thus, no new varieties have been developed or released, and no breeder, foundation or registered seed produced. Thus KIP and other rice schemes are left on their own. It is also questionable if WARDA and IRRI would actually provide many aromatic lines. It has never been a major interest in their breeding programs, and is not included in the primary list of characteristics used for searching the genebank. They have always been more concerned with basic food security and calories produced plus disease, and insect resistance, rather than the finer consumer qualities of the grain.

The primary aromatic variety used in the scheme appears to be Togo Marshall. It appears to have been obtained informally from neighboring Togo most likely by someone making an informal visit to friends or relatives across the border. It was appreciated, informally multiplied, and distributed to farmers throughout the scheme. It is a good indication of how informal extension programs can be effective as well as how a single individual or small group can be innovative and effectively impact an entire community.

Togo Marshall mostly likely is derived from Thai Jasmine, although it might be difficult to fully trace its ancestry. Unfortunately, although self-pollinated, rice has a 3% out crossing and thus the seed will deteriorate after being retained for several generations. This can result in some serious off-types extending above the canopy (Fig. 2). While they will not noticeably interfere with yield for a few generations, eventually they will and it will necessary to obtain a fresh supply of seed. With the national variety improvement and seed distribution program not fully operating, it will be left to the farmers in KIP with the assistance and encouragement of the KIP management unit to maintain their seed quality. This is relatively easily done by removing the off-types, but the farmers having been trained and encouraged to rouge out the off-types appear reluctant to do so. It must not be as big a concern to the farmers as to the management, or the farmers would be responding.

*Fig. 2. Off-type rice plants extending above the canopy. Most likely not enough to reduce yields but will be in a couple additional generations.*

The implication is that farmers would be reluctant to pay the extra cost for true certified seed. Thus a commercial certified seed program may have difficulty recovering the cost for producing true certified seed including rouging out the off types, as well as recovering the administrative costs for certification, that includes three field visits and a final germination test. In Madibira, Tanzania a trial comparing the project seed with the seed being distributed by farmers failed to demonstrate any advantage (Table 1). There is a Korean agriculture training school operating in the scheme that is undertaking some seed quality work. This needs to be encouraged and expanded upon if possible, but with a realistic strategy of how much "certified" seed is needed and how much will be retained by the farmers, etc.

***Table 1. Yield Comparison of Project and Farmers' Seed for 3 Varieties In Madibira, Tanzania***

| **Subarimati** | | **Zambia** | | **IR 54** | |
|---|---|---|---|---|---|
| **Source** | **Yield (t/ha)** | **Source** | **Yield (t/ha)** | **Source** | **Yield (t/ha)** |
| Project | 1.72 | Project | 0.61 | Project | 1.44 |
| Farmer 1 | 2.24 | Farmer 4 | 1.11 | Farmer 7 | 0.97 |
| Farmer 2 | 2.01 | Farmer 5 | 1.01 | Farmer 8 | 1.68 |
| Farmer 3 | 1.56 | Farmer 6 | 0.42 | Farmer 9 | 2.28 |
| Ave. | 1.89 | Ave. | 0.79 | Ave. | 1.59 |
| Std. Dev | 0.57 | Std. Dev | 0.57 | Std. Dev | 0.80 |

The scheme does not get involved with red rice or brown rice as with other schemes in Ghana. Thus it was not possible to determine if the references to red and brown rice in Ghana refers to a genetic definition of red rice as one of several specific varieties that have a red endosperm, that is not removed during milling and polishing. As such this can be the most noxious weed in non-red rice fields that will severely down grade the quality of the milled rice. Or, is it referring to process of milling rice to remove the hulls without polishing leaving the bran as is the normal definition of brown rice.

Obtaining additional genetic material to replace the current varieties will be a challenge. It may require some quiet visits to neighboring schemes or countries such as Togo, or perhaps contact with the Thai embassy to see if new Jasmine lines can be obtained directly from Thailand. It would also be possible to contact IRRI and request aromatic lines similar to Jasmine. They most likely will provide KIP with 10 or 15 lines to evaluate. Also, the Korean agriculture training school may have sufficient external funding to facilitate contacts with WARDA, IRRI or their own sources to bring in fresh material. They should be contacted and encouraged to assist the scheme in obtaining new genetic lines to the extent possible. Again this would be analysis to the situation in Madibira where the national program had similar financial difficulties as the Ghana program and the project had to obtain new genetic material from a JICA project near Kilimanjaro, all the way across the country.

**Improving Rice Recovery**

Since the consultancy occurred during the harvest period the field visited concentrated on looking at the harvest procedures and harvesting losses. These losses were estimated at $20^{+}$% of the yield which if added to the recovered yield of 6.5 t/ha would total 8.2 t/ha. The losses appear associated with the extensive manual handling of the rice including cutting with a simple sword knife (Fig. 3), whacking into whacking boxes (Fig. 4), and manually winnowing aided by the wind. This then left considerable rice either on the ground or still clinging to panicles. This left over rice was then picked up by gleaners (Fig. 5), and the first time this consultant as seen gleaners in rice fields in over 30 years. The last time was in the

*Fig. 3. Cutting rice with simple sword knife and stacking it on the ground where it can become contaminated with mud clods etc.*

*Fig. 4. Threshing rice into threshing boxes that allow ample opportunity to scatter grain on the back swing as suspected by supervisors.*

Philippines in the late 1970s. Gleaning represents some exceptionally hard work for very little recovery. It is usually done by women who will work for several hours in the hot sun for perhaps 10 kgs of paddy.

*Fig. 5. Gleaning rice after the main threshing has is finished. A hard day's work in the sun for 10 kg paddy.*

The whacking boxes appear unique to Ghana or perhaps West Africa. They allow up to four individuals at a time to whack the cut rice plants against the upper edge of the box. This knocks the grain lose so it falls into the box where it can be transferred to bags, winnowed and taken to the drying floor for drying and further cleaning. It also provides hired laborers an opportunity for deliberately or semi-deliberating leaving rice behind during the back swing or just not whacking enough before setting the straw aside. It would then be possible for the spouse of a laborer to follow-up and glean the remaining rice. While this may be difficult to appreciate from a western perspective, if casual labor wages barely balance the calories exerted, then it can be at least partly appreciated[1].

Unfortunately the only solution is to increase the mechanization of the entire harvesting process. The simplest would be to shift to mechanical threshing such as the axial-flow threshers developed by IRRI several years ago (Fig. 6). The blue-prints are freely available from IRRI by going to IRRI's website (www.irrig@cgiar.org) and requesting them. They can then be locally manufactured without incurring any intellectual property rights concerns as all outputs of the IARC's are public domain. They come in two sizes one small enough to be hand carried into the field over the bunds and the other large enough to be trailer mounted. Both could be powered with a belt drive to 12 hp power tillers. Mentioned was made that these had too small a capacity and each hectare would require several units or it would take several days to complete. The suggestion was to look at some threshers seen in Egypt. They are actually known as Turkish threshers (Fig 7). They are designed for both wheat and rice, but

*Fig. 6. Small axle-flow thresher developed by IRRI for threshing rice. Photo credit: IRRI*

*Fig. 7. Turkish Thresher Commonly used for both rice and wheat in Egypt but requiring a full 60hp Tractor for power.*

[1] *http://lamar.colostate.edu/~rtinsley/CalorieEnergyBalance.htm*

require a 4-wheel tractor for power and might not be compatible with basic mechanization based on rice power tillers.

The next step in mechanizing the harvest is to consider providing access to small combines that are progressively being used throughout the fully irrigated areas of Thailand and other parts of Asia (Fig. 8). They have a two meter head, are equipped with tracks, and discharge the combined paddy directly into bags. They are effective in fields as small as one rai (1/6th ha), the standard land measurement in Thailand. They can harvest a rai in about an hour and do at least one hectare per day. If KIP has it crop spread fully extended the scheme could provide full employment for 20 such small combines. That is one hectare per day for 120 days and 20 machines would cover 2400 ha. This will be far more appropriate than the four brand new New Holland Combines that recently arrived with their six meter heads (Fig. 9). By the time one of these large combines fully entered a field at KIP, it would be approaching the other side. Hopefully the small combines swapped for the two of the large combines will be similar to the small rice combine in Fig. 8.

*Fig. 8. Small combine designed specifically for smallholder rice fields. It is currently widely used throughtout fully irrigated areas in Asia and allows much cleaner recovery of paddy and faster crop conversions.*

The use of mechanical harvesting could have some interesting additional benefits. One being the harvest is cleaner with fewer grains left on the straw or scattered in the field. This will then completely remove the gleaners from the field. Hopefully, they can find more rewarding employment. Second, since the rice will have less contact with the ground there will be far less stones or mud clods in the rice and the destoning process in milling could be eliminated. This would reduce the milling cost and should provide the farmers a higher price from the traders. Finally, the combining will reduce the amount of time committed to harvesting and threshing and allow a more rapid crop turnaround leading to an increase in crop intensity and more overall economic opportunity for the beneficiaries and supporting laborers, etc.

*Fig. 9. Large inappropriate combined provided by government for KIP, but fortunately partly traded for hopefully combines like that shown in Fig. 8.*

The unit costs for these small combines should be about US$ 50,000. This is far more than any individual farmer can afford and individual farmers should not attempt to purchase them other than to give up farming in favor of full time custom combining. Thus they need to be made available on a custom contract basis. As such there should be full time opportunities for at least 20 individuals as combine operators plus additional opportunity for mechanical support persons to assist with maintaining them. Since this is mechanical it should also be in private hands such as the private mechanization unit close to the KIP office that contracts out tractors, mostly for upland use. Thus, while the initial two small combines may be owned and operated directly by KIP, any future combines might best be managed in private hands, with some major financing made available to assist with the purchase.

**Crop Intensification**

If the scheme is operating at or near the climatic yield limit for lowland humid tropics, the best way to increase the total scheme output may be increasing the crop intensity. With full 365 days per year irrigation and 120 day rice varieties the current potential is two crops per year, with some projected seasonality for each. However, the timing of the rice is slowly getting spread out so that rice is beginning to be seen in all stages of development simultaneous. It is thus possible to increase the crop intensity from two crops per year to five crops in two years. This would be consistent with the fully irrigated areas of Thailand.

The key to doing this is to reduce the crop conversion time. Currently this is around 60 days divided almost equally between 30 days for harvest, threshing and securing the first crop and 30 days for establishing the second crop. The 60 day crop conversion period is somehow a near universal constant across many smallholder production program particularly those that emphasis manual or semi-mechanizations. This would include the Philippines, Sri Lanka, and Egypt of countries I have worked in. The key to increasing the crop intensity is to increase the level of mechanization which for KIP would again emphasize mechanizing the harvesting process. Again this would imply the use of the small combines mentioned above. This should reduce most of the harvest and threshing time and allow faster access for replanting. It will not reduce the drying time which appears to be a major constraint the harvesting post harvest handling process. This is basically the Thai model. If the 30 days for harvesting and threshing could be reduced twice a year the time saving would be close to 60 days or half a rice growing season, or half a rice crop.

One of the problems with increased intensification would be the continuous source of foods for both birds and rats. The birds are already a major concern and one reason the crop is often harvested with more moisture than desired and the need for extensive sun drying. The harvest moisture is often over 20% and has to be dried to at least 14% for safe storage. A process that could take three or four days per 10 bag batch with up to 90 bags per farmer to dry. However, so far birds and rats appear an unsolved concern for rice production, at least at the production economics level.

**Drying and Winnowing**

The drying and accompanying winnowing is actually a major constraint in the post harvest handling that consume virtually all available drying space within the scheme and surrounding villages.  This includes designated areas by KIP, plus drying floor associated with the different mills, and other paved open space or even unpaved areas that are covered with tarps

(Fig. 10). If the spread in rice cropping continues to increase so the seasons become less pronounced, this constraint could ease somewhat.

This is also the time that most of the winnowing is done to remove most of the chaff, straw, and empty grains. This is mostly done by hand, but it often appears that the winnowing is doing little more than transferring the chaff, etc. from one farmer's rice to the next downwind farmer. Perhaps it eventually works its way off the downwind side of the drying area. There are some hand operated winnowing machines in the area (Fig. 11). These are similar to machines extensively used in Egypt for rice, wheat, broadbeans and other grains, but rarely seen in other smallholder areas. They are normally manual operated as it very difficult to gear down even small petrol engines enough to prevent blow the grain away with the chaff, etc. It might be desired to encourage the use of these winnowing machines, as they most likely do a faster and cleaner job, which should lead to higher prices from the traders. It would be necessary to make a quick evaluation of the business model associated with using them as most likely they are rented out instead of individually owned. Ultimately a measure of value added has to be from a clean bag of grain that does not have to be recleaned and commands full value, than an attempt to market substantial trash with the grain that traders anticipate and discount both for the estimated volume of the trash and the cost of removing it. Winnowing will not remove the stones and mud clods that continue to devalue the grain and have to be removed prior to milling.

*Fig. 10. One of several drying floors in the areas that are overwhelmed during the post harvest processing of rice, forcing farmers to stack rice in piles waiting for a chance to dry and winnow it.*

*Fig. 11. A simple manually operated winnowing machine being used in the scheme. Such machines should make winnowing faster and more effective and should be encouraged.*

### Marketing and Milling

Most of the marketing and milling appears to be done by private traders, mostly women. They appear to purchase the paddy from the farmers and then have it milled locally at any of several small mills in the areas. Having the rice milled locally reduces the volume that needs to be transported by about 1/3rd. It also leaves the hulls and bran in the area where the bran is sold for animal feed and the hulls discarded. The bran has to be used fairly quickly as it contains some 20% oil that could go rancid if held too long. It is estimated the shelf life for the bran is one month. Discarding the hulls is normal for rice as they contain too much silica to be used for feed or even incinerated, as the silica has a sandblasting effect in the smoke.

Most of the mills are simple two stage single pass mills that first dehull the rice and blow the hulls away, and then polish the rice to remove the bran and drop the bran on the floor, with the rice collected in a bin (Fig. 12). These single pass mills are really the norm for small family owned and operated rice milling enterprises, and are used extensively in Tanzania, and Kenya as well as Ghana. The result is a reasonable good quality of rice with about 14% broken. This would not qualify for the international market but would be suitable for the local market. Some of the mills have destoner that can destone the rice prior to milling (Fig. 13) and also sieves that can remove some of the brokens after milling. After milling the traders will bag the rice under their label. All this equipment is operated with electric motors from the power grid without the need for diesel back-up reflecting some confidence in the power supply.

*Fig. 12. Simple single pass, two stage rice mill used extensively in the scheme.*

*Fig. 13. Destoner placed in front of rice mill in Fig. 12 to remove stones and mud clods from the paddy prior to milling.*

**Mechanization – Power Tillers**

The use of the power tillers was most appreciated (Fig. 14). They seem the ideal mechanization for smallholder rice production, and are used extensively throughout Asia completely replacing the water buffalo in many areas. This conversion started some 30 years ago so that many farmers are on their third if not fourth unit. I would claim that the conversion to power tillers for rice was a major reason for the success of the “green” revolution in Asia. As best I can estimate it the power tiller in Asia halved the crop establishment period and thus brought twice as much land within the desired timeframe to take full advantage of the “Green Revolution” technology being developed and disseminated concurrently, from IRRI, CIMMYT and the other IARCs.  However, this goes largely unrecognized by the development community, including those now attempting to bring the “green revolution” to Africa.

*Fig. 14. Asian rice power tiller becoming common in the scheme and needs to continue to be encouraged.*

The power tillers also greatly reduce the drudgery associated with the manual land preparation with a hoe. This then brings the calorie energy balance more in line with what farmers have access to so farmers can spend more time managing their land, and will have the energy to do so. The alternative of manual land preparation typically will expect farmers to exert more caloric energy than they have access to, and result in their only being able to work three or four hours a day[2]. This will greatly prolong the crop establishment period, limit the total area a farmer can cultivate, and render any agronomic recommendations based on timing null and void.

The power tillers equipped with cage wheels can easily operate in the rice paddies in whatever number of bunded individual paddies farmers divides their allocated parcel into. It may be slow but it does not get bogged down and bearings remain free of the grit that damages larger tractors in paddy. Also, when equipped with plank and after the paddy is well puddle a power tiller can easily level a hectare in a day to make certain the water management is uniform across the paddy. This is something that could be important if most of the rice is directed instead of being transplanted.

The number of power tillers the scheme can support may need to be looked at more closely. My estimate is that you should have one power tiller for every six hectares of rice land. That is again based on Thailand where most rice farmers manage six hectares and own a power tiller to assist them with land preparation, pumping water when necessary (Fig. 15), and transport of paddy from field to home and on to market (Fig. 16). These Thai farmers now have a fairly comfortable life style usually including motor cycles, if not pick-up trucks, refrigerators, TVs with VCRs, and the essential cell phone, etc. I think Ghana rice farmers

*Fig. 15. Power tiller in Thailand being used for low lift pumping into rice fields.*

*Fig. 16. Power tiller in Madibira, Tanzania overloaded in bringing rice plus laborers home for fields.*

[2] *http://lamar.colostate.edu/~rtinsley/CalorieEnergyBalance.htm*

can enjoy the same benefits. At one power tiller for every six hectares the scheme can support some 500 power tillers which if they have a 10 year service life means a turnover of some 50 power tillers per year which should be enough to support one or two competing dealerships in Akuse.

It was also nice to see the power tillers were being made available under a subsidized purchasing program supported by one of the Asian Tiger economies. Someone apparently got the right idea. In Madibira, Tanzania, when I return on a private visit five years after the expatriate facilitation ended, there were approximately 50 Asian rice based power tillers in the area. All were self financed by the farmers independent of the donor community.

It is not recommended that you attempt to use larger 4-wheel tractors in the rice fields. They not only can become more bogged down in the mud, but sand will get into their front wheel bearing and quickly wear them out. In Bolivia it was estimated that the bearing would last only one season compared to three seasons when not working rice, and the replacement cost was approximately US$ 400.00. On an operating hour basis it added US$ 3-4 per hour. It was noticed that the private tractor unit located near the KIP headquarters was using mostly 60 to 70 hp tractors from India. These were mostly contracting for upland use and avoiding paddy for fear they would get bogged down in the flooded paddy. This is the most common size tractors serving smallholder communities.

**Land Allocation**

The land in KIP is intended to be one hectare per family. This is really not enough for full time rice cultivation and implies that individuals will have to divide their time between working in the scheme and working rainfed upland areas outside the scheme. This can lead to some conflicts in time allocation that could hinder the overall operation of the scheme, particularly if the mechanization is intensified to obtain the five crops in two years.

The problem is that when someone is managing both rainfed and irrigated land, when the rains come, the priority immediately shifts to the rainfed lands since, if they are not promptly established, the opportunity will be lost, even though the rainfed yields are lower and less reliable. Meanwhile, the irrigation system provides flexibility for managing the irrigated lands. This is shown in the Tank System of Sri Lanka (Fig. 17) as well as small irrigated rice schemes in Malawi where the conflict was between irrigated and rainfed rice. Typically, it will take six to eight weeks for the rainfed lands to be sufficiently established to allow farmers to return to the irrigated areas. For those managing the irrigation scheme this can be a very frustrating time.

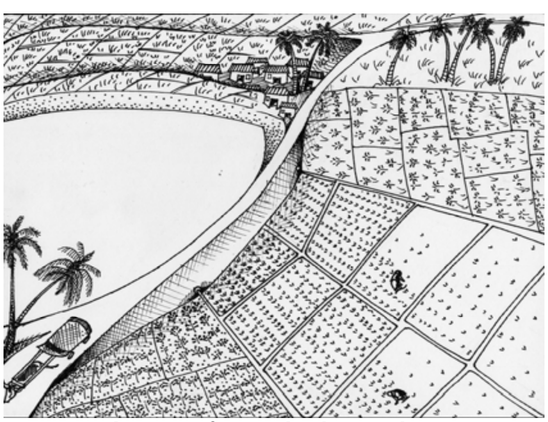

*Fig. 17. Tank system of Sri Lanka showing the priority to the upland rainfed crops over the irrigated paddy crops during the rainy season.*

Within the scheme the recommended farm size for full time rice farming is five hectares. I might raise this to six. There are several ways this can be quietly done, that are currently being undertaken by the farmers. These include registering more than one member of the family for land. Typically this would be spouse or sibling, but occasionally minor children. The same informal registering of multiple members of the family occurred in Madibira with its one hectare allocations. It is also possible to rent land for seven bags of paddy a year. Since this is actually leading to a more viable scheme with the potential for intensification, the management should quietly allow this to proceed at least up to the five or six hectares suggested for full time rice farming. It might also be desirable to consider revising the overall policy so farmers can legally register for up to five hectares of land in the project, and become full time rice farmers.

**Crop Establishment**

The crop establishment appears mostly direct seeding rather than transplanting. This is good and consistent with trends elsewhere, particularly as management units creep up toward the five or six hectares needed for full time rice farming. At that level of cultivation the transplanting costs are just too high and the required labor for timely transplanting may not be available. The ability to effectively direct seed can depend on how level the paddies are as at the very early growth stages, basically the first week to 10 days, rice can be very sensitive to water management and the seeds have to be in an aerobic environment (Fig. 18). If they become anaerobic the rice will drown, as was observed in some fields within KIP after a heavy rain. Once the rice is about seven centimeter high it should be survivable with modest flooding from a sudden rain. It is possible to make small drains furrows of about 15 cm wide and 5 cm deep radiating from the field outlet to help remove excessive water during the critical germination stage. This is a common practice in Sri Lanka.

*Fig. 18. A well established directed seeded rice on a well leveled paddy.*

**Cooperative & Credit**

The project does have a credit program working with the rural development bank. This is a closed system, which only offers loans to member of the cooperative, who were also cultivating rice. None rice farmers in the areas are not eligible for loans. The loans have an annual interest rate of 30%. This may sound high, but most likely represents the administrative costs of managing what are basically small loans, and is based on the overall administrative costs, as administrative costs for managing loans are based more on the number of people involved than the amount of the individual loans. Thus the administrative costs for a large loan can be nearly the same as a small loan, but represent a much smaller percent of the large loan.

As has been the standard with most development projects, the credit is administered through credit clubs in which the members are collectively responsible for the repayment. The problem was before shifting to the credit club system there was a history of poor repayments when loans were given directly to members. I tend to tread very carefully here as most of the time credit clubs have had limited success, and become an invitation for massive side selling. Typically after initially having some of their rice confiscated to pay off neighbors loans, honest and responsible farmers will consign to the project just enough rice to cover the loan and then side sell the rest to any private trader in the area. This should be considered an astute business decision on the farmers' part.

While the loans are quoted in cash, repayment is accepted in kind with some kind of conversion determined prior to the harvest, but well after the loan has been made. The in-kind repayment is usually good as it encourages the timely repayment of loans. However, in this case the process looks very cumbersome. This adds to the overhead costs of administering the loans that has to be recovered from some source or in this case absorbed by the government in the overall subsidize of the project by covering the salaries and benefits of some 120 employees. This would also include the cost of managing the warehouses in which the paddy is stored and absorbing the post harvest storage losses. The credit costs can and should include the cost of monetizing the in-kind payments back to cash. This could include some extensive storage time with related post harvest losses to rats and weevils, etc. if the project holds the rice for any substantial period of time. Still, the bottom line of the credit program is that it is only serving about 10% of the beneficiaries which means 90% are self-financing their rice production, and program cannot be seen as truly successful. Either for most of the beneficiaries it is not really needed, or most of the farmers for some reason are not eligible for credit.

The credit appears only available for production loans covering seed, fertilizer, and crop protection materials. It does not include funds for contract tillage or labor for harvesting and post harvest handling. Even so the total loan could be as much as GH¢ 2179.00 (US$ 1535). Which when the 30% interests is added could bring repayment obligation to GH¢ 2800.00 (US$ 1931). This would require some 56 bags of paddy at 82 kg/bag. If the farmer's yield was 5.5 t/ha he would have to provide some 56 of 67 bags to pay is obligation leaving him only 11 bags for consumption and profit. Allowing 2.5 bags for subsistence needs there would be only 8.5 bags for cash which at GH¢ 50.00 (US$ 34) for perfumed rice would provide a cash income of GH¢ 425 (293). If the yield was increased to 6.5 t/ha, the farmer would have an additional 12 bags of paddy that could provide an additional cash income of GH¢ 600 (US$ 414). However, while the loans were packaged to a certain recommended level of inputs, the farmers do not have to accept the entire package, and could take out only what they feel they need. They are also given the loan in cash, so it could also be diverted to other needs or obligations that arise in the course of a year. This is a major improvement on many loan programs that require full acceptance of the entire production package and disperse the loans as chits to be redeemed at the supply depot, either private or public.

*Fig. 19. Agrodealer in Akuse dealing in full range of supplies including crop protection chemicals and fertilizer, plus vegetable seed but not rice seed.*

The inputs specified in the loan are readily available from any of a number of well stocked agro-dealers in the area (Fig. 19). This allows the farmers to easily adjust or "fine tune" the recommendation to their specific needs and interest. The only problem would be the certified seed component of the package, but most farmers would decline that portion.

Credit is not available for purchasing power tillers or other mechanization needs that could enhance the cultivation and lead to higher level of crop intensity. This is something that might be worth considering in the future.

## Water Management

As with most irrigation projects, the water management can be critical and also can be the most challenging to be effective, particularly for smallholder schemes. This is the case with KIP.

### Primary & Secondary Canals

The basic design appears to be sound and most of the control structures remain in good repair. The use of duck-bill weirs at the secondary canal outlet allows for some major control with very limited head. This is the same as in Madibira and reflects Hunting Technical Services design of both schemes. However, as with most public sector irrigation schemes intended for the benefit of smallholder producers the funding for the routine maintenance of the main canals has been a problem. KIP has the heavy construction equipment required for maintaining the main canals free of weeds and sediment, just not the funds for fuel and preventative maintenance to keep the equipment running so it can regularly clean the canals and drains. This is exasperated by herds of cattle walking into the canal to drink water (Fig. 20). This has resulted in some massive slumping over the relatively short length of canal involved.

*Fig. 20. Cattle drinking from the main canal and slumping the canal bank into the bottom reducing the canal conveyance capacity.*

However, if not corrected fairly quickly the conveying capacity of the main canal will be restricted and water will not reach the further ends of the canal resulting in land going out of use and farmers being displaced.

Perhaps the easiest way to address the problem would be to initiate a request to the AfDB, the original funder of the project, to provide a rehabilitation and upgrading of the scheme loan to return the main canal to its original design, while also installing some effective means of allowing the cattle access to the water for drinking, etc. without damaging the canals. There are two cattle drinking places in the original design but they are far from where the cattle damage is occurring and rarely actually used. Also, there are some innovative approaches on how to accommodate the cattle by providing a drinking trough on the outside of the canal bank, with pipes through the bank to just below the normal water level so small amounts of water can make a brief loop through the watering trough. Part of the justification for the renovation funding would be to recognize that the canal altered the previous cattle circulation pattern away from the original watering points to where the damage is being done, and the adjustments need to be made.

There is actually some urgency in doing this because it typically takes two years or more for a development project to materialize after the original project identification paper is put forth. In two years it is possible for the capacity in the main canal to deteriorate sufficiently for land to go out of cultivation, and farmers are forced to start abandoning their lands.

In addition to the cattle damage, the main canals and drains are over grown with weeds that reduce the flow (Fig 21 & 22). This is more of a problem for the canals than the drains as the drains were dug to provide fill for the canals and are thus over capacity. Also, since they normally carry less water the water will eventually makes its way through the weeds. The biggest problem will be when there are heavy rains and the full capacity of the drains is briefly required. Then the weeds will result in some temporary flooding and damage to maturing crops, as occurred during the consultancy.

*Fig. 21. Main canal with weed growing across sections of the canal and reducing flow.*

*Fig. 22. A ford in the drain with footbridge and behind the drain fully blocked with weeds.*

**Tertiary Canals**

With the secondary and tertiary canals as with the main canal the control structures remain in tack and operational. Most are simple concrete structures built to accommodate some wooden flashboard that often could be locked in place (Fig. 23). Also, sometimes they were jerry-rigged with a sandbag to close them as needed. However, as with most public sector irrigation schemes the tertiary canals are expected to be maintained by the famers through some form of farmer organization usually referred to as a Water Users Association. The expectation is that the farmers will take responsibility for the canal adjacent to their lands. However, it might be interesting to review this according to the changing vested interest as one progresses down a tertiary canal and passes individual field outlets. The result of this is to note that the weed adjacent to a farmer's field but past his outlet are actually beneficial to the farmer since they slow the water down and generate backflow that provides him more water (Fig. 24). The weeds that are a greater concern are those immediately in front of his outlet and adjacent to his upstream neighbor. However, normally the upstream neighbor will object to having the weeds removed as these weeds are beneficial to him, so there needs to be a clear mandate from the scheme management that will allow farmers to maintain tertiary canals prior to their fields. If not than little cleaning will be done without some substantial external facilitation from the scheme management and most of the time the tertiary canals will be full of weed, etc. (Fig. 25). An example of how farmers understand and appreciated the changing vested interest would be from Egypt where a farmer carefully removed the weeds from the beginning of his land until the inlet for his sakia that lifted the water to his field, but retained the weeds past the inlet as they slowed the water so more reached the sakia (Fig.26)

*Fig 23 Concrete control structure for controlling water into tertiary canals.*

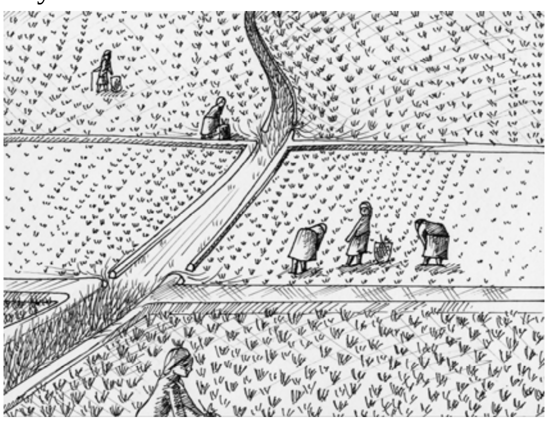

*Fig. 24. Diagram illustrating how weeds adjacent to a field benefit the farmer while those in front are his main concern.*

*Fig. 25. Typical tertiary canal in need of cleaning but not in vested interest of those designated as responsible for cleaning.*

*Fig. 26. Tertiary canal with weeds completely removed until the inlet for the sakia, but fully retained after the sakia inlet.*

The same problems of tertiary canal maintenance occurred in the sister scheme in Madibira, Tanzania, and resulted in the following proposed management statement that KIP might which to consider in its present or modified form.

***Operational Proposal for Madibira***

*The proposal put forth by the author for organizing the tertiary blocks in Madibira included:*

***Entitlement****: Every farmer was entitled to an equal share of the water entering the block. Admittedly this is a weak and nebulous statement but all that was really available under the circumstances.*

***Right to Intervene****: All farmers have the right, either singularly or as a group, to physically intervene above their inlet and adjacent to their neighbors' fields to assure they receive their equitable share. This would include removal of pipes through the canal bank, smearing the canal walls to reduce seepage, adding material to the top of canal banks to prevent overtopping, removing weeds and sediment from the canal, etc. They would also be entitled to obtain any necessary fill material from the first 30 cm of a field (1 transplanted rice plant) as well as from the bottom of the canal, to assist with raising the canal bank.*

***Recourse****: Any 10 of the 30 farmers in a tertiary block could partition the management to intervene in the tertiary block management. If so partitioned, every member would be assessed TSh 1000 ($1.50). This would be just to keep frivolous complaints out. It represents less than one day's wage for a project hired casual worker. Once it receives a complaint the irrigation management would suspend the leadership of block and appoint a 3-person panel to review the problem. The panel would consist of one member from management, one farmer from another tertiary block and one member from the community at large. Each person would receive TSh 5000 for the effort. That represents half the money collected, with the other half going to the project for overhead costs. The panel would then investigate the complaint, listen to the plaintiffs and defendants, visit the block, check to make certain it was receiving the allotted 75 l/s of infow, and make certain no unnecessary water was being discharged into the drains, etc. The panel would then render a decision that could include fining individuals, dismissing the block chairman and calling for new elections, expelling individuals from the block and scheme, or simple recommending more effective rotations systems, including the use of check structure in the field canals during an individual turn.*

**Field Inlets**

The field inlets were really very simple pipes through the bank that could easily be plugged with a gunny sack filled with rags if desired to prevent water from going in (Fig. 27). Typically the only time a rice farmer would not willingly accept all the water possible is during maturity and harvest when the desire is for the rice to dry. However, it might be desirable to consider small concrete or concrete covered brick check structures suitable to insert some flashboard to lift the water and enhance the flow of water into the individual field and reduce the flow being discharged out the end of the canal.

*Fig. 27. Field inlet as simple pipe with plug for when water was not desired.*

**Funding Irrigation Operations**

KIP, like all the other public sector irrigation schemes, has difficulty raising the money it needs to operate the scheme and undertake all the maintenance, particularly for roads and canals that will assure the easy flow of goods and equipment as well as sustained the overall operation of the system. This would include escrowing funds for the eventual replacement of the different control structures that ultimately do breakdown and need replacement or at least renovation. Unfortunately, there does not appear any easy solution to this problem. KIP does have a reasonable financial arrangement to cover the costs but too many farmers fail to pay their obligations and the money falls short. The fee structure involves an annual fee totaling GH¢ 120 (US$ 82.76) that can be transparently divided between land rent (GH¢ 1.25 (US$0.86)), water management (GH¢ 98 (US$ 68)), project development (GH¢ 14.75 (US$ 10)) and post harvest handling (GH¢ 6.00 (US$ 4)). The majority of these fees are allocated for water management, which is consistent with the overall costs of maintaining the scheme. However, collecting the fees all gets tied up in the inability to enforce payments when there is no effective way to shut off water to an individual in the middle of a tertiary canal, while still delivering water to the paid up neighbors.  The lack of payment by a few then quickly spirals until very few actually make the payments. Ultimately the scheme collapses and has to be rebuilt.

In trying to figure a more effective payment method it is essential the KIP keep a very careful evaluation on the overhead costs for collecting funds. This can become very high if any attempt is made for a true volumetric charge. One thing KIP might consider is contracting the cleaning of the primary and secondary canals to contractors. This would save the project the necessity of buying and maintaining some heavy construction equipment that gets only a limited amount of use each year. Often it is cheaper to contract for this service and allow the contractor the problems of maintaining equipment as well as using it for other projects so the equipment is more fully utilized.

## Summary and Conclusions

Overall the Kpong Irrigation Project is doing quite well. The most urgent need is to address the problem of main canal maintenance particularly the problem of cattle drinking from the canal and damaging the bank. This may need to be referred back to AfDB for a rehabilitation loan. As this could take a couple years to put in place there is some urgency in initiating the process. There is also the problem of main canal maintenance from the normal accumulation of weed and sediment and the difficulty of collecting maintenance funds from the members. This actually is common to most smallholder irrigation systems and there no easy solutions without a clear leasing agreement and right of the project to evict non-paying members.

Other than these pressing issues the project is doing well. The yields of six to seven or more tons per hectare are approaching the climatic limit for a lowland tropical area. The targeted yields of 10 t/ha are more associated with longer summer days of the sub-tropics and temperate area, that only have one season per year. The scheme is mechanized around the Asian rice power tiller as is common throughout most of Asia and has lead to substantial intensification. If this mechanization of the harvest operation continues this could lead to a more intensive cultivation culminating in producing five crops in two years instead of two crops per year. Again this is consistent with the fully irrigated areas of Thailand. One benefit of increasing the mechanization of harvest could be cleaner harvests eliminating the gleaners that follow the threshing as well as reducing the amount of stones and mud clods in the paddy that often require an extra destoning step during milling. This could bring the farmers a higher return for a clean bag of paddy. There is a major bottleneck for drying as the paddy is harvested fairly wet around 20% moisture, to reduce the bird damage.

Inputs are readily available through any one of a number of small agro-dealers in the area. This allows the farmers to adjust their input level as they think best. There is a credit program but it is only used by a small minority of farmers with payment in kind. The process appears rather cumbersome and may need to be reviewed to see if it can be made more efficient.

**Activity Log Ghana**

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|---|---|
| Thur. 15 Oct. | Arrived in Ghana after two hour flight from Abuja, was meet at the airport and proceeded to the hotel, near the airport. |
| Fri. 16 Oct. | Morning meeting with Alexis Ellicott to wrap up as best possible the Nigeria assignment and proceeded briefly to the ACDI/VOCA office before heading to Akuse and the Kpong Irrigation Project. Briefly met with the irrigation authorities and checked into their guest facility. |
| Sat. 17 Oct. | Mostly free day to become familiar with my new surrounding and essential facilitates needed to operate for the next three weeks. I was able to work on Nigeria report and in the evening go to the next town to become familiar with internet café availability and let my family know I was on a bush assignment. |
| Sun. 18 Oct. | Again a slow day, but did attend Church with Thomas, then a full day of rest and work on the Nigeria report. |
| Mon. 19 Oct. | First real work day, included visit to the irrigation scheme, brief look at the head works and then some fields where women were gleaning already threshed rice. Continued to look at some harvesting and threshing, using a threshing box with amble opportunity for rice to be scattered outside the box. Finally, I attended an extension meeting that was mostly a progress report on the harvest with some yield estimates ranging around seven tons per hecatre, basically a good yield. |
| Tue. 20 Oct. | Field visit to the end of the canal and looked at several massive drying effort for new rice. With each farmer having approximately 70 bags of 84 kg, it requires a lot of space. Also, saw a small fertilizer trial on rice, mostly looking at foliar applications of K and comparison of Urea and Ammonium Sulfate. It looks like the basic rate is around 120 kg N/ha. Finally, drove through the banana estate operated by the French but occupying 1000 ha of scheme. This is the high area requiring about a two meters lift and use of drip irrigation. |
| Wed. 21 Oct. | Accompanied Thomas's daughter to the market to get the consumer prices I usually need, and got most of them. |
| Thur. 22 Oct. | Accompanied Thomas to visit nearest Agriculture Research Station. It had a mandate for rice, but had not received any fresh genetic material in over 10 years. Apparently the connection from IRRI through WARDA had broken down with all WARDA's problems finding a country with enough political stability to operate. The program was basically financially stalled. |

On returning stopped by a private rice processing facility that was custom processing rice via destoning, milling and grading to remove broken. The mill was two stage single pass similar to what was in Madibira. It did separate the bran from the hulls and sold the bran as chicken or pig feed claiming a one month shelf life. The stop was to allow Thomas to collect some bran for his pigs.

Fri. 23 Oct. With Thomas dealing with ministry people on four large combines that were completely inappropriate for a smallholder scheme, and Jacob also with other obligation I was on my own. Thus went down the hill and interview the credit bank manager, than stopped by the private mechanization unit. The owner/manager was not in but called me shortly thereafter and we met at Sancourt for soda that continued into lunch. Andy was also an ACDI/VOCA FtF host. We covered full range of issues on mechanization.

While having lunch Frank from ACDI/VOCA stopped on a routine field visit. He was surprise do meet Andy. He also brought the needed exchange funds so I can pay my bill.

Sat. 24 Oct. Weekend spent on site working on Nigeria second draft.

Sun. 25 Oct Weekend, when to church and continued on Nigeria report

Mon. 26 Oct. Discussion with maintenance manager on irrigation system became concerned with the silting of the main canals that could close the system within a couple years. Accompanied Jacob to the field to check on drying floor activity for his rice and cooperative rice. Meet briefly with president of farmers association. Returned for weekly extension meeting

Tues. 27 Oct Lengthy discussion with Jacob on rice management including varieties being used. Went out to send quick email message.

Wed. 28 Oct. Lengthy meeting with the president of the farmers' cooperative. Mostly on the somewhat cumbersome credit system and that only 10% of the farmers used it. Most self financed but claimed to want financing. Also, noted land was rented out to other members for seven bags a year.

Thu. 29 Oct. Brief visit to field and continued interviews with KIP staff.

Fri. 30 Oct. Extensive visit to all aspects of irrigation from control structures to field canals, etc got good photo of threshing boxes and use of power tillers, etc

Sat. 31 Oct. Quiet day around the area

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|---|---|
| Sun. 1 Nov | Attended Church, quiet day around area, and prepared power point for Monday’s presentation |
| Mon. 2 Nov | Held workshop for 40 people with good response |
| Tue. 3 Nov. | Final field visit to look at repairs to siphon, and returned to Accra |
| Wed. 4 Nov. | Debriefing with KIP and ACDI/VOCA Staff, completed final paper work |
| Thu. 5 Nov. | Toured Accra and departed for Nairobi |
| | End of Log |