Farmer to Farmer Program
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Volunteer Consultant to the Rural Community in Development For Evaluation the Potential of Micro Irrigation

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Declaimer

This report represents the insights of a short term ACDI/VOCA sponsored volunteer consultant to the Rural Community in Development (RUCID) Project. As with all such consultation there was not enough time to meet with everyone involved or collaborating with the Project. The evaluation, therefore, has to be viewed in terms of the limited visits and interviews made and the information derived from them. This could result in some inaccurate statement, interpretations and excessive extrapolations. None of these are intended, but often can not be avoided. When this has occurred, please accept the consultant's apology and advise him of any erroneous interpretations or information omitted. Also, the ideas and concepts expressed in this report are the author's who is solely responsible for the contents. The opinions are not necessarily those of RUCID, Misereor, ACDI/VOCA or USAID.

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List of Acronyms

ACDI/VOCA	Agricultural Cooperative Development International and Volunteers in Overseas Cooperative Assistance
ET	Evapotranspiration
HIV/AIDS	Human Immunity Virus/Acquired Immunity Deficiency Syndrome
KCl	Potassium chloride
K_2SO_4	Potassium sulfate
PFV	Pesticide Free Vegetables
RUCID	Rural Community in Development
Misereor	German Catholic NGO funding RUCID
NGO	Non-Government Organization
psi	Pounds per square inch
UNICEF	United Nations Children Fund
US	United States
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USh	Uganda shillings
UV	Ultra violet light
WHO	World Health Organization

Executive Summary

The consultancy to evaluate the potential to develop micro drip irrigation systems for the RUCID center and it cooperating farmers quickly identified that the soils appeared to be anion active soils from either the USDA Andisol or Oxisol soil orders. These soils are characterized by high infiltration rates and deep water tables. This resulted in recognizing that, while there may be ample water available in Uganda, getting it to the hilltops where most of the cultivation is done would be a challenging task.

The more critical water issue was really enhancing the availability of domestic water. Currently, women will trek up to one kilometer with a vertical climb of up to 100 m to collect water. The result is they will spend up to 1/5th the daylight hours just to obtain 100 liters of water. This is the minimum standard for two people, a husband and wife without any children. This water comes from turgid springs and does not appear sufficient for more than domestic use without extensive development. It will also require high pressure pumps and accessories to lift the water from the springs to the cultivated fields, and all the additional expense associated with buying and using the high pressure equipment.

Alternative sources of water are urgently needed. The most appropriate would be domestic boreholes or wells but they also require some major lifting which would need donor assistance to drill. Other water sources would be harvesting rainwater from roofs. This is good, but most likely would be limited to supplementing the domestic water and briefly relieve the drudgery associated with obtaining it.

The availability of water and difficulty in accessing it very much justifies a close look at drip irrigation, but on closer evaluation it may not be the most suitable form. This is primarily because in irrigating tree and perennial crops, it would be possible to use a simpler hose distribution system and still apply no more water than the crops require. This will negate the water conservation aspects of drip and make the extra hassle of managing drip systems an inconvenience, and thus not economical. However, it would be appropriate to at least demonstrate the use of drip irrigation along with all the extra managerial concerns it requires.

It is suggested that RUCID proceed to develop an irrigation demonstration based on linking the existing roof harvesting tanks into a single distribution system that can use simple garden hoses to distribute the water. However, it is recognized that institutional use of the roof harvested water will rightly have higher priority than irrigation and thus there may not be a lot of water available for irrigation at least from the upper tanks needed for the kitchen and hostel use.

On other issues, it is necessary to continually be aware that the resource base the farmers have to manage their lands is normally considerably less than the demonstration farm. Thus, it is necessary to continually evaluate what the farmers are accepting, rejecting, and more importantly modifying. At present, the organic practices promoted by the project are taking about five hours a day of additional effort with the use of compost effectively rejected as too much time and effort for too little returns. Similarly the suggestion of using one wheel-barrow load of organic material

per square meter will require some 300 tons of material and 10,000 trips. This material just is not available within a farm, and thus exceeds the limits the farmers can obtain for acceptance over an entire farm. It also must be recognized that most organic farming with the exception of nitrogen fixation by legumes is more a movement of nutrients from one place to another in a zero sum effort than the manufacture of additional nutrients. The natural removal of nutrients with the marketed produce eventually has to be replaced from an external source. Also, recovering organic nutrients requires extensive time and effort, for which the energy required for the nutrient recovery may actually exceed the extra energy produced by whatever increased yield is obtained by recovering the nutrients.

It should also be noted that the soil type reduces the importance of some of the water harvesting and conservation terracing activities, particularly the water harvesting ditches. Since they typically drain within one day, they will not contribute substantially to the water needs of the plants. They would have to store water for at least four or five days to be effective. The terracing effort is more effective and is developing some soil behind the vegetative barriers.

Finally, a cautionary note on moving your farmer organizations from farmer associations, primarily involved in information sharing and facilitation, to farmer cooperative business ventures. Cooperative business ventures as part of development projects tend to be less effective than expected with substantial amounts of the produce being side sold via private traders. The private traders normally considered as exploitive of smallholders, may really be more the victim of a fragmented marketing system and actually be living near or below the international poverty standards. Prime examples are the banana traders plying the highways around Mityana with overloaded bicycles.

INTRODUCTION

This report is prepared by an ACDI/VOCA volunteer consultant as part of the USAID funded Farmer-to-Farmer program. The consultancy was to assist the Rural Community Development in Development Project (RUCID) evaluate the prospects for providing irrigation for their demonstration farm and cooperating farmers and farmer organizations. RUCID is a small local NGO devoted to promoting Organic Farming and land conservation. It receives most of its funds from Misereor, a German Catholic Charity. It was anticipated that the conditions in the RUCID project area would be conducive for drip irrigation.

The consultancy was for three weeks starting 18 June and extending to 8 July 2005. The consultancy consisted of one week of field visits, one week of synthesis discussions, and a final week for a seminar, report drafting, and final wrap prior to departure. The consultancy was based at the RUCID demonstration farm and training center in Mityana some 60 km west of Kampala.

IRRIGATION POTENTIAL

Soils and Land

Anion Active Soils

During the field visits it quickly became apparent that something unusual was taking place. There were few domestic wells and people, particularly women, were spending considerable amounts of time hauling water from springs located approximately one kilometer from their homes and up to 100 m below them. This led to the opinion that the soils in the area were anion active soils. The designation is my own and is based on their dominating colloidal composition. However, the important points for this discussion concerning irrigation potential are the physical characteristics of these soils.

The anion active soils are those soils that belong to two USDA taxonomic soil orders at opposite ends of the weathering sequence. They are the very old Oxisols containing large amounts of iron oxides that give them a deep red color, and the very young and usually highly fertile Andisols derived from volcanic materials. The rather dissected landscape would at first favor the Andisols over the Oxisols, but when informed the area is not derived from volcanic activities I will have to consider the Oxisols. It really does not matter as the conditions concerning this report are true for both.

Reason for Suspicion: My suspicions the soils are anion active is based on:

- The very low water table
- The high infiltration rates as noted in the water harvesting ditches draining within a day

- General red soil color, although not as deep a red color as I would have expected
- Limited signs of erosion, and steep nearly vertical road cuts
- Limited water holding capacity based on need to frequently irrigate tree crops that should easily survive the three month dry seasons, how-be-it with some moisture stress affecting both the dry season yields and produce quality.

Properties of Anion Active Soils: The anion active soils are just as easy to understand and predict as more typical cation based soils for those who have encountered them and taken the time to understand them. However, their properties are considerably different from most soils, so those who do not take the time to understand them will find them confusing. Since they mostly occur in the Tropics they are normally not included in most soils classes unless the institute is directly involved with them. They are also rarely included in the soils curriculum of national universities in the tropics, when these curriculums are based on temperate soil curriculum. There basic properties are:

- Deep soils with limited horizontal differentiation,
- High permeability and rapid infiltration of water,
- Low erosion potential,
- Highly stable soil structure permitting nearly vertical road cuts,
- Very low water tables,
- High soil water content, but low water availability as most water is held below the permanent wilting point,
- Easy to work even shortly after heavy rains and thus suitable for sustainable upland rice cultivation (Fig. 1),
- High organic matter content, but mostly tied to colloids and thus not contributing to soil fertility. Organic matter remains an equilibrium between what is generated and what is decomposing, just the measured amount is higher.

Fig. 1. Soils are easy to work even shortly after rains.

- High level of Phosphorus retention most of which is unavailable to the plants. However, phosphorus deficiency was not observed in the crops examined.

The critical properties relative to the project are:

- Deep water tables making any irrigation efforts require substantial lifting, making wells for domestic water expensive, and limiting the effectiveness of the water harvesting ditches as the water disappears within a day,
- Low erosion hazard limiting the need for and effectiveness of conservation efforts.

However, the quick pH test for anion dominance was not as conclusive as expected. The test is to compare the pH in water, potassium chloride (KCl), and potassium sulfate (K_2SO_4). The expectation is the pH in KCl will be less than in water, as happens with most soils including these. However, in strongly anion active soils the pH K_2SO_4 will be higher than in water (Table 1). This did not happen as the pH in K_2SO_4 was only equal to the pH in water. This would still indicate a substantial amount of anion activity, but not overwhelming.

Table 1. Comparative Soil pH in Water, KCl, and K_2SO_4 as a test for anion activity

Soil	Water	KCl	K_2SO_4
Top Soil	6.55	5.99	6.46
Sub Soil	5.56	4.93	5.55

Land Use

In the context of the project area, most of the land is in V-shaped valleys as compared to U-shaped valleys (Fig 2). V-shape valleys have steep lower slopes going to the bottom with more gentle slopes at the top. Thus, the cultivated land is mostly on top of the hills, while the available water is at the bottom of the hills with up to 100 m of vertical lift to bring the water to the cultivated areas. One hundred meters of lift equals 10 atmospheres which at 15 pounds per atmosphere results in a lift pressure of up to 150 psi just to get the water to the cultivated areas. This represents more expensive high pressure pumps and other equipment including the pipes, hoses and fittings and other accessories that can withstand the high pressure, at least at the bottom of the hills where the pressure will be highest. Lower pressure sensitive equipment can be used near the distribution area as the pressure will have decreased. While 100 m is the estimated extreme, for most communities visited the lift would range from 50 to 75 m with only one farm having a more reasonable 30 m lift to get water from their spring to the highest field. Effort to cultivate the lower slope closer to the water would result in cultivating some steep, up to 100% (45˚) slopes which, even for these soils, would have a high erosion potential (Fig. 3).

Most of the land is in perennial crops such as bananas, coffee, papaya and citrus (Fig 4), with some annual crops such as cassava, sweet potatoes, maize, beans, etc. grown in the lower canopy below the perennial crops. It should also be noted that cassava is increasingly the HIV/AIDS mitigation crop that people are shifting to when either

infected by HIV/AIDS and do not have sufficient energy to manage other crops, or have swollen families resulting from relatives dying from HIV/AIDS and leaving them with minor children to raise. Cassava provides the most calories per unit of labor of all crops. The whole cropping system is known as multiple canopy cropping or canopy stacking intercropping. The perennial tree crops are relatively easy to manage and do not require heavy land cultivation to begin each season as occurs with annual crops such as maize and rice.

Fig. 2. Landscape view of a V-shaped valley with most cultivation at the top of the slope and the available water at the bottom.

Fig. 3. Efforts to cultivate lower slopes with severe erosion potential.

In Zambia, one elderly man was shifting to bananas cultivation as his "retirement" crop. His family was fully grown and living independently, and with that his income requirements reduced along with the energy he had to manage his lands. Thus he and his wife felt they could manage with the reduced income and reduce effort required for banana production. In the Philippines, the retirement crop is also a permanent

crop, but in this case it is coconuts. If not used as a retirement crop the lower management allows for larger farm units. This seemed to be the case as most farmers were managing in excess of four hectares compared to two hectares, the typical farm size for smallholders producing mostly annual crops. These perennial crops are normally managed in a highly organic manner with little inputs and a lot of mulching of the weeds etc., primarily as the most convenient means of disposing of the weeds. It might be interesting to compare what your farmers are doing compared to what is normally done to get a quantitative measure of the degree of intervention you are managing.

Fig 4. Typical combination of perennial crops including bananas, vanilla, coffee and papaya

This is actually a fairly common land use for these soils. An example is the canopy stacking cropping system in Cavate, Philippines. In this case it is based more on coconuts, but includes bananas, papaya with pineapples and other crops at the bottom of the canopy (Fig. 5).

Fig. 5. Similar multiple canopy cropping pattern on similar soil in Cavate, Philippines.

Water Resources

Spring Water

Within this overall soil land use pattern the water resources are deceptively limited. While there appears to be several large papyrus swamps in the area which contain a substantial amount of water that should be available for irrigation, the recovery of this water to the cultivated hill tops would in all probably not be economically viable. What you do have are small springs at the bottom of the slopes that, with considerable effort, can be used for domestic water (Fig. 6). These efforts include carrying 20 liter jerry cans up slopes that approach or exceed 100% (Fig. 7). None of these springs appear to contain more than a few cubic meters of water and none were flowing into a stream of some sort even though this is considered the end of the spring rainy season with some rains lingering each day.

To effectively use these springs for irrigation would require extensive developing of the springs so that there would be sufficient water to irrigate most of the command area before the springs are pumped dry and has to be allowed to recharge from seepage into the spring from the adjacent saturated soils. If the dry season ET for the mid elevation tropics is five millimeter per day and you were irrigating every four days it would require two centimeters of water. Thus, to irrigate a hectare it would require some 200 m^3 of water per irrigation or 400 m^3 to irrigate the two hectare RUCID demonstration farm. Thus, the four tanks currently installed at the RUCID facility would be sufficient for at most one irrigation. The water needs would vary linearly according to the actual irrigated area. If used in their present conditions the springs would most likely be pumped dry in about 10 minutes. Given the lift necessary to reach the fields, a large percent of the water would still be in the pipes when the spring dried, and most likely drain back to the spring once the motor is turned off. Not an efficient water recovery.

Fig. 6. Typical small spring found in the area with somewhat turbid water from suspended sediments.

Fig. 7. Steep path over which people must carry water to meet domestic needs.

Also, these springs are communal with several families deriving domestic water from them. Thus, any spring development would have to be a group effort with the expectation that all members would have an equal opportunity to pump water for irrigation. The lack of surface flow from these springs would indicate the total water was too limited for this.

Domestic Water

At present these springs are the primary source for domestic water. This takes considerable amount of heavy drudgery, mostly on the part of women. Typically, collecting water is a kilometer trek with a vertical decent of up to 100 m and lifting the water the same 100 m up hill on the return. Usually, it will take at least 30 minutes for a round trip to the spring and back carrying a 20 liter jerry can filled with water. If a person makes five trips a day, they will consume some 2.5 hours or nearly one-fifth the total daylight hours and have only 100 liters of domestic water. If the international minimum standard for domestic water is 50 liter/person/day, then the 100 liters represent sufficient domestic water for a husband and wife, without any children. The 2.5 person hours needed to obtain a minimum domestic water supply is labor diverted from more economic advantageous activities such as better crop and animal husbandry including the additional labor required for more organic sustainable agriculture. The major economic need in the area may be improving the domestic water availability in a way that will reduce overall farm drudgery as well as improve health.

I understand domestic water needs have often been identified in participatory surveys, but the projects associated with the surveys were not in a position to address the issue and it was dropped. Unfortunately, that is the nature of the development business with the commitment to the intervention including definition of professional staffing taking place up to two years before anyone has the opportunity to meet and talk with any farmer beneficiaries. The participatory process then has to be leveraged toward the intended intervention regardless of more urgent needs of the farm community.

Ground Water

The other alternative would be groundwater. However, there are very few wells in the area. This is surprising as in other areas the consultant is familiar with that have a similar soil type, there were domestic wells. They were deep and required lifting with a bucket and rope rather than hand pump, but at least it was possible. In this part of Uganda it looks very difficult. With this soil type the normal depth to groundwater following the general curve of the land up the hills, apparently does not exist so the static water level is near the bottom of the slope even under the center of the hill. Thus, even well water has to be lifted up to a 100 m. Thus borehole well construction will be expensive and will require some form of donor assistance. It is our understanding that those wells and boreholes that had been dug in the area were financed by UNICEF (Fig. 8). They should be encouraged to continue and other donors sought for additional wells. One possibility would be the Canadian based NGO Engineers Without Borders. They have a major mandate to assist with domestic water supplies. Unfortunately, developing domestic water sources is usually undertaken as a health issue, and not a drudgery relief issue. It should be looked at equally in both terms. However, drudgery relief is normally not as high a priority for the donor community as for the farmers and their families that actually have to undertake the tasks.

Fig. 8. One of the few domestic wells in the area.

Alternative Sources of Water

The project is promoting a program of water harvesting with an emphasis on collecting rainfall runoff from roofs into tanks. The training center actually has installed four 40 m^3 tanks and is actively collecting roof water (Fig. 9). Most of which is currently used for institutional use in support of the hostel. Given the alternative for getting water, this is actually a well founded effort. It should be continued and expanded as much as possible. However, it must be recognized that few farmers have the total roof area as the center, so their potential for collecting roof water is substantially below what the center can collect and the area for irrigating is usually larger. During the field visits only one farmer was actually collecting roof water, but on a much smaller scale. Another farmer expressed concern for the biological activity such as mosquito larvae with the potential for malaria and algae that will develop in such tanks (Fig. 10). This is a valid concern that needs to be evaluated. Still, given the roof area available it is unlikely that harvesting roof water will do much more than provide a temporary reprieve to the drudgery of carry domestic water up from springs and will not be available in sufficient amounts for irrigation other then a few key plants around the homestead.

Fig. 9. Water harvesting from the roof at the RUCID center.

Irrigation Prospects

While it is conceptually possible to irrigate any piece of land if one wishes to invest the time and money to bring the water to the land, it is often not economical to do so. It is the opinion of this consultant that this is the case for the project areas in Uganda. There is probably more then sufficient water in the papyrus marshes, but getting it to the primary agricultural lands at the top of the hills would be prohibitively expensive, and most likely would not have a positive cost benefit ratio, even for drip irrigation with its potential high application efficiency.

Fig. 10. Farmer's effort to harvest rainwater from the roof.

Irrigation Water Requirements

Irrigation tends to consume large quantities of water. Most of this has nothing to do with the plants. Instead it is based on the external energy load from solar radiation, etc. Most of this energy goes into the "latent heat of evaporation" or the energy needed to convert water from a liquid to vapor state. The energy required is approximately 550 kcal/cm^3. This change of state for water has a cooling effect, and is the plants' main means of keeping cool in the same manner sweating cools people. The net result of this is that to meet the evapotranspiration needs of a plant during a three month dry season it will require approximately 50 cm^3 of water for every centimeter of land surface with a plant canopy. This is not the leaf area index of the plant, which measures the number of overlapping leaves, but the shadow the plant casts on the ground. That is because the lower canopy leaves intercept less solar energy and transpire considerable less water than upper or fully exposed leaves. Applying less water then the potential ET will result in varying degrees of stress and yield loss mostly in direct proportion to the reduction in water applied. Given the source of available water it would be difficult to obtain enough water for any major irrigation activities.

This estimate of water requirements is good for most crops. The major exception and a crop of concern to the project is pineapple. Pineapple has the unique feature that it closes its stomata during the day and opens them at night. This greatly reduces the transpiration rate. The thick waxy leaves serve as an insulation to prevent overheating. Pineapples are basically xerophytes or desert plants.

Drip Irrigation

Overview: The form of irrigation expected to be recommended for the project is drip irrigation. Certainly the availability of water and cost of delivering it to the crop lands on the hill tops would justify a close look at the potential for drip irrigation. However, drip irrigation is normally not associated with smallholder irrigation. The

exception I am familiar with is Jordan and Iraq. In Iraq, drip irrigation is common in the south near Basra for tomatoes that are established in temperatures exceeding 40 C° and water comes from dug wells (Fig. 11) that are typically over 10 m deep. That is too deep for a suction pump and requires placing the motor pump near the bottom of the well. However, that is all the lift required (Fig. 12).

Fig. 11 Drip irrigation being used for vegetable production in Southern Iraq.

Drip irrigation enjoys a tremendous ideological appeal from donors, governments and natural resource conservationists, etc. for the potential to reduce water use. This is correct. When properly used and under the correct situations, drip can save 30% or more water relative to sprinkler systems and even more compared to surface irrigation. However, drip irrigation for water saving only becomes viable when the minimum water application of the alternative methods, such as surface or sprinkler, is greater than the crop water requirements. When this is not the case the water savings advantage of drip is lost. For this reason the advantage of drip is usually associated with incomplete canopy crops such as vegetables, fruit trees and vineyards. This is because the precision application to the individual plants eliminates the surface evaporation from the soil surface where there is no transpiration demand. Drip quickly loses its water conservation advantage for full canopy crops, and often has difficulty keeping up with the total evapotranspiration demand of such crops particularly on hot days.

Drip irrigation can have some extra benefits in improved access to fields. Large vegetable farmers shifting to drip in response to high water costs appreciated the continuous access to the fields for frequent picking of cucumbers and other similar frequently and multiple picked vegetables without having to wait a couple days for

the fields to dry as necessary with surface or sprinkler irrigation. Also, it can be easily used on irregular land that can not easily be shaped for surface irrigation or accessed by self propelled sprinkler systems. In addition, it can have added advantages for crops, such as grapes, that are sensitive to mildews and other diseases that are promoted by high canopy humidity. Finally, for tree crops such as bananas, the micro-sprinkler systems will allow farmers to irrigate under the canopy with applications similar to sprinkler applications.

Fig. 12. Dug well in Basra, Iraq used for drip irrigation of tomatoes. Note pump at bottom of the well.

Water users are also ideologically interested in drip irrigation to save water but they have the task of integrating the drip system into the rest of their overall crop management activities. This can result in their concern for water conservation becoming considerably less and perhaps far more local than the other promoters of drip irrigation. Consistent with their overall outlook as individual entrepreneurs, their concern for water conservation really only extends to their immediate farm situation with little concern for their neighbors even if sharing the same spring. Farmers also have to be concerned with costs, time and effort to manage the system, as well as the extra care that may be required in working around the drip lines for weeding, harvesting and other field activities. This can make drip irrigation a difficult sell except under situations of immediate water shortages. It might also be noted that major recent shifts in irrigation water savings in Colorado, going from siphon tubes to gated pipes, then center pivots, and now some buried drip was motivated more by labor savings than water saving. The water savings and opportunity to earn additional income by “renting” the surplus water was a nice by-product.

Available Drip Equipment: The drip equipment available in Uganda is mostly Israeli manufactured equipment. Israel was the place that originated drip irrigation and the equipment is good, perhaps over sophisticated for the intended use in Uganda, but certainly useable. The emphasis is on drip tape with manufacture embedded emitters uniformly spaced along the tape. Emitters are the not simply the hole in the tape that is clearly seen along the tape, but hidden within in the tape is a pressure compensating devise to assure a uniform water application all along the drip line (Fig. 13). This is accomplished by what is called a torturous track in which the water must work its way through a snake like path between entering the emitter and being allowed to exit into the soil. The torturous track increases the friction losses and slows the water flow to the calibrated drip rate regardless where on the drip line the emitter is located and how much undulation in elevation there is along the drip line. If there is any sediment or debris in the water it will also have to work its way along the same tortuous track. If it fails to negotiate the path the emitter will quickly become plugged and have to be replaced. For this reason most drip systems include some type of extensive water filter that will remove the sediment and other debris from the water.

Fig. 13. Drip emitter available in Uganda, with torturous track for pressure compensation.

Drip tape is designed primarily for vegetables and other crops with a uniform but fairly close spacing. It is less effective for tree crops such as bananas and citrus, as it would require looping the drip tape around the tree and then over to the next plant with several emitters losing water between the plants. They do have some micro sprinklers available that are more appropriate for bananas and other perennial crops but do not seem to have any individual emitters for customizing a drip line as needed for the mixture of perennial crops most farmers are growing. Also, available is some plain drip lines without emitters and various connectors, but these are basically an accessory to assist in getting from the water source to the field. Actually, the emitter being manufactured in Zambia by an Indian businessman may be a better design as well as those used in Jordan and Iraq (Fig. 14). The Zambian emitter is simply a capillary tube that is looped around a small support post. By tightening the loop it is

possible to control the flow and adjust for pressure differences in the field. It appears to be a simple but effective emitter where there is sufficient labor to make the necessary one time individual emitter adjustments.

Fig. 14. Drip emitter manufactured and available in Zambia

Using Drip Irrigation: For all the potential water savings drip irrigation offers, it has some additional management concerns which increases the operational costs or labor requirements, and reduces its overall competitiveness. The most important of these is water quality. Initially, the biggest concern in water quality is sedimentation in the water plugging the emitters. This would be a major concern for water pumped from turbid springs. All those observed were turbid with fine suspended sediments. They would also be suspected of containing algae or other suspended debris. It would be a lesser concern, but still something that needs consideration, for water pumped from wells or harvested roof runoff. In normal commercial drip irrigation the sediment is removed by large sand filters which require changing every couple years, even when the water is good quality well water. In Uganda they have in-line filters available in various sizes depending on the command area and water quality. It would also be desirable to hold the water in a storage tank at least overnight to allow as much sediment as possible to settle out.

Once the sediment and suspended debris in the water has been taken care of, the next problem is algae developing around the emitter outlets and plugging them from the outside, particularly those laid on the surface and exposed to sunlight. This is developed from the algae normally found in the soil, and is different from the algae in the spring water plugging emitters from the inside. To remove these algae it is normally necessary to flush a surface drip system occasionally with chlorine to kill the algae. This can normally be done with Clorox or other readily available household bleach. The system then has to be flushed with plain water to leach the Cl^- from the soil.

Another problem would be calcification around the emitters that forms a crust and again plugs the emitters. Calcification is a major concern when the water,

particularly well water, contains large amounts of Ca^{+2} or Mg^{+2} bicarbonate that precipitate as oxides when exposed to air as it emerges from the emitter. It is the same material that forms the white crust on plumbing fixtures or scum on pots and pans. It would be less a concern for surface water, and roof harvested water. In cases where calcification is occurring, it is necessary to periodically flush the system with acid to dissolve the crust and allows the Ca and Mg to move away from the emitters and ultimately contribute to soil fertility. In the US this is normally done with sulfuric acid. However, in Uganda it might be possible to simply add a bottle of vinegar to the settling tank periodically. It is important that this be done before the emitters become fully plugged, as once plugged it will be very difficult for the acid to be effective.

In a similar manner, drip irrigation, with its minimum precision applications, does not allow for sufficient salt leaching. Thus depending on the conductivity of the water, salt can build up in the soil over time. This could become a problem with long term drip use, unless there is a substantial rainy season as there is in Uganda to periodically leach out the salts.

Another problem with drip, particularly when exposed on the soil surface, is the plastic will interact with the UV component of sunlight. This slowly changes the molecular structure of the plastic and makes it brittle. Typically, exposed drip lines have to be replaced on an annual or biannual basis. This can become expensive and reduce the overall competitiveness of drip irrigation. The life of a drip line can be prolonged by covering the line with banana leaves or other cover material that will shade it from the sun. This will also reduce the algae and weed growth around the emitters. However, this is not commonly done, but with bananas the main crops would be possible in Uganda. There can be considerable difference in the useful life of drip equipment depending on the quality of the plastic used. In Iraq the locally manufactured drip material had to be replaced each year, while the imported would last two to three years. Disposing of used drip equipment can be a major environmental problem as the plastic does not readily degrade, and quickly fills dump areas in what can be a major eyesore. It can be burned but like all plastic it will have some toxic fumes.

Finally, drip systems with all the emitters and lines over the field result in a more meticulous and time consuming effort for weeding and other field activities (Fig. 15). This is even more complicated by weeds normally concentrating around the emitters stimulated by the extra water at least until the crop canopy can shade the emitter. The larger the area under drip irrigation the more the available labor will be stretched which could lead to decreasing yields and/or quality of the crop. The extra labor required to work around drip lines is actually an indirect cost that normally is not included in the estimate labor costs of operating drip systems. However, it is a reoccurring cost that is repeated with each field activity. The need to work around drip lines will also reduce the potential for any kind of mechanization including animal mechanization and hand tractors. Although with tree crops as the main crops, mechanization is limited and thus this is not a problem for RUCID and its clients. As an indirect cost the extra labor requirements are often overlooked except by the farmers who quickly recognize the problem. How the additional time and effort to operate a drip system effects its overall competitiveness is something only the farmers

can sort out in their acceptance and continued use of drip irrigation. It was noted during the seminar that some of these concerns have already been identified and resulted in at least one farmer attempting drip irrigation only to give up after a brief trial period.

Fig. 15. A precisely laid drip demonstration that requires meticulous and time consuming weeding, etc.

Alternative Irrigation Suggestions

Given that any irrigation will most likely be to perennial tree crops and not the lower canopy annual crops, the simplest method might be to simply move a hose from one plant to the next and fill the small basin already constructed surrounding the base of each tree to harvest rain water (Fig.16). Since the tree crops such as bananas, coffee or citrus all have a fairly large canopy, it should be possible to surface irrigate the relatively small basins and only apply as much water into the basin as necessary to meet the crop water demand without over irrigating. Thus, even if you applied up to 10 cm to the basins, when pro rated over the entire plant canopy it would allow the two centimeter application envisioned earlier, and negate much of the potential water savings expected with drip irrigation. The labor requirement might be somewhat higher, but it would avoid all the hassle that could come trying to manage a drip system as outlined above. It would also have a lower initial cost and not have to be frequently replaced. This is the way most of the micro irrigation in Zambia was done pumping water from wetlands via either treadle pumps or motor pumps (Fig. 17).

Potential for Using the Wetlands

If getting the water to the cultivated lands is not viable, perhaps the water can provide economic returns where it is (Fig. 18). There are several techniques to obtain economic return from wetlands in an environmentally friendly manner. The best example is rice. The project I worked on and returned to just prior to this consultancy in Tanzania was a 3000 ha irrigated rice scheme. It was developed in a swamp similar to the papyrus swamps observed in Uganda and probably, with all the drains

Fig. 16. Banana tree at RUCID center with small basin at base ideal for simple surface irrigation application.

Fig. 17. Flexible hose moved from basin to basin for irrigation from Treadle pumps in Zambia

installed in constructing the irrigation scheme, yields more water into the river for beneficial use down stream than before it was built. Perhaps a better example would be Thailand where virtually all the tangerines are produced on acid sulfate soils. These are the most severe form of wetland soils, that when drained release sulfuric acid into the water sufficiently to kill both plant and animal alike. They developed them with a ditch and dike system in which mud in the ditch is converted to a dike and crops are planted on the dike (Fig. 19). The farmers then use small boats to manage their lands for irrigation, chemical applications and pure cargo. There is also the potential for fish farming with either fish pens or fish ponds, provided excessive pesticides were not used that would kill the fish.

Fig. 18. Papyrus swamp with plenty of water frequently found in Uganda.

Fig. 19. Wetlands used in Thailand for Ditch and Dike cultivation of tangerines and other crops.

Irrigation for the RUCID Center

In developing an irrigation system for the RUCID center the most important consideration is to keep it simple. Most irrigation is more an experience based art than an exercise in precision science and engineering. Trying to make irrigation a precise science has resulted in considerable waste of time, effort and money.

Surface Irrigation

The proposed pre-consultation irrigation system for the RUCID Center was based on making maximum use of harvested rainwater from the building roofs, storing this in the attached 40 m^3 tanks, discharging the tanks into a below ground larger storage tank and pumping it back for irrigation (Fig. 20). The general idea is very sound except for putting water in the below ground storage tank and pumping back. Basically, why give up head only to have to recreate it? Better to keep as much water in the collection tanks where it can be distributed by gravity and allow the overflow to fill the below ground tank. A siphon feed or buried line can then be rigged to the below ground tank that will allow it to gravity irrigate most of the lower fields of the center.

Fig. 20. Storage tanks at RUCID to collect rainwater from roof in background and below ground tank in foreground.

How much of this water could or should be used for irrigation and how much reserved for institutional use for washing, meal preparation, etc.? This is a question for RUCID management, but I would expect that most of it would go for institutional use, particularly if the hostel is heavily used, and particularly for the upper tanks that can be used by the hostel and kitchen under gravity. I accept this as the higher priority for the available water. The balance and most of the lower tanks could go to irrigation but mostly for demonstration purposes rather than wide spread production use. The best recommendation for this, that should be reasonably inexpensive but provide the most operational flexibility, would be to run an underground two inch poly-plastic pipe down the slope from highest tank to the lower part of the farm. This would be

placed 15 to 30 cm underground to minimize interference with other farm or institutional activities. The two inch pipe with only ¾ to one inch garden hoses for delivery is intended to reduce friction losses and allow more than one hose to be irrigating simultaneously. Then, connect each of the storage tanks to this main line so that all tanks can contribute to a single distribution system. However, it will be necessary to provide each tank with an individual faucet and possible in-line filter to remove any major debris that has collected in the tanks. If the tanks were not fitted with individual valves, the head differences will allow the higher tanks to quickly overflow the lower tanks. It would also be possible for the higher tanks to recharge the lower tank as desired, but again this requires individual controls. Next, periodically, at 25 to 50 meter intervals, as the main distribution line passes the demonstration fields, place a riser from the buried line to a convenient height above ground for a hose outlet, and fit it with a standard hose outlet. Then, as needed, attach a flexible ¾ to one inch garden hose and proceed to water the plants. The pressure from the tanks should be more then adequate to provide the necessary water for gravity flow.

Water should be released from only one tank at a time, starting with the lowest tank capable of reaching the field being irrigated. This will allow the higher tanks to gravity refill the lower tanks as needed, but not the reverse. The irrigation should be concentrated on the lower fields which could be commanded by all tanks and thus would have the most available water. It would also be possible to run a one inch pipe from the main line to provide running water to the office building, food processing plant and other buildings in the complex.

The irrigation rates and schedule will have to be obtained from experience, but don't get to fancy, it is not worth the time and effort. Twice a week would be a good starting place.

Drip Demonstration

Given the restriction on water it is appropriate to at least demonstrate drip irrigation with a clear understanding of its potential, extra management requirements and other limitations. This can really be fairly simple. Once the main line is installed, add an extra faucet next to the field for the drip demonstration. Then permanently connect this outlet to the drip line and add an extra small in-line filter to make certain all debris has been removed. You can then either lay out the drip system as an E with a main manifold and three lines each with an individual valve or as an S snaking back and forth across the field. These drip lines should be approximately one meter apart. Finally plant your vegetable crops so each emitter will irrigate two small plants or one large plant. The fixed spacing of the emitters in the drip line overrides the recommended spacing for the individual plants. Thus, plants should be either crowded closer together or spread further apart from recommendations to accommodate the emitter spacing. Plant spacing was never intended to be precise but only estimate intended for local fine tuning. In Zambia a cotton trial using drip irrigation used the recommended cotton spacing instead of adjusting for the emitters and made a major mess of the crop.

Once installed, irrigations should be three times per week for 20 minutes at a time with the time increasing as the plant grows and the canopy becomes closed or there is a heat wave for a few days. The real danger is turning the water on, going about other activities and forgetting it is on. There is very little visible water or wetted soil surface from the drip line to indicate the system is operating. If you leave it on overnight or over the weekend it could easily drain a tank.

Note of Caution

As will be discussed shortly, any research or demonstration effort normally operates with a resource base greater than the clients. This often restricts the level of acceptance clients can make of the results even when they are interested and anxious to accept. This will most definitely be the case of any irrigation done at RUCID. With the extra roof area for harvesting water, RUCID is starting with enhanced available water relative to the farmer clients. Also, once an additional resource is available, it is difficult not to utilize it just because it is not as readily available to the client farmers. The result is that as any irrigation is utilized and demonstrated it has to be recognized that the relative resource base between the center and client farmers is diverging rather than converging.

ORGANIC FARMING

Though not part of the assignment I would like to continue my report with some observations and commentary on organic farming as it occurs in developing countries and might need consideration by RUCID as the program continues to unfold. My objective is to assure the maximum effectiveness of the RUCID effort in serving the farmer clients. Most of this follows discussion with Elisha Sebadduka and Immaculate Nakanwagi. To some extent my comments go beyond the promotional material normally associated with promoting donor agendas such as organic farming to how and why the promoted technology has to be adjusted when applied to smallholder farmers and farming communities. The intention is to assist RUCID to concentrate on ideas with the maximum potential for acceptance and avoid ideas that exceed the resources available to the smallholders to implement and have thus been appropriately rejected by the farmers in other areas promoting similar organic farming programs.

Different Resource Base

The RUCID demonstration farm is doing an excellent job of demonstrating many aspects of organic and conservation farming. This is important and needs to continue. However, demonstrations are inherently done with an extended resource base relative to the farmer clients. This is usually in terms of additional capital and the labor that can be hired and utilize with it, and less concern for the overall profitability of the innovations. This usually makes it difficult for farmers to fully utilize the technology and concepts being demonstrated even when fully interested and committed to the project ideals. Demonstrations, like all crop production research and extension programs, are an evaluation of the physical potential of the environment without consideration for the resources available at the farm level for implementing them. Thus, they represent a maximized return to the land and assume the farmers have the

means to extend this over their farms. Farmers are actually more interested in maximizing the returns to their labor with the idea of maximizing the total return to all farm enterprises and not any single enterprise. This results in a major drag on the physical potential and considerable fine tuning of demonstrated technology. All of which results in a slight disconnect between farmers and project, that ultimately needs to be taken into account and evaluated.

The end result is that demonstrating an agronomic technology and training in its use is the easy part of the task. The difficult part is evaluation of how the farmers make use of the ideas demonstrated and trained. Thus, there is a continuous need for low level dialogue with farmers determining:

a. Acceptance,
b. Rejection, and
c. Modifications.

Of these, the most critical is "c" modifications. This indicates an interest but without all the means to fully accept, or recognizing the economic optimum is below the physical potential. This then becomes feed back into the demonstration and training effort. As mentioned above, it needs to be a continuous process and not waiting for an assessment survey to make the evaluation. An assessment survey, such as the one currently being organized, should contain no surprises, but simply a quantification of what is already known.

Currently, the debriefing for the assessment preparation indicated that the organic farming was requiring considerably extra labor estimated at five additional hours per day, and the compost practices were rejected as too much time and effort for too little return. The extra five hours per day is a substantial amount in what I normally consider a labor short environment. Where this labor comes from is a valid question. The extra labor required would also provide additional justification for enhancing access to domestic water supply. It would free labor for implementing additional sustainable agriculture practices. The rejection of compost making should be accepted and is consistent with other experiences with organic farming for smallholders. Continuing the demonstration is harmless, but extensive promotion with the expectation of wide spread acceptance is not justified, and to the extent your clients recognize the impracticality of composting, distracts from the promotion of more realistic practices.

Organic Nutrient Management

When I consider organic farming I tend to divide the concerns between nutrient management and pesticide use. Of these I am primarily concerned with the use and abuse of pesticides particularly the use of synthetic pesticides on vegetables and the residues left on the consumable portion. When I was in Thailand, I had a couple students make some detailed analysis of this and found real abusive application of pesticides with residue levels on the consumed produced exceeding WHO standards. I am considerably less concerned with the use of chemical fertilizers. I am not really certain that we can have fully organic farming, particularly if limited to the resources contained on an individual farm with no external inputs. In RUCID the interest

appears to be more on inorganic fertilizers with less concern for pesticide use, which I assume is because of limited need for pesticides with the crops being grown, although a full range of pesticides are readily available in the agriculture supply stores in Matyana (Fig. 21).

Fig. 21. Full range of pesticides available in agriculture supply store in Matyana.

Most of my experience has been with annual cropping systems and thus may not fully apply to perennial cropping systems you are involved in which normally tend to be managed in a more organic manner.

Sustainable Land Balance

I have some concern for the total land use balance in which the total global demand for agriculture production is inelastic, while there can be considerable elastic demand for specific commodities. For example, you can shift stable food around between wheat, maize, rice, potatoes, cassava, sweet potatoes and bananas, but the total demand for calories will be the same. This implies some interesting trade offs. The most noticeable is that if you deliberately reduce yields for more sustainable production, then someone someplace will have to bring more land into cultivation to accommodate the inelastic demand in total production. This most likely would include cultivation of more marginal lands better suited for forest or nature reserves. Similarly the higher the yields, as allowed by chemical fertilizers, the less total land needs to be cultivate and the more marginal land can be left in nature reserves, forests, and other set asides. Someplace there needs some policies that balance this out, in a manner that assures food security needs are met with the least detrimental impact on the natural resource environment essential to support agriculture.

Nutrient Uptake

My biggest concern with organic nutrients is with the plant physiology of nutrient uptake. That is, plants can only uptake inorganic ions and not organic compounds.

Thus, for organic nutrients to become available to plants they have to be mineralized to the inorganic form, which is the same form as chemical fertilizers. The mineralization is a micro-biological process during which the microbes actually get first priority on the mineralized nutrients particularly nitrogen. The process is known as nitrogen immobilization and can be a major problem. Thus, an application and incorporation of organic materials to a crop can induce nitrogen deficiency for a couple weeks while the organic material is decomposing. This may not be a serious problem for the perennial crops used in the project as the organic material tends to be left of the surface more like a mulch then incorporated into the soil. However, the availability of the nutrients to the crop may be considerably delayed.

Most chemical fertilizers are really not very detrimental to the environment, if handled in a conscientious manner and not applied in excess. Ultimately they may be needed to replace the nutrients removed with the marketed crop. It should be noted that most organic farmers in the US operate in conjunction with animal operations from which they obtain the manure as an additional source of nutrients imported into the farm.

Nutrient Manufacture or Nutrient Movement

My next concern is to what extent does the use of organic material represent a manufacture of plant nutrient or simply a movement of nutrient from one place on the farm to another in what is essentially a zero sum effort. With the exception of nitrogen fixation by legumes, where can any additional nutrient come from? Thus, you can only add nutrient to one field at the expense of another. If the source area is also used for crop production then the removed nutrients will have to be replaced by some mechanism. In Thailand, the organic material was used exclusively for the fields near the house, while more distant fields received chemical fertilizers. In your program is the cut and carry of forages for stall feeding goats and cattle coming from within the farm or from communal areas around the farm? Are you providing any external supplement feeds or minerals to the animals including the chickens that would represent an infusion of nutrients from off-farm?

Available Nutrient Supply and Bulk Handling Requirements

A similar issue is the supply of organic material that is required for full fertility. If the recommendation is for one wheel barrow load per square meter and if a wheel barrow represents 30 kg of material, the total requirement is some 300 t/ha. and require 10,000 trips to and from the source. Within a specific farm where will all this come from, and how much time and effort will it take to move it from source area to application area? This is another case where a small plot demonstration can exceed the resources available for most smallholders to duplicate it across their entire farms. When determining an application level for organic materials it might be desirable to do some simple computation to estimate how much material is required, and from where it will come. Furthermore, the energy required to recover these organic nutrients in term of accumulating, redistributing, and incorporating the organic materials, could easily exceed the energy gained from the additional production, a situation that needs investigation. If this represents a net loss of energy in the system, it will be unsustainable in the long term and can only proceed at the long term health

risk to the farmer. Fortunately, the farmers will most likely quickly recognize this and discontinue the practice, as already noted for composting.

Part of this is to recognize the concentration of mineral nutrient in plant residues and fresh plant material. For fresh plant materials needed for forages, the dry matter will typically only represent at most 10% of the weight. Of the 10% dry matter, some 95% percent will be the structural elements made up of carbon, hydrogen, and oxygen that are derived from water and the air, and not required as mineral nutrients. Thus, for every ton of fresh material you have to move, you will get at most five kilograms of mineral nutrient. Depending on how far it must be carried, it represents a lot of effort per kilogram of nutrient recovered. This is the main reason organic material as a nutrient source is usually restricted to the homestead gardens. Again, some simple computations would highlight the situation.

Compost & Manure

An interesting question is "what is the difference between making compost and making manure as a source of organic nutrient"? Fundamentally, are they not the same process? Both represent the microbial decarburization of plant material with hopefully a concentration of the mineral nutrients in a less bulky more easily managed form. In the compost making this is done by soil microbes, while in manure making it is by the ruminant bacteria in the goats or cattle (Fig. 22). If this is fundamentally the same process, the question becomes which is quicker and more effective? In this case, it is manure making through the animals, a process that takes days rather then weeks. In annual cropping systems such as rice or maize, the real impact of grazing crop residues maybe the conversion of plant residues from something that is normally burned to something that is normally incorporated into the soil, as manual or even with animal traction incorporating crop residues takes too much time and effort unless you are assisted by power tractors. Again, it is easy to demonstrate the value of

Fig. 22. Goats being stall fed and the bedding collected for application to the land and nutrient recovery.

incorporating organic material on a small scale, but difficult to extend to full fields or farms, when the urgency of getting the task competed vs. the decline in potential yield with each day's delay in crop establishment makes burning the crop residues the most economic viable option.

Given that manure making provides some additional animal production not available from composting, it might be best to concentrate on manure production. It also explains why the farmers appear to accept the animals as part of the system but reject composting. However, working with manure it is often a question of the need to dispose of the animal waste, and thus which is the main product and which is the by-product? Is the application of manure and bedding primarily a waste disposal with the nutrient recovery a by-product, or the other way around (Fig. 23)? In the US, the concern is more with the disposal for which the land application is the most convenient and economical with the nutrient recovery basically a by-product.

Fig. 23. Manure and bedding from goat stall feeding enterprise being applied to the banana garden weekly. How long will it take for the nutrients to be released and made available to the bananas?

Nitrogen Fixation

The fixation of nitrogen by legumes or blue-green algae as is the case in paddy rice does represent an increase in nutrients to the system. However, it is not totally free. The chemistry of nitrogen fixation requires eight electrons to convert N_2 to NH_3^- in accordance with the equation:

$$N_2 + 8H^+ + 8e^- \rightarrow 2NH_3 + H_2.$$

This requires considerable energy. This energy can only come from the host plant and represents a loss in dry matter accumulation. If the fixed nitrogen was not beneficial to the plant the relationship between legume and bacteria would be parasitic. The estimate is that for every kilogram of N fixed the plant gives up 10 kg of dry matter accumulation. The total nitrogen fixation is normally in the range of 20

to 50 kg/ha which is about 50% or less of the Nitrogen required to produce a commercial annual crop such as maize or rice.

The question is, when will this nitrogen be available to non legume crops? The answer is that normally the legume will hoard the nitrogen for it own use having already made some major sacrifices to produce it. Thus, it will not normally release the nitrogen until the legume completes its life cycle, dies back and decomposes in the normal nutrient mineralization process. This normally will not occur until the next cropping season. However, if there are some clear growth cycles in the legumes induced by changing climates such as tree legumes going through a dry season or forage legumes being cut or grazed, the equilibrium between the plant tops and roots will be disrupted, and some nitrogen may be released (Fig. 24). The best example of this is the *Acadia albedo* tree that defoliates during the wet season and stimulates more succulent annual crop growth under it (Fig. 25).

Fig. 24. Tropical legume grown under bananas to increase soil nitrogen. How and when does the fixed Nitrogen become available to the bananas?

Fig. 25. Millet receiving additional nitrogen from Acadia Albido tree in Sengal.

Marketing Organic Produce

While not normally involved in "organic" produce I did get extensively involved in marketing of Pesticide Free Vegetables (PFV) in Thailand. I think they are similar to RUCID's organic produce marketing effort. I also took the time to visit your organic outlet shop in Kampala (Fig. 26). In most of Asia there is considerable abuse of pesticides on vegetables with residues exceeding international health standards. In Thailand, with the King's blessing, there was a major promotion for producing PFV. Most of this was grown under fine insect proof nets (Fig. 27). It was also driven by individual name Dr. Kitti (Kitti Vitoonvitlak) who markets the PFVs under the brand name Doctor's Vegetables. In contrast to your program of marketing organic produce via a small individual outlet store, Doctor's Vegetables are marketed via the major supermarkets in the Bangkok area. In order to prevent contamination by someone moving regular vegetables to the PFV display for the extra profit, Dr. Kitti has to have a totally independent marketing channel with all produce arriving at the super markets pre-wrapped in clearly identifiable tamper proof packaging (Fig. 28). This was done to the extent that I was confident that if I purchased something with the label, it came through his system but I still had to trust him that the produce came from his farm or one of his contractors and they did not use any synthetic pesticides.

Also, because even PFV have to be sold by appearance he has to remove any signs of pest damage. Thus his discards normally exceeded 50% of the produce arriving at his packing shed (Fig. 29). To cover his extra production and processing costs he has substantial mark-ups from the normal vegetables. These mark-ups ranged from 15 to 200% (Table 1). This is in contrast to your effort where the mark-ups relative to regular produce are based on your estimates of the premium your customers are willing to pay for organic produce, and has little if anything to do with any additional production costs. If the mark-up is less than the extra production costs it will be difficult to sustain the organic market without continued donor assistance.

Fig. 26. The organic outlet store for RUCID production.

Fig. 27. Pesticide Free Vegetables being produced under insect restricting netting in Thailand.

Fig. 28. Doctor's Vegetables label for marketing pesticide free vegetables

As for actual sales, he is obliged by the supermarkets to sell his produce on consignment and recover any unsold items. This automatically gives him lower priority for shelf space. Observations of his market volume indicated that during one hour periods he would have only 10 people show an interest in his PFV with only one person actually purchasing any. The net result is that his business was not profitable and he was dependent on donor support to continue in business.

Fig. 29. Sorting Pesticide Free Vegetables to remove all indication of pest damage with over 50% discarding of produce.

Table 2. Price Difference for Pesticide Free Vegetables in TOP Supermarket, in Rangsit, Bangkok, 21 February 1998 (Baht/kg)*

Vegetable	Normal	Pest Free	% Increase
Baby Corn	45	73	62
Bitter Gourd	32	76	137
Cabbage	20	40	100
Coriander	60	186	210
Cucumber	15	39	160
Green Mustard	17	48	182
Green onion	50	96	92
Lettuce	35	84	140
Tomato	30	52	73
Winter melon	14	16	14

* US$ = 25 Thai Baht

The net lesson is that the PFV as well as Organic Produce will serve a very restricted niche market of those who can afford the extra cost and who are health conscience enough to be concerned. In Uganda as in Thailand where discretionary income is limited, most people can only afford to continue purchasing produce based strictly on costs. The relative lower level of economic development in Uganda compared to Thailand would make this a bigger concern in Uganda than Thailand. Unfortunately, this also includes me as my wife, who as the family purchasing agent, always opted for the cheaper normal vegetable instead of the PFV, despite being fully knowledgeable of the excessive residues and health risks associated with them.

Conservation Measures

Water Harvesting Ditches

If, as expected the project area contains a large number of anion active soils the expected benefits from some of the soil and water conservation practices undertaken by the project will be greatly reduced. This is simply the nature of the soils involved and does not reflect on the quality of the effort undertaken by the project. The biggest concern is with the water harvesting ditches (Fig. 30). With the high infiltration rates of these soils, the surface runoff expected to accumulate in the ditches is limited, and

whatever water accumulates in the ditch seeps out within a day. Thus, the water harvesting ditches do not offer much assistance. They are doing no harm, but not much benefit except for possibly encouraging more water to go directly to the water table some 50+ m below the surface. If the ditches held water for four or five days, and the water could be applied to the crops, then the expected benefit would be obtained. As is, there is very little benefit. The recommendation is to keep what you have but not put much emphasis on them in the future.

Fig. 30. Water harvesting ditch that has reduced effectiveness because of high soil infiltration rates.

Conservation Terraces

The other issue is the conservation terracing (Fig. 31). This has more potential, although because the soils are potentially less erosive then most soils the benefits are again reduced. However, there are sufficient benefits to justify the promotion and use and there is a noticeable soil accumulation behind the vegetative barriers to justify continued promotion. The nearly vertical benches developed behind the barriers by the terracing effort should remain stable.

Farmer Organizations

Finally, I would like to comment on farmer organizations as they appear to operate in developing countries such as Uganda. RUCID is working with farming communities through farmer organizations. At present, this is primarily for information sharing and facilitating the implementation of organic farming. This is good. It represents the US farmer associations model. In the US, virtually all farmers regardless of size belong to some form of farmer association. These are primarily information sharing organizations providing newsletters, trade journals, and annual meetings. They are also involved in political empowerment through lobbying various state and federal legislatures, etc. They do not normally get involved in business activities.

Fig. 31. Effort to develop some conservation terraces that reduces the slope of the cultivated areas.

In contrast, there are farmer cooperatives in the US which are farmer owned business enterprises. In the US the cooperative system handles less then 30% of the market share with only the dairy cooperative handling a majority (80%) share. The number is following a long term decline in both market share and number of members. Furthermore, FarmLand, a conglomerate of cooperatives was forced into bankruptcy three years ago and has since been dissolved. The net result is that there appears to be something inherent in cooperative system that makes for a weak business model compared to private traders and private agro-business companies. Most likely this is associated with the extra administrative activities which contribute to overhead costs required for keeping individual members' records as well as the inconvenience of consignment selling vs. direct payments. When these are factored in, it is possible that the overhead costs of managing a cooperative business venture will exceed the profit margins of the competing private traders and reduce the expected competitive advantage of the cooperatives

Thus, be very careful if you want your farmer organizations to move from the farmer association model of information sharing and program facilitation, to a farmer cooperative business model. You could easily destroy a good thing. In Zambia on the first leg of this safari, a substantial majority, perhaps as much as 60 or 70%, of the produce designated to be marketed via the farmer cooperative societies was side sold through private traders. The farmers were exercising their right to use the marketing channel they considered to have the most competitive advantage to them. The big problem was that consignment selling promised payments within three weeks but would typically extend to six weeks or sometimes three months. The farmers were more interested in immediate cash payments for which they would accept a 20% discount from the cooperative received price to obtain the cash payment. Beware!! When I had discussions with both your organic outlet store and the food processing company I got the impression you were already experiencing some side-selling of produce. Also, if you do become involved in cooperative business activities, be careful of promotional accounting that stops at the cooperative and overlooks the

cooperative handling charges or surcharges that reduces what the farmers actually receive. To be valid and objective, your accounting needs to extend all the way to the farm gate. Be certain the farmers are well aware of any differences.

This also implies a major reconciliation with the private traders and make certain what is usually condemned as exploitive mark-ups is not a fragmented marketing system which mandates high mark-ups so the traders can make sufficient profit to feed their families. The best example would be the banana traders plying the highways here in Mityana with overloaded bicycles (Fig. 32). The one we interviewed left home at daybreak, traveled some 40 km to the villages, purchased 100+ kg of bananas for USh 15,000, returned to Mityana pushing the overloaded bicycle up the hills. He hoped to sell the bananas for USh 25,000, but might have to settle for USh 20,000 so he could return home after a hard 13+ hour work day and feed his family of six with his USh 10,000 profit. Thus what appears as an exploitive 40% mark-up on the selling price or 60% on the buying price for a USh 10,000 daily wage. If the international standard of poverty is one US dollar per day this trader's hope for daily income of USh 10,000 would still have his family classified as impoverished. Is that exploitation or fragmentation?

Fig. 31. Banana trader trying to earn USh 10,000 from the proceeds of 100+kg of banana, which he will attempt 40% mark-up on the selling price or 60% of the purchase price to obtain an income that is still below the world poverty standard.

RECOMMENDATIONS

1. Concentrate on developing domestic water supplies before becoming overly concerned with irrigation water. Some of this can easily be justified as freeing labor needed to assist in implementing more organic sustainable forms of farming

2. Continue looking at water harvesting from roofs to the extent it is possible, but consider this mostly enhancing domestic supply and not irrigation.

3. Proceed with the installation of an irrigation system at the RUCID center but emphasis on simple surface irrigation using a garden hose to fill the basins already established for individual trees.

4. Proceed with a small drip irrigation demonstration, but be certain to fully emphasize both the benefits and limitations of drip irrigation.

5. Make a brief comparison between the crop management being endorsed by the project and what the farmers are normally doing as the primary crops are usually managed in near organic manners. This will quantify the innovations you are promoting.

6. Monitor the changes in the area devoted to cassava, sweet potatoes, and other root and tuber crops as a possible index on the impact of HIV/AIDS to the farming communities.

7. Be aware of the resource differences between the center and the beneficiaries and continually monitor the acceptance, rejection and modifications farmers are making to demonstrated technology.

8. This would include accepting the farmers rejection of composting as too much effort for too little return, which is consistent with other areas where it has been promoted and rejected.

9. Be careful of the total amount of organic material that is recommended and make certain that it is realistic for the farmers to accumulate.

10. Make certain that the time and effort to recover organic nutrients is less than the extra energy derived from the increase in crop yields.

11. Look at alternatives to market registered organic produce through normal supermarkets instead of independent outlet stores. It would make the produce more convenient for buyers and could encourage more demand.

12. Be careful in moving your farmer organizations from information sharing and facilitation to commercial business activities. These have usually not been as effective as envisioned and resulted in substantial side-selling.

13. Take note that the private traders may not be as exploitive as usually projected and may actually be living below the international poverty standards.

APPENDIX

A. Consultant Itinerary

B. Consultant Bio-Profile

C. Developing Smallholder Agriculture: A Global Perspective

ACDI/VOCA

Farmer to Farmer Program
Volunteer Consultant to RUCID

Evaluation of Irrigation Potential for RUCID and Cooperating Farmers

R.L. Tinsley
Itinerary

18 June	Arrived in Kampala
19 June	Sunday, Rested in Hotel in Kampala
20 June	Orientation in Kampala, by Robert Gensi, banking and travel to Mityana
21 June	Orientation to RUCID, by Samuel Nyanzi, Elisha Sebadduka, Immaculate Nakanwagi, tour of demonstration organic farm
22 June	Field visit to *Haji* Abul Nsereko, Mbaliga Village – Busimbi Sub-County, and Mr. Muwonge, Musaba Village
23 June	Field visit to Mr. Mukasa Miggadde, Kijjudde Village, Sekanyonyi Sub-County, and Mr. Sehkaayi with Kanzira Farmer Group, Kanzira Village, Myanzi Sub County.
24 June	Visited Kasejere Kikandwa Environmental Association and Mr. Kakembo, and Mr. Bukunduga at Babambula Village
25 June	Saturday, day off
26 June	Sunday, day off
27 June	Visited Tropical Ecological Foods Uganda, Ltd. (TEFU) and acting director Mr. Joseph Mayanja. Reviewed irrigation potential
28 June	Remain in Hotel working on report
29 June	Conceptual discussions at RUCID
30 June	Continued conceptual discussion at RUCID and worked on report draft.
1 July	Day trip to Kampala to visit National Organic Agriculture Movement of Uganda's Outlet store, meet with Derrick Tenywa
2 July	Saturday, day off
3 July	Sunday, day off
4 July	Drafting Report
5 July	Continued Drafting Report
6 July	Preparation for Seminar
7 July	Seminar, preparation of CD and return to Kampala
8 July	Wrap-up in Kampala, Depart for Johannesburg and US

Consultant's Bio-Profile

Richard (Dick) Tinsley is professor emeritus in the Soil and Crop Science Department at Colorado State University. He has over 30 years of experience assisting smallholder producers and their communities. He has worked in Asia, Africa and the Middle East. He is the author of Developing Smallholder Agriculture: A Global Perspective, published by AgBe Publishing in Brussels, Belgium, an electronic copy of which was included with the CD left with RUCID at the conclusion of the consultancy. Chapter 6 on Sustainability of Smallholder Systems is the most relevant Chapter for RUCID. He also manages the Website: www.smallholderagriculture.com. This is a website committed to promoting the understanding and development of smallholder agriculture as it occurs in developing countries. He can be reached by email at: Richard.Tinsley@ColoState.edu, or by mail at:

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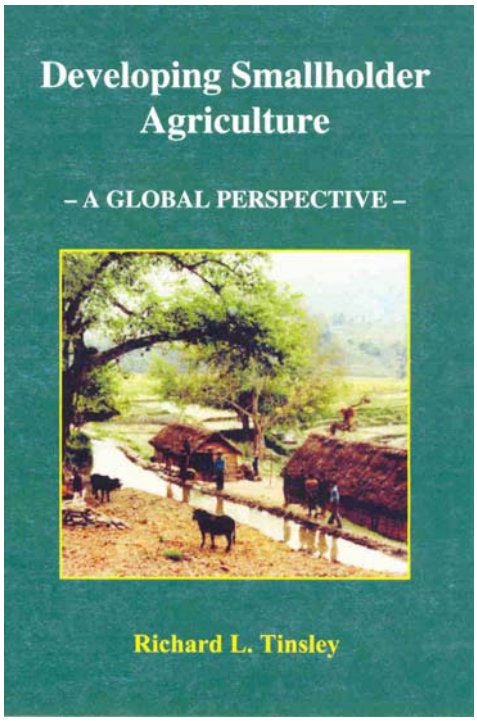

Developing Smallholder Agriculture

– A GLOBAL PERSPECTIVE –

By Richard L. Tinsley
AgBé ; 2004 440 pages, 24 Tables, 30 Figures, 30 Graphs, 70 Photos, 25 Boxes. US $ 49.

This book presents a synthesis of nearly three decades of work with smallholder producers and their communities. It takes the farming systems work of the 1980s and 1990s a step further, and pays particular attention to those factors and issues that have proven to constrain agricultural development in developing economies.

Developing Smallholder Agriculture is thus a very practical book. As a synthesis of experience from countries in Asia, Africa and the Middle East, the book is not specific to any country. However, most readers should be able to quickly relate the subjects to their country. The photographs and other illustrations, which give examples from many different countries, help this.

Much of the information contained in this book is derived from unpublished project reports. In many ways the book presents lessons learned from farming systems programs as they developed and evolved over the last three decades. The book carefully reviews the hypotheses on which most assistance to smallholders has been based; that is smallholders' failure to fully exploit their physical environment was the result of limited motivation, and a desire to minimize risks by delaying crop establishment until more assured climatic conditions prevailed. It replaces this notion with an appreciation for the limited resources smallholders have at their disposal to manage their land which often results in a six to eight week extended crop establishment and low yields.

For this reason the book concentrates less on the agronomy and soil science of the author's professional background, but more on the various factors that impinge on the farmers' ability to implement more productive crop husbandry. In so doing, the book promotes looking beyond technology and development. Dissemination concentrates on the supporting services that smallholders need to enable them to enhance their crop management. It emphasizes the importance of village-level, private micro-enterprises as a cost-effective means of assisting smallholders, and questions the potential of governments and public sector institutions in providing these support services.

The book's perspective is that of a technical assistance advisor working through host country clients, for the ultimate benefit of the smallholder producer. As such, it addresses many of the stereotype ideas that advisors confront when working with host institutions.

Developing Smallholder Agriculture is one of the few books that directly addresses practical problems in the overall context of the socio-economic, political and technical environment of

the smallholder. Forging links between different subjects and disciplines creates a holistic approach. The book uses both a scientific *and* a practical approach, and a specialized *and* a general point of view.

The book is aimed at a wide readership: depending on the background and interests of the reader, different chapters can be used as a textbook for students, a handbook for extension workers and consultants, and a resource book for development practitioners, researchers and policy makers. It is sufficiently technical for the agricultural scientist as well as being sufficiently general for decision-makers and specialists in related fields.

CONTENTS

1. Characteristics of Smallholder Producers

This Chapter introduces smallholders as individual entrepreneurs, who despite limited education, are skilled practitioners of agronomy. They are usually constrained by circumstances outside their control and have limited resources such as labor. This results in prolonged crop establishment that limits their prospects for adopting time sensitive innovations. The Chapter develops the concept of financially-suppressed economies, and how this impacts on farm management.

2. Determinants of Smallholder Systems

This Chapter reviews the physical, economic, social and biological determinants of farming systems; how they interact, in terms of what can be produced; what is produced; how well it is produced; and who has control over the different determinants. It ends with a discussion of rainfall variability and the extent it can be used as a planning tool. A case study of rain-fed rice in the Philippines is given.

3. The Role of Land Tenure

This Chapter evaluates land tenure including ownership, cash rent, share rent, customary, communal, landlessness, etc, and how this impacts on crop production and prospects for long-term investments in protecting natural resources. The Chapter also examines the relative well-being of estate workers and independent smallholders.

4. Support for Smallholders

A major Chapter that looks at both private and public sector support services. It contents that the private sector is more effective, while big parastatal companies and corporative societies are usually detrimental to smallholder production, because of high overheads. The Chapter divides the private sector into small, family-based village enterprises that are in direct contact with the farmers, and large corporate enterprises that eventually process and distribute the produce. Case studies are from Malawi for the public sector and from Nepal for the private sector.

5. Technology Transfer

This Chapter contents that extension efforts are now more an instrument of government policy aimed at supporting a suppressed price policy than a program to promote farmers' well-being. The Chapter looks at how much information is actually flowing through informal channels and how this can be enhanced. A discussion of integration, and how both innovations and the farming environment can be adjusted to make the innovations more acceptable to farmers, is offered.

6. Sustainability of Smallholders Systems

This Chapter takes a developing world definition of sustainability as "the need to balance food security with environmental protection". The chapter reviews the trade-offs between the power required to protect the natural resources and the fossil energy based inputs to assure a commercial yield. A next section looks at the issues surrounding nutrient cycling, composting, etc. It evaluates the ratio of the land from which nutrients must be collected to that on which they need to be applied to obtain sustainable yields. The final section looks at the use and abuse of insecticides. Examples are from India, Vietnam, and Thailand.

7. The Role of Mechanization

This Chapter emphasizes the importance of mechanization in providing farmers with the necessary resources to cultivate enough land in a timely manner. The emphasis is on privately owned contract mechanization versus public ownership. Also discussed is how the smallholder environment reduces the equipment's efficiency because of difficulty in accessing small fields and excessive turning once in the small fields. Private contract mechanization is discussed for land preparation in Egypt, Pakistan, and Iraq.

8. Irrigation Development

This Chapter looks at how irrigation can be provided to smallholders through large schemes: Egypt and Pakistan are the main example. It looks at pragmatic issues such as the minimum amounts of water needed to push a wetting front across a field; at water depletion; and the substantial period between crops in which little irrigation water is used. The emphasis is on bottom-up planning as an effective management tool.

9. Practicalities of Smallholder Farming

A Chapter discussing various concerns for those assisting smallholders. Items discussed are: casual crop management, certified and hybrid seed versus retained seed, soybeans, intercropping, soil testing, impact of HIV/AIDS, etc.

10. Assisting Smallholders

A summarizing Chapter that looks at the impact of various factors on developing projects aimed at assisting smallholders. It focuses on smallholders as individual entrepreneurs that are more restricted by labor and other shortages than knowledge or motivation. The Chapter reviews how projects might concentrate more on off-farm support services than on technology development and promotion, and the mechanism to effectively do so.

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