EXPERIENCE WITH SMALL-SCALE SPRINKLER SYSTEM DEVELOPMENT IN GUATEMALA: AN EVALUATION OF PROGRAM BENEFITS

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EXPERIENCE WITH SMALL-SCALE SPRINKLER SYSTEM DEVELOPMENT IN GUATEMALA:

AN EVALUATION OF PROGRAM BENEFITS

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PREFACE

This study was conducted as part of the Water Management Synthesis II Project, a program funded and assisted by the United States Agency for International Development through the Consortium for International Development. Utah Sate University, Colorado State University and Cornell University serve as co-lead universities for the Project.

The key objective is to provide services in irrigated regions of the world for improving water management practices in the design and operation of existing and future irrigation projects and give guidance to USAID for selecting and implementing development options and investment strategies.

For more information about the Project and any of its services, contact the Water Management Synthesis II Project.

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PROLOGUE

In September 1985 USAID/Ecuador and SEDRI (Secretaria de Desarrollo Rural Intregrado) initiated a unique farmer-to-farmer technology transfer activity. An agricultural engineer and two farmers (to act as construction foremen) were brought from Guatemala to work with members of selected Ecuadorian communities, showing them how to install their own gravity pressurized, sprinkler systems. The Guatemalans were some of the most experienced "products" of the Small Farmer Irrigation program operated by Guatemala's Extension Service. To date, loans arranged though USAID/Guatemala and managed by technicians of the Extension Service have supported construction of about 125 micro-sized systems in the Western Highlands.

Although Utah State University advisors to USAID/Ecuador and SEDRI were confident that the basic technology plus many other aspects of the self-help model could be transferred rapidly and effectively by a Guatemalan team, a weak element in arguments for testing the model in Ecuador was incomplete information about the general and specific economic performance of the individual Guatemala systems, especially those that have had the greatest longevity (LeBaron, et al., 1985). The present document is the outgrowth of an effort to fill that gap.

The data and conclusions presented are based on field surveys undertaken by a USU graduate student in agricultural economics. He was assisted by his wife who also spoke Spanish. In addition, during much of the data gathering period, one or another USU senior staff member listed on the title page accompanied the basic team in the field and supervised other data collection activities where possible.

Informative how-to-do-it manuals, containing PVC sizing and "hand-move" design criteria as well as organizational and installation suggestions, for micro-scale pressurized systems are available through the AID/Washington, Science and Technology Bureau sponsored project, Water Management Synthesis I (Embry & Adams, 1983 a & b). Contacts concerning these and other WMS I and II research and technical assistance reports directed to the Dept. Agricultural and Irrigation Engineering, Utah State University.

ACKNOWLEDGMENTS

A study of the type reported here would not have been possible without the assistance of many individuals, all of who we wish to thank. German Garcia, Jefe Proyecto Miniriego Region I-DIGESA (Direccion General de Servicios Agricolas), and his assistant, Mario Guentes, were especially supportive and informative in the early stages of activity in Region I. Francisco Masariegos, Jefe Proyecto Miniriego Region V-DIGESA, and his assistant, Jorge Mendez, graciously made arrangements for the surveys in their zone. George Like and Cecil McFarland of USAID/Guatemala were generous with their time and support.

The field work itself would not have been possible without the assistance and support of the Small-Scale Irrigation Program sub-region coordinators who were very patient with insight, information and interest in success of the survey team.

The search for backup information and statistics was made much easier by personnel of various Guatemalan institutions, including: Boris Lemus, Vice President of the Instituto National de Comercializacion Agricola, Pedro Rodriguez, Director de Servicios Tecnicos, and Jorge Perez, DIGESA Region 1 Hortaliza specialist. The staff of the AID/Guatemala Office of Economics was very cooperative.

ABSTRACT

During the Spring of 1986 a field study was undertaken to evaluate the economic success of Guatemala's Agricultural Extension Service program (mini-riego or M.R.) of installing small, self-help, auto-financed, hillside sprinkler irrigation systems amongst highland villages. The aim of developing such systems is to enable farmers to irrigate a portion of their land during the dry season so that some degree of agricultural production can be assured year-round. This effort is funded partly by the Government of Guatemala via loans from the U.S. Agency for International Development.

Most M.R. systems are pressurized by gravity and are created on a micro-scale, each serving only a few acres and families. Material costs have ranged from as little as $250 to $65,000 per system, but the majority of 125 or so projects have been built for under $10,000 each, excluding the value of technical assistance, general program administration and farmer donated labor. These latter items add another one-third to one-half to basic materials cost. In addition, loans for materials purchases are granted at the concessionary rate of two percent. Despite these subsidy elements, an important feature of the program is that a significant portion of each project's total annualized social costs are auto-financed (on average, above 75 percent). From an administrative standpoint, this means, for example, that all recurring costs are the sole responsibility of the water user groups, but that they benefit from the cheap loans and free design and installation assistance.

The USU survey of operations on 26 of these projects revealed that most of the M.R. groups have moved steadily in the direction of producing vegetable crops during the dry season, for cash markets, although the new irrigation sources are also used to augment family stockpiles of traditional foods. Analysis of the economic information obtained from 24 of the projects shows that all of them apparently generate positive internal rates of return and some of these rates are quite large.

The Abstract Table summarizes a few of the key interrelationships derived from the field data collected. It is noteworthy that a lot of the projects have been inexpensive to build and maintain. Nevertheless, there has been a great diversity in installation costs and subsequent economic performance of the various systems--no two are alike. The higher cost projects require an off-setting commitment to production of high valued crops if the internal rate of return (IRR) is to be held up. Although these observations are based upon gathering our own first-hand information, there may be considerable margin of error in the reported IRR values; even so, the data suggest that actual values for a number of these micro-sized projects are pretty impressive. A key economic success factor has been the general availability of an open market for non-traditional crop sales such as cool climate vegetables, and more exotic items such as strawberries and flowers.

ABSTRACT TABLE. SUMMARY OF MICRO-SCALE SPRINKLER PROJECT INDICATORS
(Irrigated portions of total land holdings only--Quetzals)

NAME & SIZE OF PROJECT & RANGE OF AVERAGE HOLDINGS		AVERAGE IRRIGATED HOLDING ha	NUMBER OF INDIVIDUAL HOUSEHOLDS	PROJECT AVERAGE PER FAMILY: NET CROP INCOME AVERAGE DRY SEASON Q	% INCOME FOR: O&M	% INCOME FOR: Loan Repayment	APPROXIMATE RESIDUAL NET INCOME	ORIGINAL INVESTMENT COST: Materials	ORIGINAL INVESTMENT COST: +TA & Labor	IRR/30 YR: Mat.	IRR/30 YR: Total
0 - 0.25 ha											
Los Enquentros	7	0.22	32	750	4.0	4.3	686	326	524	69	46
Las Hortencias	6.5	0.22	30	1016	3.9	3.2	944	529	794	58	40
La Estancia	8.69	0.23	37	815	6.6	3.5	733	461	692	52	36
S. Chamac	1.47	0.2	20	171	36.3	5.0	106	141	190	26	19
San Ramon	5	0.22	23	489	8.4	1.9	439	152	205	110	85
0.25 - 0.5 ha											
* Santiago	20	0.33	60	317	30.6	24.3	143	1500	2125	17	14
Los Mixcos	30	0.39	76	600	5.3	4.7	540	460	618	32	23
Los Frutales	8	0.46	16	507	7.9	10.5	414	874	1029	17	14
S A. Chapil III	6.6	0.26	25	517	1.9	2.3	495	196	392	90	38
* Rincon Grande	20	0.49	41	1022	20.3	0.5	809	744	1054	30	21
0.5 - 0.75 ha											
Saraya	14	0.52	27	497	5.2	5.5	444	444	704	17	10
Pacul	12	0.57	21	599	5.7	2.4	550	238	443	62	35
Lo de Silva	32	0.63	51	861	3.3	2.7	809	384	600	68	46
Quiajola	37.8	0.55	69	456	7.9	7.8	384	580	783	24	17
Pueblo Viejo	44.4	0.56	80	288	11.5	11.1	223	525	684	12	9
Rosario II	22	0.52	42	674	8.3	4.9	585	543	733	38	28
Pasac II	0.72	0.72	1	828	12.9	7.4	660	1000	1350	24	17
S.A. Chapil I	15	0.65	23	496	7.5	4.2	438	339	458	45	33
0.75 - 1.0+ ha											
* Xenacoj	28	0.85	33	799	15.9	14.6	555	1909	2288	10	8
La Estancia I	15	0.83	18	436	15.4	9.0	358	178	271	19	14
Esquipulas	65	0.86	76	258	13.2	13.5	189	525	857	12	6
* Cauque	20	1.0	20	2320	12.4	3.3	1956	1250	1805	51	34
Santa Rita	24	1.41	17	1128	4.8	2.6	1045	471	635	100	64
Los A Lisos Tzaley	148	1.32	112	363	12.7	7.2	291	429	579	25	18

* Pump

Annual loan repayment and O&M obligations do not appear to create cash flow pressures for any but a few user groups. Few complaints about system design and performance were made to the USU survey team. Conflicts over water use and distribution occur, but are not a major problem. A big benefit for participant families is that on a large share of the projects the developed water sources are used for potable water, not just for irrigation.

Readers may be interested in what effect paying full costs for borrowed capital would have on the groups listed in the Abstract Table. Merely doubling the annual repayment percentages shown (as a share of net irrigated farm income) will create the effect of paying interest at about 10 percent.

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LIST OF ACRONYMS

Agency for International Development	(USAID/Guatemala)
Banco Nacional de Desarrollo Agricola	(BANDESA)
Direccion General de Servicios Agricolas	(DIGESA)
Direccion de Riego y Avenemiento (Del Instituto Nacional de Riego y Drenaje)	(DIRYA)
Direccion de Recursos Naturales Renovables	(DIRENARE)
Instituto Nacional de transformacion Agraria	(INTA)
Instituto de Ciencia y Tecnologia Agricola	(ICTA)
Instituto Nacional de Comercializacion Agricola	(INDECA)
InterAmerican Development Bank (or BID, Banco Interamericano Desarrollo)	(IDB)
Ministario de Agricultura Ganadaria y Alimentacion	(MAGA)
Unidad Sectorial de Planificacion Agricola	(USPA)

CONVERSION FACTORS

1 ft -- 0.3597 varas
1 meter -- 1.196 varas
1 manzana -- 10,000 $varas^2$
1 manzana -- 1.7266 hectares
1 hectare -- 14,312 varas

1 $cuerda_a$ -- 25 x 25 varas (1 ha = 23 cuerdas)
1 $cuerda_b$ -- 32 x 32 varas (1 ha = 14 cuerdas)
1 $cuerda_c$ -- 36 x 36 varas (1 ha = 11 cuerdas)
1 $cuerda_d$ -- 40 x 40 varas (1 ha = 9 cuerdas)

The USU survey team encountered villages that used $cuerda_a$ and $cuerda_d$ as measures of area.

LAND, WATER, AND HUMAN RESOURCES IN MARGINAL AGRICULTURE

Traditional Farming Practices

Most of the rural poor living in Guatemala's "western" highlands depend upon maize and beans grown during the six month wet season (May-October) for part of their basic food supply. The remaining six months of the year are essentially dry, and few farming activities are undertaken. Any basic foods they do not raise themselves must be purchased.

In the highland region very small farms, under 0.5 ha, are the rule. The valleys are quite narrow and the farms are mostly on hillsides. Many families work only 1 to 2 _cuerdas_ (0.05 to 0.1 ha), or about 1/12 ha, and those with access to as much as 1 _manzana_ (0.7 ha) may be counted fortunate. A total land holding generally consists of small parcels divided between both flat and steeper slopes. The various plots of a group of farmers may be more or less contiguous and comprise a larger block of land , say 10-15 ha, in size, that is associated with a certain community. The farmer-owners who work the individual plots, are members of the community.

Steep hillsides are planted to maize and beans, alone or in combination. A planting stick can be employed in the most difficult terrain, however, the soils are usually worked by hoe. Animal or machine traction is seldom seen in subsistence situations. A noticeable aspect of many of these plots is that they are "terraced" by carefully made furrows (to control rain run-off) running on contours. There are also many examples of what would be thought of as ordinary, leveled, terraces that are farmed dry or irrigated. There are also many examples of poor soil conservation.

Plots lying nearest to the houses of the farmers also will be planted to traditional crops unless some form of irrigation (including potable water) is available to support a larger than normal family garden, or small crops of vegetables. Some vegetables may be grown near rivers or streams if water is carried to the land. The sizes of such plots are extremely small (Johnson, p. 132).

Elevations of 2,300 m or more and cool daytime temperatures combine to hold down the yield of traditional crops in many of the Guatemalan mountain valleys. The transition to higher yielding hybrid maize, which has been made in nearby El Salvador, has not occurred at these elevations because hybrids are too site specific for the climatic conditions. However, the cooler, foggy mornings prevalent in the higher elevations are well suited to cultivation of many vegetables, and a majority of farmers devote some fractional amount of land to this purpose, especially during the wet season. Vegetables are important for home consumption but cash sales are made if possible. The nation's marketable supplies, and consequently, prices, of wet season vegetables fluctuate a great deal and subsistence farmers tend to be wary (Fletcher, et al., p.173). Whether a specific farm family depends upon vegetable production for significant amounts of income is determined by availability of a suitable water supply and reasonable market accessibility.

Guatemala's regional reputation as a supplier of vegetables for export markets depends to some extent upon developed irrigation resources in the highlands that support production during the normal dry season. These developments are not extensive because they have to be located in valleys that have some flat portions that compliment a water supply suited to surface irrigation management techniques. Land/water configurations of this high caliber tend to be concentrated in the hands of non-subsistence farmers.

Off-Farm Employment

Often, lack of land prevents a subsistence farmer from producing enough maize and beans to feed his family. Off-farm income is required to take up the slack (Smith, pp. 21, 28). During the dry portion of the rainfed crop cycle many able-bodied men, and even whole families, migrate to the South Coast where they cultivate and harvest commercial export crops such as cotton or sugarcane. These annual seasonal migrations apparently involve 300 to 400 thousand people (Fletcher, et al., pp. 50, 86; Johnson, pp. 52-54).

Surplus highland labor is not just a dry season phenomenon. Even during the wet season an ample supply of workers is locally available. Day labor is bought and sold by all kinds of farmers. Johnson studied numerous highland families in the early 1970s and concluded that, under rainfed conditions, these marginal farmers would have to control about 3.0 ha in order to make an adequate living from farming activities alone (2.0 ha with credit and technical assistance) (pp. 134, 297-8). Few families control that much land. A 1964 study of Highland marginal farms (minifundia) indicated that 0.5 to 2.5 ha farms only require 50/70 days labor per year for traditional crops (cited by Fletcher, et al., p. 50). In the absence of enough farm husbandry demands to keep a family fully occupied, off-farm employment plays a dominant role in whatever levels of annual income are attained.

The apparent general mismatch of available highland family labor supply relative to that required by land area farmed, has been noted by other observers of Guatemalan agricultural development (Fletcher, et al., p. 87). A relative over-supply of labor is consistent with farming behavior observed by the USU Team inside the small-scale irrigation projects' community groups. M.R. farmers report maintaining a lot of personal off-farm employment links even after they receive irrigation supplies; in this connection, they also hire a lot of people to handle irrigated cultivation tasks. Second, women do not work in the fields every day, especially when men are around, because additional hands are not needed. Women market farm produce (and certainly know how to perform any field chores) and do many other things, but in response to the specific question of why more of them are not seen in the fields, the invariable answer is, "They are busy in the house."

In summary, a high man/land ratio is the chief explanation why such a large corps of intermittent day laborers, plus institutionalized patterns of seasonal farm labor migration, have developed. In any event, off-farm employment has been estimated to provide 65 to 75 percent of a family's income within the pattern of subsistence rainfed agriculture described (Johnson, p. 175). Fletcher, et al., argue that, "income earned by migrating workers is...[an]...almost crucial...element in their survival," (p. 51).

Demographic Pressures

In 1950 the average small plot holding in the Western Highlands was 1.35 ha and by 1964 it had reduced to 1.03. One prediction is that demographic pressures will push the size down to 0.43 ha by the year 2000 (Johnson, Table 2.3). To some degree development of irrigation water supplies offsets this trend, because the amount of effective land area is increased. Irrigated land in the Guatemalan Highlands will support at least one or two additional crops per year as well as supplement normal precipitation levels during the traditional wet season. Unfortunately, only a relatively small portion of the zone's cultivated land can be developed for irrigation.

Irrigation development also must contend with demographic pressures of another sort because the demand for water for non-agricultural uses and the need for potable water is always growing. Both large and small municipalities must make provision for current and future household and commercial water supplies. In this type of competition, irrigation use takes a back seat. In one instance, near Quezaltenango, spokesmen for a M.R. group told the USU Survey Team that the water right they have on a river might be taken away in the next four or five years by a local municipality. Anticipating this, they are looking for a spring or other water source they can buy.

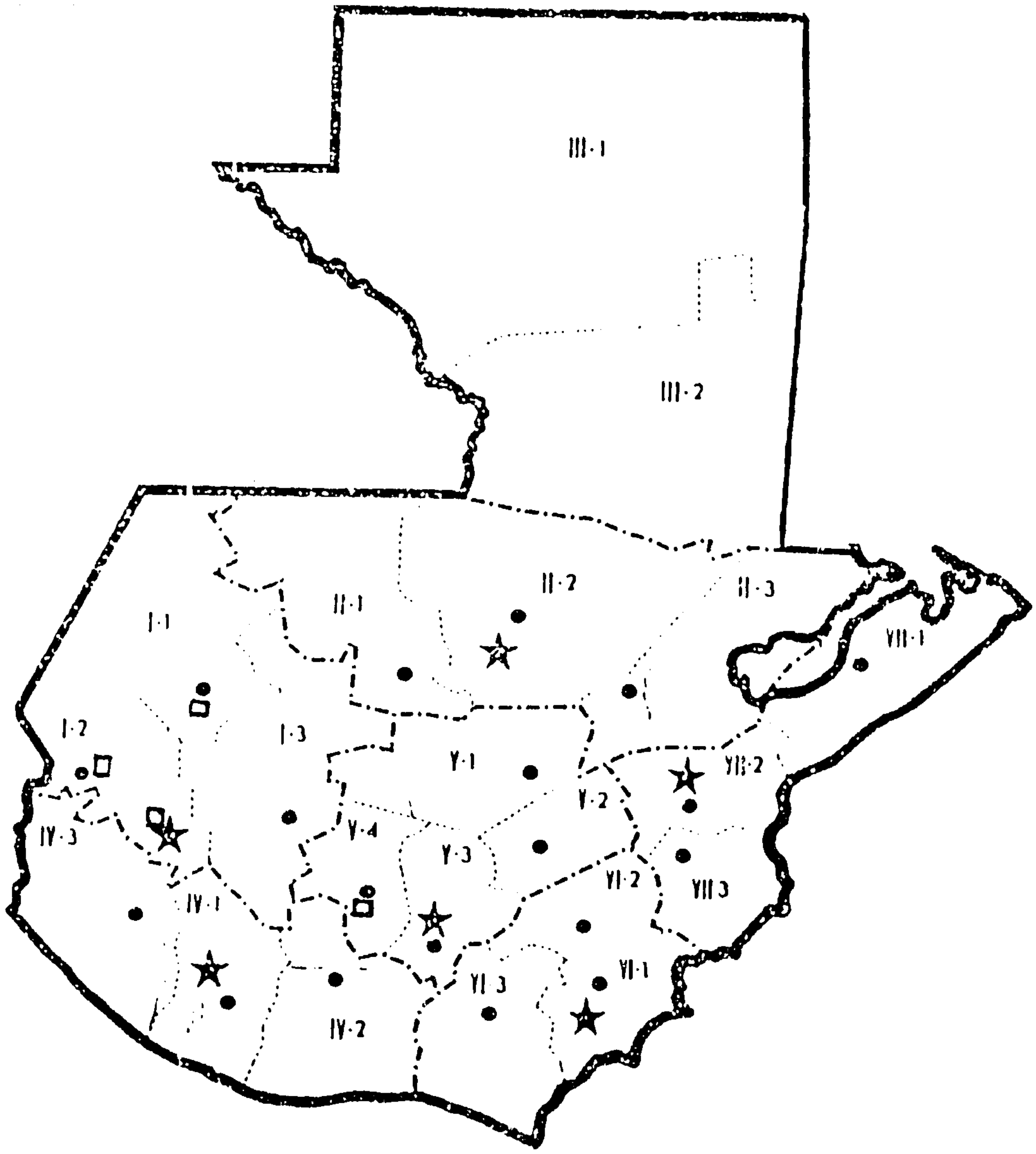
Non-Traditional Crops Grown in Mini-Riego Projects

As mentioned above, farmers in the Western Highlands have a tradition of wet season vegetable growing in locations that are at all suitable. And, as the small-scale pressurized irrigation projects have come on line, the water users have moved in the direction of producing non-traditional crops during the dry season, when higher prices are more predictable. The community surveys revealed the general impact of the micro-scale irrigation systems on the pattern of crop production (see Table 1).

In Region I, which is in the West (Map 1), only 17 percent of the groups raised non-traditional crops during the wet season. Before joining the M.R. program production concentration was on maize/beans. Now that the systems are in place, 54 percent of the same groups include some non-traditional crop production. The response has been different in Region V, which is centered closer to Guatemala City. Fully 50

TABLE 1. SOME EVIDENCE OF CHANGING PRODUCTION PATTERNS

Name	Before		After	
	Wet Season	Dry Season	Wet Season	Dry Season
Lo de Silva	trad	none	trad	non-trad
S. A. Chapil I	trad	none	trad	non-trad
Santa Rita	trad	none	trad non-trad	non-trad
Saraya	trad	non-trad & trad (irrig)	trad	non-trad
La Estancia I	trad	none	trad & non-trad	non-trad
Santiago	trad non-trad <--irrig	none	trad non-trad	non-trad
Rincon Grande	trad & non-trad	none	trad & non-trad	non-trad
Los Mixcos	trad & non-trad	none	trad & non-trad	non-trad
Esquipulas	trad	none	trad	non-trad
Los Frutales	trad & non-trad	trad ?	trad & non-trad	trad & non-trad
Pueblo Viejo	trad & non-trad	none	trad & non-trad	non-trad
Quiajola	trad	none	trad	non-trad
S. I. Chamac	trad & non-trad	none	trad & non-trad	trad & non-trad
San Ramon	trad	none	trad & non-trad	non-trad
Pasac II	trad	none	trad & non-trad	non-trad
Rosario II	trad	none	trad	non-trad
S. A. Chapil III	trad	none	trad & non-trad	non-trad
L. A. Tzaley	trad	none	trad & non-trad	non-trad
L. Hortencias	trad	none	trad	non-trad
L. Encuentros	trad	none	trad	non-trad
L. Estancia	trad	none	trad	non-trad
Xenacoj	trad	none	non-trad	non-trad
Pacul	trad	non-trad	trad	non-trad
S. M. Cauque	trad & non-trad	non-trad	trad & non-trad	non-trad
S. Pedrito	?	?	?	non-trad
Nimasac I	?	?	trad	non-trad



Regional Boundries

Regional Headquarters

Approximate Nodes of M.R. Activity

Map 1. DIGESA (Extension Service) Regions (7) and Sub-Regions and General Locations of M.R. Project Activity percent of all the groups surveyed raised non-traditional crops to some extent before the advent of the M.R. program. This percentage has not changed.

The impact of the M.R. program on dry season land use has been dramatic. Prior to installation of the pressure systems, there was almost no dry season production of either traditional or non-traditional crops among the surveyed groups in both zones. After installation, dry season production of non-traditional crops is found in every system. (Of course this new production is confined just to the plots served by the irrigation installation.)

In Region I, centered on Quezaltenango, cool climate vegetables such as carrots, cabbage, cauliflower, beets, potatoes, radishes, turnips and lettuce are some of the main vegetables grown under irrigation in the dry season. M.R. projects tend to lie at higher elevations in this zone (6,000 to 9,000 feet). A range of vegetables typically will be grown by an individual farmer. Small amounts of broccoli and brussels sprouts grown on the projects are accumulated by intermediaries and exported. Garlic is exported from Guatemala on a fairly large scale, and some of this also comes from M.R. projects. It is probable that other vegetable types produced on M.R. projects in this zone, are included in exports, but only these two were clearly identified to the USU survey team.

All of these crops were cultivated in this zone on a commercial basis before the advent of the M.R. program, broadly during the wet season, and on a more specialized basis by a relatively small number of farmers who had water during the dry season. In a few instances, this number might have included some farmers who now are "inside" the M.R. schemes. A considerable number of M.R. farmers are benefiting from this wet season tradition.

The valleys in Region V (Map 1) are generally lower (3,000 to 6,000 feet) and the crops are different. Dry season specialties encountered in visits to small-scale irrigation projects include onion, chile, guisquil, chayote, celery, tomatoes, snow peas, strawberries and flowers. In this region vegetables such as those grown in Region I, while commonly observed in limited plantings, are mostly for home consumption.

Given Region IV's proximity to Guatemala City, the survey did not reveal as much specialization in certain crops as might be expected. Most of the M.R. groups around Guatemala City produced at least five different commodities during the irrigation season. A year round emphasis on a single crop was encountered in only one system. This was strawberry production by the Rincon Grande group. (Smith mentions flowers in Rincon Grande; p. 32.) Some snow peas raised in M.R. projects are exported.

During the wet season M.R. project farmers in both regions continue to grow traditional crops of maize plus black and broad beans. Some groups do not raise any marketable quantities of vegetables at all (cf. Smith, p. 31). The Extension Service agronomists are trying to talk the farmers into more reliance upon higher value vegetables in this season as well. However, as noted, vegetable prices do not attain dry season levels and are highly variable besides (Rivera D, conclusion; Ibarra M, conclusion). In addition, farmers who are intent on covering as much of their food security needs as possible are effectively insulated from market forces. To pull out even a small share of land and put it "back into the market place" might not be too attractive. Even during the wet season an alternative to cash crops is to use the supplemental water supply to protect and increase yields of traditional crops.[1] This mode of operation is being abandoned by a few farmers in Santa Rita who purchase all their family food staples and emphasize production of cash crops as much as possible (cf. Smith, p. 28).

MECHANICS OF THE SMALL-SCALE SPRINKLER PROGRAM

General Considerations

When the first small-scale irrigation systems were introduced, many farmers were skeptical. They did not want to go into debt. Some did not believe that sprinkler pipes actually could be run to their land; others were simply afraid of something they did not know about. Once the first projects were in place it became easier to convince other groups to organize to obtain their own systems.

Most farmers receiving irrigation water for the first time have limited experience in raising vegetables and must learn the finer points. This is at least one of the reasons why not every farmer wants to be part of a water users group, to accept the responsibility to repay a loan, or be tied to the requirements of demanding crop and land management.

Farmers have to get used to the idea of moving the hoses, transplanting seedlings, weeding and other more intensive operations necessary to raise vegetables or other non-traditional crops. Efficient utilization of irrigation water in small-scale settings always involves

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[1]Virtually every document dealing with western highland marginal agriculture reviewed by the Survey Team involves the argument that the "net returns" to vegetables are three to ten times as high per area of land as traditional crops. But such arguments fail to take into account that costs of maize and bean cultivation are quite low, and if allowance is made for the extra effort vegetable production requires, i.e., the relatively greater amount of land that can be worked in traditional crops with the same effort, the real differential in net value to a farm family may not be as wide as imagined. In this connection, the return per dollar of expense is a useful indicator of relative benefits. Sanchez, for example, calculates a B/C ratio per cuerda of maize of 2.5 vs. 3.0 for cabbage (pp. 65-72).

more human energy per unit of land. Farmers have to become convinced that the rewards are worth the effort.

Composition of DIGESA Teams

Each of the two Extension Service regions where the M.R. program is active, has one or more special technical teams composed of a civil engineer or agricultural engineer, agronomists (ingenieros agronomos), agriculture technicians (peritos agronomos), a surveyor, draftsmen, and secretaries. Field foremen, who are farmers themselves, are also trained, and form part of each group. The make up of the actual teams has always been short of engineering skills, however. In fact, other skill positions also have been under-staffed relative to what was proposed by foreign advisors who helped with original program design (Embry 1981).

Individual agronomists are put in charge of a sub-region and are responsible for locating new groups interested in joining the M.R. program and for the projects that are developed in their sub-regions. Once a project is started at least one field foreman with installation experience is assigned to work witn the community members during the installation phase of their system. In effect, he is a construction foreman and is paid by DIGESA. This special agent lives in the village during the installation period and the newly organized water user group provides him with food and shelter. An important aspect of this learning by doing program is that during the installation phase the villagers not only install concrete boxes PVC pipes and brass fittings, but at least a few of the members usually understand how to operate and maintain their system once it is placed in service. Thus, in the overall learning process, there is some emphasis upon training guide farmers (Guias agricolas) who can be information resources within their own or neighboring groups later on. This idea of utilizing pioneer farmers to demonstrate new techniques apparently was especially emphasized in the companion land conservation (terracing) sub-project.

Some Conditions Precedent

Each family in a project community must decide whether or not it wants to be part of the proposed small-scale irrigation project. Since some do not choose to participate, project plots finally included are not necessarily contiguous within village owned lands. Maybe only 20 families out of a community of 100 will be involved. This explains why it is common to see green irrigated patches scattered about brown hillsides during the dry season.

Sometimes when non-participating farmers observe the success of a project (whose buried pipes often cross their land) they decide to organize another group of potential irrigators. If the attempt is successful, the result may be that neighbors wind up getting their water from two different projects.

Interested farmers get together, identify a source of water, and contact the local Extension Service M.R. team. An engineer meets with the group, explains the requirements and measures the water source. If there is sufficient water, he ensures that each potential participant family "register" their land holding in the municipal (Municipio) offices (actual land titles are rare). Any family that for some reason or another cannot be registered is excluded. All of the affected public agencies are contacted to ensure that a water "right" on the selected source will be granted and recognized. (No extensive water code has been adopted in Guatemala.) Next, the team surveyor is called in and a topographical study is made. Then a system design is drawn up and cost of materials is calculated. The local Agricultural Development Bank (BANDESA) representative is contacted for financing. This person visits the group and explains the bank's lending requirements. The Bank (and the Small Farmer Development Program in general) can loan to various sorts of groups: co-ops, municipalities, or informal farmer associations. But in the case of the informal water user groups, the organization must be "legalized" by filing papers with the local Municipality before the Bank will do business.

Once individual family land registration is complete and it is known that the group can obtain a water right, the prospective members must then decide if they are willing to provide the construction labor, obtain legal recognition, and borrow the money from the Agricultural Development Bank. (Technical assistance from the M.R. team is provided gratis by the Extension Service [DIGESA]). If the group is not happy about the arrangements and progress to this point, they can opt out and owe nothing.

The assigned M.R. engineer is responsible for all aspects of project supervision, including arranging financing through BANDESA. One or more construction foremen handle the actual day-to-day installation activities following the design as laid out by the engineer. This means that the foremen may live in the area two to three months while a system is being constructed. As mentioned, the community members must house and feed these foremen. Some groups financed their own irrigation systems, but enlisted the free technical help of the project engineers and support team, including the live-in foremen.

Terracing and access roads are two further requirements, where deemed necessary. Normally terraces would always be encouraged and road improvements might or might not be necessary. Access road improvements and land conservation technical assistance are sub-activities, along with small-scale irrigation, in the overall Small Farmer Development program sponsored by the government of Guatemala (with assistance from USAID).

Terraces are constructed using an "A" frame and plumb bob to maintain a level and the cuts and fills are made with hoes, wheel barrows, or other simple hand tools. Once again, labor is provided by the farmers themselves relying upon technical assistance from project engineers. At the beginning of the small-farmer irrigation and soil conservation program, a "social cost payment" was made to the farmers to encourage them to terrace their own land. Apparently many families, nevertheless, have been reluctant to do very much terracing. At the same time there are instances where the guide farmers are active and a certain amount of terracing continues on a voluntary basis (Smith, p. 10).

Access roads are usually financed by the government and laborers are paid for their work. Engineers from the Agency for Rural Road Maintenance and Construction (Caminos Rurales) are in charge. There is no necessary connection between road improvements and a particular irrigation development, just as there is a lot of land conservation activity (terracing) on rainfed lands as opposed to concentration on irrigated developments (Smith, p. 35, et passim). In some instances, the farmers organized themselves to get a road built, and arranged for technical help as best they could (Embry, 1987).

Material costs for each new system, which must cover PVC pipe, faucets, fittings, concrete water collection boxes, hoses and sprinkler heads are borne by the group. Loans from BANDESA are written for up to twenty years with interest rates as low as 2 percent. The loans are broken into proportional elements and either individual farmers are responsible or subgroups composed of four or five farmers are formed (each subgroup can borrow up to 5,000 Quetzales). One way or another, each farmer is directly responsible for his portion of the total. The total borrowed only includes the cost of materials. Agents of the Agricultural Development Bank are very easy to work with. The policy is to permit a grace period of up to three years on repayment of principal and grant additional time if bad crop years occur. Managers of the Agency are interested in seeing that these projects succeed.[2] All labor is donated and the Extension Service covers the cost of technical assistance provided by its engineer and the rest of the design and installation team.

Installation of PVC

Water for a M.R. project might be taken from a river, one or more springs and, in at least one case observed, a seep (see photo #1). Any sort of project may be designed and built, but in practice, pressurized sprinklers have been chosen in order to deal with the slopes and location of water sources. Most of the systems are pressurized by gravity; only about 10 pump systems have been constructed. The following section concentrates on the gravity design version.

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[2]In a 1984 study, Ladman and Torrico show that the Bank is slowly being decapitalized as an inevitable consequence of losses on loans and the low interest rates charged. Consequently, BANDESA really does not act like a bank (even though rural saving mobilization is supposed to be one of its functions), but concentrates mostly on its other rule, that of a development bank, and administers trust funds (p.54).

As a general rule, DIGESA engineers hold to a minimum of 0.6 l/s/ha (continuous) as a key design parameter. This rate of flow is considerably less than what would be required for supply to a surface system. The relatively greater amount of land that can be irrigated by utilizing sprinklers is one of the great advantages of moving to this technology.

When the source is a river, the diverted portion is led into a small area where suspended materials can settle, and from there the water is routed via a screen into a cement collection box where it is filtered again before it enters the mainline PVC pipe. Silt control measures do not have to be very elaborate with some sources, such as springs. Most systems have a mainline shut-off valve immediately after the collection box for ease in repairing or cleaning pipe. The mainline is buried and eventually divides into smaller PVC laterals that run underground to individual farmers' plots (see Figure 2).

All trench excavation and pipe burial is done with picks and hoes provided by the farmers. Depending on the distance to the water source and project topography, the fall in the mainline from the collection box to the point where the first lateral leads off ranges from 25 m to 1,200 m, with the average being under 100 m (only a small part, under 100 m, of long falls can be pressurized). Not all M.R. systems are pressurized by gravity, however. In Region V several pump systems have been designed and constructed. At least one of these lifts water a full 200 meters. This particular system has three pumps in series. Often it is cheaper to purchase several smaller pumps (25 horsepower) than one or two larger sets. It is easy to have some reservations about resorting to pumps--they add cash costs and O&M complications that may hinder success for the farmer user groups. At least one pump system supplies furrows rather than sprinklers.

On-Farm Equipment

A standpipe and faucet are provided at the rate of one to every five _cuerdas_ (based on a 25 x 25 _varas_ measure), or two _cuerdas_ (based on a different measure of 40 x 40 _varas_), or at least one to each farmer if he owns less ground. If the water comes from a spring (or is drinkable), additional standpipes may be placed next to houses. Each farmer is given one hose (garden type) and one sprinkler head per standpipe. 5/8" or 3/4" hoses are used and oscillators with nozzles that deliver from 3.5 to 4.5 G.P.M. are all part of the initial installation.

Design for Equity

When irrigation is introduced there seldom would be enough water in the source to irrigate all the land the participating group farms. Therefore, the projects may be designed to give each farmer an equal

REPRESENTATIVE MINIRIEGO PROJECT

Approximate design of the Santa Rita project

B. Embry October 1987

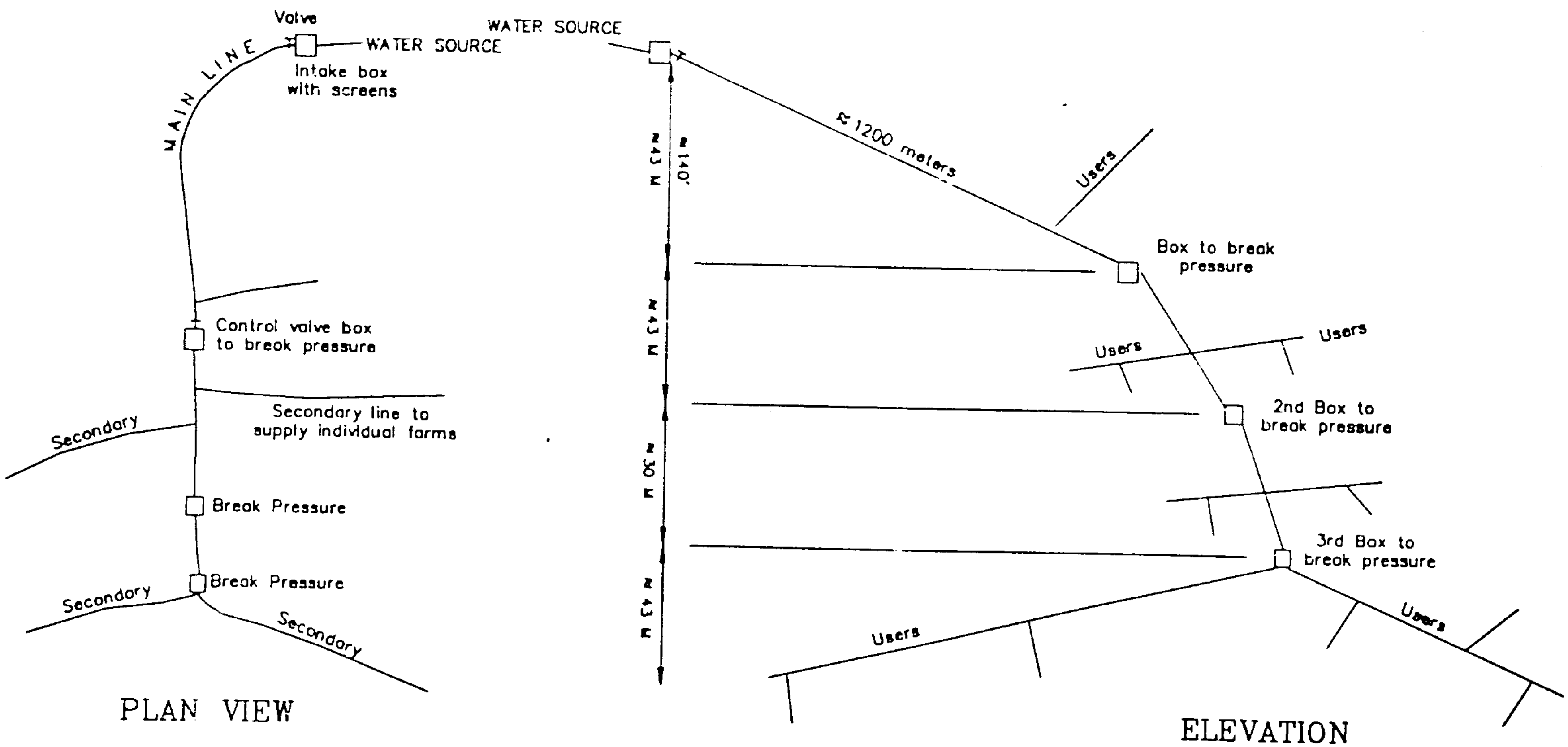

Photo 1. Left. One of several tubes tapping a seep. Small collection box is visible.

Photo 2. Below. Off-take from a running stream. Two PVC sections are visable.

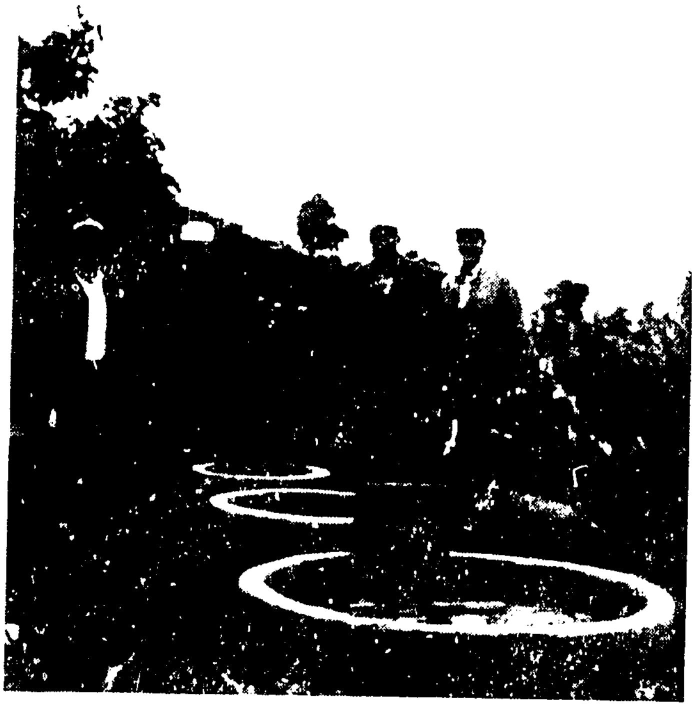

Photo 3. Left. DIGESA engineer, farmer, Dr. Embry, T. Tenney. Testing pilot questionnaire. Methane digester in foreground.

Photo 4. Below. Sprinklers operating on plot behind farmer families. Dry farmed hillside plots are visible.

amount of water, regardless of the number of cuerdas each family owns. For example, in one project visited, all the farmers are allotted water enough for five cuerdas. Some only own 3 and others 20, but the allotted amount of is the same for all. On the other hand, if the source provides enough water, the individual farmers decide prior to construction what they want to irrigate and are allocated repayment and maintenance shares and chores accordingly. Either way large amounts of land are not involved. The average amount of land under irrigation per family in the older, established M.R. projects surveyed by the USU Team is 0.58 ha.

Nearly 50 percent of the M.R. groups visited by the USU Team were operating true demand systems, the rest were operated on rotation (turns). Demand designs are very convenient for farmers because the timing and amount of water application can be scheduled to meet crop requirements. (This does not imply that M.R. farmers are especially knowledgeable about such matters.) In a sense, everyone is treated equally if water flows at the turn of a tap. However, several farmers are bound to want water at the same moment, and allowing for this possibility means that demand designs require much greater main line and lateral capacity, in order to be responsive to peak loads. On-demand convenience and equity, therefore, comes at a price. Fundamental equity guarantees are still maintained by equalizing the land area served per family, or by proportional cost sharing.

In some cases, even where "abundant" water exists in the source, only enough is brought down to the group's plots to irrigate the best land (Masariegos). The thinking of the small irrigation project engineers is that maize and beans do not return enough to justify a system whose design is extended to water the poorer lands. Based on this reasoning, as noted above, M.R. water users are discouraged from irrigating traditional crops, and are pushed into vegetables as rapidly as possible.

In an effort to economize on construction materials, all newer small-scale irrigation projects are designed to be operated on turns. This somewhat more complicated operating method is the trade-off. The engineer in charge of installation helps organize the turns. These agreements and other rules may not be written down. DIGESA engineers told the USU Team that they try to get the water user groups to put their agreements in writing, and that this is slowly being done.

Operation

Each water user group must create a "Committee" (Comite) to head up its own project organization. The leaders of the Committee rotate annually and serve without compensation. They generally consist of a president, vice president, secretary, treasurer and several "vocales" who basically do administrative leg work (notifying organization members of meetings, etc.).

The Committee is responsible for establishing any water rotations, undertaking major repairs, organizing routine maintenance and cleaning, and administering any funds held by the group, plus storing spare parts and managing conflict resolution. Newer water user groups (formed since about 1984) hold meetings on a regular basis and, according to DIGESA engineers, this practice is followed because there are now more technical personnel to attend and instruct the user groups about operation and maintenance of their systems. This regular contact also helps keep conflict to a minimum, as the opinions of the engineers and agronomists are generally respected.

DIGESA engineers seem to strike up a continuing relationship with the various water user groups and help them out by buying needed supplies wholesale or by bringing spare parts to the projects. These wholesale buys include such items as valves, sprinklers, hoses, replacement pipe and twine.

Each group is in charge of cleaning and maintaining its own system. This involves "walking" the mainline to the collection box in order to check for leaks or serious breaks and to clean trash screens as needed. This is a daily task for some groups and only weekly, monthly or seasonal for others. One project mainline is 15 kilometers long, and mainlines of several kilometers are common. Thus, the inspection routine may require a large number of hours per season if daily checks are necessary. Systems are designed with drain/cleaning valves at low points in the pipeline so debris and sand can be easily flushed. Of course, other cleaning efforts are required on other system features, such as collecting boxes.

Most systems are designed to run 24 hours per day. But due to the reduced flows of water in some sources during the driest part of the year (March and April), the system owners in these situations are told from the beginning not to count on a full supply during these months. Pacul is a sprinkler system that suffers from this supply irregularity. During the driest part of the year the water users' committee cuts each family's irrigated land area by about one-half, i.e., they drop from an average of 3 cuerdas apiece to 1.5 that can be irrigated.

Individual farmers are solely responsible for their own on-farm system operation. The main requirement is to keep sprinkler nozzles unclogged.

Conflict and Resolution

The main forms of conflict detected by the USU Survey Team were rooted in water shortage. This seemed to be true regardless of whether or not there was a need for irrigation turns. No farmers complained as long as they were receiving the water they were told they could expect when the project was planned, or once they understood how any shortages were being handled. Some common reasons for not receiving water as designed include: other uses taking water out of turn; sprinklers being removed to let hoses run wide open; larger nozzles being attached which throw more water: adding unauthorized hoses; and owning land situated on a lateral especially sensitive to drops in line pressure.

If a farmer feels that he is being injured, he may air his feelings at one of the community or water user meetings. Many times the conflict can be resolved there. However, if the farmer obtains only minority support, he might be ignored. In at least one case the complaining farmer was the Committee president, and no one would listen to him, so he could do nothing. In another case, one farmer let his son utilize his (the father's) tap to irrigate adjoining, but non-project, land. This, of course, lowered pressure for the others and possibly "shorted" them. Even though the offender was confronted, he continued the practice. This situation was still unresolved at the time of the USU Team visit and the Committee had not determined just what to do. Another conflict, similar in nature, arising on a M.R. project near Guatemala City, required Municipio intervention through a judge. Thus, apparently, higher level remedies can be called upon if necessary.

Committee members must learn and develop their own decision-making and group control abilities. Since they "own" the systems, most groups dislike outside intervention in conflict resolution. This creates an incentive to find solutions of their own making. The following table contains experience with conflict in the older M.R. systems as reported to the USU Survey Team.

TABLE 2. REPORTED EXPERIENCE WITH CONFLICT ON OLDER SYSTEMS

Share of Sample	Demand Systems 48%	Rotation Systems 52%
No Conflict	50%	31%
Rare Conflict	25%	46%
Occasional Conflict	25%	23%

Other knowledgeable persons were also questioned about water user conflicts and their answers suggest that really destabilizing situations seem to be quite rare. Many of the community leaders interviewed by the USU Team stated that their groups had not had any conflicts. As might be expected, there seems to have been less conflict within demand systems; the overall sample did not cover many projects with intermediate or shorter life histories, where experience with settling conflict may be lacking because all the time necessary for a system to "settle down" has not passed.

Maintenance

Water user groups are also completely responsible for maintenance of their own systems. Seldom does this create any difficulties, however, since members put the system in place themselves. They learned the correct procedures for replacing pipes, valves and other important parts of the system from the construction foremen. There are times, of course, when difficulties arise that require outside help. The majority of these more technical problems are associated with the pump systems and involve questions that are beyond the realm of farmers' abilities. DIGESA engineers are generally available, however, to provide back-up solutions to maintenance problems. DIGESA is putting more emphasis on gravity-fed systems, given experience with some of the complicated earlier mechanical systems (Masariegos, 1986).

The M.R. systems are designed to run at anywhere from 30 to 60 psi and farmers do have to learn how to handle pressure. Several cases were mentioned where a full head of water was released at the collection box without the valves below being opened. Of course the pipes burst, and the user groups learned an expensive lesson. Plastic pipes can also be damaged if a farmer gets careless with a hoe. Rock slides are responsible for other breaks and clean-out problems.

Often the systems are not left open during the rainy season so they may be safe from silt and rock deposition that can occur due to large storms. Collection box designs also seem adequate to keep out rocks and debris; springs and seeps are sources that are little affected by storms.

The relatively few pump systems usually lift from a river. These systems have their own peculiar design and O&M problems. One man from the user group is assigned or, in some cases, paid to watch and maintain the pumps whenever they are running. Debris carried by a river can easily clog the water intake and burn out a pump. Some M.R. Committees have learned this the hard way. One project group in particular, Sta. Maria Cauque, started with 60 members and now has about 20. During the first year the pump they installed burned out and two-thirds of the farmers withdrew rather than go further into debt to buy a replacement. The 20 that continued appear to be doing fine (however, it is not clear if the amount of loan to be amortized has been adjusted, etc.).

In some projects, vandalism by non-project community members is a problem. Sixty-eight percent of the groups surveyed stated that hoses and heads were not safe if left out at night. They said these items would "change owners" by morning. Some farmers reported having standpipes broken, or experiences with other destructive actions involving their equipment. The reasons for vandalism are not clear. Several farmers surmised that jealousy was at the root of the matter. Some families may regret not having joined a M.R. group when they had the chance. As "outsiders" they are denied access to the dry season pressure supply, and perhaps they envy higher incomes enjoyed by the irrigators. One farmer apparently ignored complaints about his sprinklers wetting the road leading into the community. Later some of his irrigation equipment was damaged. Except for this case, reported vandalism was not traced to a source inside the water user group in any of the other incidents brought to the attention of the USU Team.

Responsibility for Recurring Costs

Although the cash costs of operating the small-scale sprinkler systems are very low, maintenance is another matter. Breakdown of any of the physical elements might require a "lumpy" cash outlay to repair the concrete collection box, or sections of PVC mainline or lateral. Pipe sections and other components can always be replaced on short notice, so these pressurized systems can be kept operational. If plastic pipe is kept clean, it will last an indefinite period. Some groups store a few spare sections of various size pipe.

Mainline and most lateral repairs are a group responsibility. If a farmer cuts into a lateral or breaks off a stand pipe, he will have to bear the cash, and probably the labor repair costs as well. Replacement of valves and faucets, hoses and sprinkler heads are individual farmer responsibility. Depending on the care and use the users give these parts, only hoses need to be replaced with any frequency--every other year or so. Ninety-six percent of group spokesmen said members had to replace hoses in one to two years. Valves last longer--up to three or four years. On average, at current prices, a farmer probably spends Q20 to Q25 per year replacing hoses, faucets and pipes, including the value of labor (under $10.00).

Since the M.R. systems are all farmer built, financial obligations are confined to equipment loans owed to the Agricultural Development Bank. M.R. groups pay no fees for "the nation's water" or as an offset for the free design or other TA help enjoyed. DIGESA engineers say "The projects are owned by the farmers." As a consequence, the users do not want someone mandating how or what to plant, although they accept the advice of the engineers, as explained below. They make their own operational choices within available physical limits. They do not want a "higher law" interfering. This attitude extends to handling internal conflicts, as we have seen.

In irrigated agriculture, water rights are typically an object of on-going contention, but the USU Survey Team heard relatively little reference to the topic. We have already mentioned a situation where authorities of a local municipality (municipio) might be preparing to interfere with a user group's "right" because domestic use has a higher priority than agriculture. The Team was also told of a case where leaders of a military camp tapped into a M.R. main line rather than extending the camp's own pipes clear to the source, as a separate system. A DIGESA engineer stated that the camp commanders have not been willing to rectify the situation. According to Smith, (p. 31) the water users at Lo de Silva were engaged in a water rights dispute as of 1983, however nothing of this nature was mentioned during the USU team visit.

There seem to be few difficulties in handling recurring costs. In 19 percent of the groups surveyed the Committee maintains a petty cash fund (caja-chica) for normal maintenance needs. But most of the time, when the organization needs money, the Committee imposes a special levy on the members. No problems with collection were reported (except for the pump case mentioned above). There are no water fees per se.

CROP PRODUCTION PRACTICES ON THE SMALL-SCALE IRRIGATION PROJECTS

Post Construction Technical Assistance

Nowadays at completion of installation, DIGESA engineers arrange for other agricultural technicians in the Extension Service or the construction foreman to teach the new irrigation water users what is known about the crops that grow best in their area and how to plant, irrigate, and generally take care of them. The main goal of these engineers, however, is getting more M.R. systems into the ground. Providing cropping or animal husbandry technical assistance is secondary and is provided to the degree slack time is available and as a program selling tool for construction of additional projects. If in-place projects succeed, other farmer groups will become interested and may seek Extension Service design help.

According to information obtained during the USU survey, farmers on many of the older systems did not get a high level of follow-up attention. The claim is that only a certain amount of initial crop production information was given by Extension Service representatives in general terms. Apparently, some farmers still adhere to these original recommendations. In some cases this was enough and in others it was not. Although it seems very unlikely, some respondents claim that the only instruction they received came from seed and fertilizer stores. In the villages surveyed, many farmers by now have tried new crops, so what might or might not have been partly is history.

Thirty-five percent of the spokesmen for the water project groups surveyed stated that members saw extension agents frequently. Fifteen percent said they saw them occasionally and another 15 percent said seldom. Thirty-five percent stated that their members never saw the agents.

One problem faced by extension agents and project engineers is that they must extend information about non-traditional crops based on their own (or observed small irrigation program) experience. Thus, it is unfair to judge the individual agents too harshly. They do not have a highly technical base of on-farm water management information to draw upon, especially where sprinkler irrigation is concerned. For example, in the majority of communities surveyed, it was noted that irrigation water is applied evenly or equally to all crops, regardless of differing plant needs.

In Rincon Grande, the farmers have been using the same strawberry plants for six years. Also, although it is very hard to believe, the water users on this project claim they were left so alone they did not even realize they were required to pay for the electricity to power their pumps. It is true that, in fact, the national electricity agency failed to send the group an initial power bill for quite a long time. Finally, the agency noted the group was Q7,000 behind in payments and demanded its money. Now the group has to pay for current usage, plus an additional levy to amortize the debt. (Under full-scale operation, the water users now run up electricity bills of over Q5,000/month in 1983 values [see Smith, p. 32].)

In Lo de Silva, another older M.R. project, the farmers say they have cut back production of Guisquil (a squash type vegetable) by 95 percent in the last few years because they have been hit by a certain crop plague. When this was mentioned during the Team's interview, the accompanying DIGESA engineer acted somewhat startled and explained that he knew of a chemical that was controlling this problem in other areas. Apparently, a lack of contact or communication or both existed. There have been other reports of irrigation groups giving up higher valued crops due to inability to manage the necessary level of pest control--with the effect that expensive systems are used to grow animal fodder (ICTA, 1984).

Marketing practices appear to be last on the list of things for new vegetable growers to learn. Apparently it is taken for granted that M.R. water user groups automatically will be able to benefit from the well developed and established vegetable marketing channels from Guatemala to Mexico, El Salvador and Honduras, as well as from normal growth in domestic demand. Such an assumption only seems justified to the extent that the likelihood of M.R. production saturating markets seems remote. In a very few markets, "new" output of vegetables from the M.R. producers might have some impact. Smith has noted the danger of expecting current markets and channels to be able to absorb continued increases in fresh vegetable marketings (p. 35).

Use of Production Inputs and Credit

All Guatemala farmers have had to live with increasing prices for commercial inputs. Pesticide, chemical fertilizer and seed prices have all experienced dramatic increses during the past 2-3 years. Anything that must be imported or whose base materials must be imported has become extremely expensive. This is partially or wholly due to loss in purchasing power of the Quetzal. These adverse shifts in the farm management scene were mentioned on numerous occasions during the course of the survey.

Still it does appear that M.R. farmers are using more of both chemical and natural fertilizer as experience with their sprinkler systems is gained. But the survey did not generate hard estimates of the rate of change. Traditional compost piles are becoming more common too, interviewers were told. In some cases M.R. farmers have constructed digesters that generate methane gas. These tanks make it possible to get higher quality compost, methane gas for cooking and gives farm families one more good reason to own animals.

Animals compliment crop production in many ways. Members of older, established water user groups now own more animals in 50 percent of the groups surveyed. There has been no change in number of animals owned in 42 percent of the groups; 8 percent of the groups have fewer.

Of 26 old systems visited, spokesmen for members on 18 of them reported use of production credit by at least some of their members. Average amounts by project could not be obtained, but they are quite small. Loans are requested at the beginning of each year, sometimes for production of a given crop and sometimes by cuerda (the amount of land worked). The majority of credit users reported the Agricultural Development Bank as the source.

The Survey Team noted that irrigation water generally is not wasted. This indicates that it is relatively scarce and important. One farmer the USU Team met had a faulty faucet that apparently had been leaking for days, as there was a lot of flooding in one corner of his land parcel and accompanying plant damage. This was the only case of rampant water mismanagement observed by the Team. (Diaz del Valle conducted an efficiency of field application and uniformity study in 1983 in M.R. projects Pueblo Viejo and Quiajola, and concluded that the farmers were doing quite well in their irrigation techniques. Results from both projects fell between 68 percent and 72 percent for the hand-move, garden hose systems.)

Although night irrigation is not the most joyful of tasks, a great number of M.R. project families have adjusted to the requirement or opportunity. Some of the reasons for irrigating at night, besides abiding by designated turns, are to obtain higher water pressure or to satisfy a farmer's need for an irrigation. Thirty-five percent of the users surveyed always water at night, while 31 percent never do. The remaining 34 percent were split between "usually" and "sometimes" irrigating at night.

Use of Family and Hired Labor

Although it is clear that all members of an M.R. family engage in and understand all the different operations associated with utilizing a pressure system, community leaders described a wide range of reliance upon family labor in farming operations. If the family head works off-farm, the wife apparently takes over more field work than normal. If the man is not able to work for some reason, a day laborer (mozo), generally is hired. During periods of peak field work loads, the women and younger children may be observed performing farming tasks for extended hours. During the period of the survey, which was conducted at the end of the dry season very few women were doing field work.

The majority of project farmers work their plots individually in the sense that no M.R. project members surveyed had an arrangement to trade field labor. Only irrigation system operation and maintenance is handled on a labor exchange basis. One hundred percent of community leaders surveyed stated that most members of their groups did hire casual laborers for field chores. This common practice often involves a relative or friend or someone from within the project group. But monetary compensation was always involved. Wages for a day's labor varied from Q1.5 to Q3.0 ($.75 to $1.50), depending on whether or not a meal was included.

MARKETING NON-TRADITIONAL CROPS FROM SMALL-SCALE IRRIGATION PROJECTS

Marketed Shares

The monetary goal of AID's sub-project loans for small-scale irrigation development is to create additional family employment and income during the dry season, especially by raising and selling non-traditional crops. Vegetables and other specialty crop production has certainly increased and must be the source of ready cash. Just how much is not easy to ascertain, of course. As might be expected, the USU Survey Team had indifferent success with any questions that could be linked easily to income estimates.

Community leaders surveyed stated that due to the variance in individual family circumstances and methods of farm management, it was impossible to give very precise opinions of the marketed share of vegetables produced. The best estimate the Survey Team was able to make is 80 to 90 percent. This applies to the projects whose main dry season income is from sales of common vegetables. In Santa Rita, it has been estimated that 12 percent of the value of vegetable production (including potatoes) is not sold (Samayoa V., tbl. 6). This community has more irrigated land per family than any other surveyed, but one, and devotes a large proportion of irrigated land to non-traditional crops. M.R. groups that are not yet so commercially oriented, probably consume a greater share of vegetables they grow.

Ingeniero Agronomo students at USCG/Centro Universidad de Occidente, in a 1983 survey of 10 MR projects found that the average share consumed for 7 common vegetables included 42 percent for potatoes and 20 percent for coliflower, but the others were all 10 percent or below (Seminario, Sec. 4.3.1). Of the traditional crops grown, only wheat was mainly sold, the bulk of maize and beans produced were consumed by the farm families (Table 4).

Since project families are producing at least some vegetables year-round and often on more land, it is reasonable to assume that family diets contain more vegetables than before. These fresh products are easier to get since, in some cases, women and children no longer have to expend so much effort hand watering small plantings, and because they are simpler to grow and more readily available during the dry season.

This impression is confirmed by conversations with women villagers. Still, it is only an impression. Relative to villagers without access to irrigation water, Samayoa (p. 44) says that more vegetables are being eaten in the one project she studied in detail in 1980. Embry has stated that, "the main benefits of the Small Farmer Program irrigation projects, is in better family diets," (1986). However, Smith (p. 22) states that "few farmers reported changing the pattern of their diets."

Six of the project groups surveyed produced very few common vegetables for marketing during the dry season. Instead, they focus on high value specialty crops such as strawberries, snow peas, coffee, garlic, etc. Most of such production is sold. These communities also produce small amounts of various other vegetables for household consumption. A rough estimate of the value of auto-consumption of vegetables based on calculations from survey data for this group show the amount to be about 8 percent of total value of <u>all</u> dry season crops produced.

Marketing Channels

In Guatemala individual farmers make use of three "markets" in addition to selling at the farm gate. The nearest place to sell is in the farmer's own village (aldea) or community. The municipal market refers to a nearby town where at least some government functions are exercised. A reference to a regional market is by name of the city, such as Quezaltenango or Guatemala City. Specific vegetable marketing functions include the role played by Guatemala City as a gathering place for the whole country and distribution center to international fresh markets, especially El Salvador and Mexico (Tapachu and Chiapas regions). Another vegetable market channel is geared to processing fruit and vegetables for export outside Central America.[3]

Some M.R. farmers are members of small marketing co-ops. The main ones the USU Team became acquainted with involved potato growers in the San Marcos zone and strawberry growers in Rincon Grande. The San Marcos zone is about five hours by road from Guatemala City and the Rincon Grande project is about two hours. The potato co-ops appear to be successful; at least the water users do not complain about them. Some individual M.R. farmers have done very well with potatoes. In one instance a farmer claimed his income had increased many times since irrigation had enabled him to concentrate on that particular crop. How much of the benefit could be ascribed to the co-op's influence is unknown. The co-op in Rincon Grande has been quite active and the Survey Team were told that it has been an important factor in the group's success with strawberries thus far.

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[3]Vegetable marketing has been subjected to considerable scrutiny in Guatemala. The baseline report, often referenced, was sponsored by USAID/Guatemala in 1978. Only a few reports dealing directly with M.R. projects could be located: Rivera D, 1981; Ibarra M, 1980.

More usually, the M.R. farmer is on his own when marketing produce. Depending on availability of roads, farmers and often their wives, carry produce on their backs, or utilize animals, to reach a nearby village. They utilize buses to reach municipal markets in larger towns. Normally, they would not make use of regional markets.

In San Andres Chapil and other sub-zones of San Marcos, trucks also arrive at the farm gates and drivers buy directly from the farmers after the produce has been harvested. Another method used in this same zone is for a trucker to buy produce while it is still in the ground, by the <u>cuerda</u>, and harvest, classify and pack it himself. Although this sounds quite good, many M.R. farmers do not know what an entire <u>cuerda</u> is worth, because their usual practice is to harvest and sell a little at a time. Also, they do not cultivate a whole <u>cuerda</u> so everything will mature simultaneously. (In this zone the Almolonga truckers were mentioned as being the most prone to take advantage of small farmers.)

Vegetable Marketing Strategies are Limited

Since harvest/marketing strategies for common vegetables are seldom undertaken as a group, it is not realistic to expect that, even during the dry season, M.R. project members could improve prices by some kind of supply control. Water project operation Committees have no power to dictate crops planted or quantities grown by individuals. As with farmers everywhere, the water users pretty much have to accept the prices ruling on the day they market fresh produce. In the projects lying at a distance from Guatemala City, the farmers feel that crop diversification is the only real way to protect against the probability of volatile prices. Varying planting dates and marketing dates are other options a farmer may employ.

It is possible for a few individuals in a community to club together to own a small truck that could collect produce, and possibly move it to markets where prices are better. But M.R. groups rarely could afford a large, heavy vehicle and the backup in spare parts they need to really stay on the road. Limitations also exist on other well-known options. Requirements for forward contracting (pre-harvest sales) with a middleman are hard to negotiate because individual farmers do not raise enough to make up full loads at a given moment. If one or two farmers band together, there are disagreements about quality control. Considerable time and effort is required to create a cooperative or other organization to get around these problems (Rivera D, p. 61; et passim). (Currently, USAID/Guatemala is sponsoring formation and development of a pilot cooperative program that amalgamates the members of more than one community group.)

Some M.R. projects in the San Marcos area are the oldest in the small-scale irrigation program, and the water users have learned by experience to handle their own harvest and marketing operations and pay attention to quality and yields. They now sell less frequently at the farm gate. Another problem experienced earlier by these groups, but which is now supposed to be under control, was market flooding. This tendency was corrected by farmers themselves. The interview team was told that the farmers have learned to look around and see if too much of one crop is being planted during a given period. If this appears to be the case, some of them will hold off for two to three weeks to plant that crop, or substitute another in its place. This flexibility is possible because of the well-developed vegetable marketing mechanisms that exist in Guatemala; the small-scale scale irrigation project farmers are not concerned about a general market failure.

This does not mean that they are not concerned about prices, however. A number of the documents reviewed by the USU Team contained complaints about the need for orderly marketing, grades and standards, and price stability (ICTA; Ibarra; Rivera; Seminario; Solorzano).

<u>Attempt to Measure Impact of M.R. Production on the Market</u>

An objective of the small farmer irrigation project survey was to ascertain if the M.R. program appeared to be having an impact on market prices. A more general but important objective was to ascertain if the established channels for vegetable trading can absorb the M.R. output. Fragmentary evidence on these points is not always consistent. Information was gathered from several large and small wholesalers in the Guatemala City and Quezaltenango markets as well as in the San Marcos area. Various independent truckers and managers of fruit and vegetable processing plants were also interviewed.

According to Aguilar (1982), there are 29 State irrigation systems in operation covering 15,197 hectares, and 288 private irrigation systems covering 110,465 hectares. In addition, there are 113 existing and approved M.R. projects covering at most 1,380 hectares. The M.R. program at present and underway accounts for about 1 percent of the total 127,045 hectares being irrigated in all Guatemala.

Thus, it is reasonable to conclude that the overwhelming share of small farmer irrigation is not composed of the M.R. systems. The public project lands are divided and allocated among small holders. There are also some private developments that are composed of small plots. But, of course, the bulk of the irrigation is not controlled by small farmers at all. As a consequence, it would be unlikely that the M.R. additions to non-traditional crop supplies would have much impact on national totals or crop prices in general.

The pricing data supplied by the small farmer groups surveyed were very imprecise. As might be expected, their recollection of price movements for the previous five years varied considerably from product to product. Even estimates by farmers concerning price trends of individual commodities varied so much that it is impossible to decide whether there has been any decrease in real prices at the M.R. farm gate as vegetable production has picked up over the past few years. Smith (p. 35) reported in 1983 that the M.R. groups in both Regions I and V got lower prices the second dry season of irrigated vegetable production relative to the first, and that the farmers knew their additional supplies were responsible for the reductions. Implicit in this is the notion that things have never been as good as in that initial year. The USU Team did not encounter any of these claims in 1986.

Another way to infer whether M.R. program output is having some price impact would be to detect declines in real price trends over the past few years in local markets such as in the San Marcos zone or the regional market in Quezaltenango. But, according to knowledgeable technicians in the Instituto Nacionale Comercializacion Agricola (INDECA), production statistics for crops important for evaluating the M.R. program have not been collected on a regional basis except for the past couple of years. When aggregated to a national level, the regional results do not link up with any of the earlier estimates available from that agency. There seems to be no easy way to establish reasonable time series data for price fluctuations in those specific markets where the M.R. program must have had the largest impact. The only thing that can be taken pretty much for granted, however, is that the profit margins of vegetable producers are being squeezed because it is certain that production costs are rising.

The San Marcos zone includes the vegetable producing community of Almolonga (about 200 ha concentrated in year-round vegetable production). Community members own a number of large trucks which are kept busy hauling their own vegetables and those purchased from other sources in the area (including some from M.R. groups). The USU Survey Team talked to members of this community several times about impact in the Quezaltenango region of the increase in M.R. production in recent years. They admitted that some of their local sales have been affected by competition from M.R. produce in the dry season (as much as 50 percent). But they profess to not be worried: whenever any of their regular markets are found to be saturated, according to one Almolonga trucker, they merely go elsewhere and are able to get good prices. (Any additonal costs due to this adjustment are unknown.)

The USU Team encountered considerable difficulty collecting M.R. vegetable marketing data anywhere in the marketing chain. It was not possible to obtain definitive information from from wholesalers and truckers. Of the wholesalers contacted, only two had heard of the M.R. program. Truckers collect loads of vegetables in various locations at irregular times and may or may not deal with M.R. producers on a regular basis. The truckers who do deal with M.R. groups cannot be located directly through farmer knowledge of their whereabouts. The few truckers interviewed who bought produce from M.R. projects claimed to have no feel for whether the existence of the dry season output had stimulated more truck traffic or created any impact in marketing channels. What follows is incomplete and possibly inconsistent.

The central terminal in Guatemala City presented little evidence of formal organization or administration. Truckers are permitted to unload their produce at any time and at any location they desire. There are a few possibilities for truckers to go directly to permanent stalls provided by certain companies. Wholesalers and retailers come into the terminal to purchase produce for their own outlets, but it appeared as though there were few long-term relationships that had been established between persons selling at the terminal and those retail firms purchasing. Nobody had any knowledge about where produce was coming from or how much produce could be expected to arrive at the market each day. In the absence of formal terminal administration, only outside agencies such as INDECA gather data with regard to wholesale prices or make any estimates of traded quantities involved.

The only other regional market which would be potentially influenced by non-traditional crop production from M.R. projects is in Quezaltenango. Quezaltenango is the major city in DIGESA Region I. The organization of the market terminal in Quezaltenango apparently is as informal as that seen in Guatemala City. There were no recognizable linkages between those selling at the terminal and buyers from smaller stores. While almost nobody knew of the M.R. program emphasis on vegetables in the Guatemala City market, some wholesalers and truckers of Quezaltenango were familiar with the small-scale irrigation systems. Nevertheless, no one could be located who was willing to surmise what long-run impact dry season M.R. production had had on prices. The most that could be obtained was an observation encountered among some specialty wholesalers (strawberries) in Guatemala City to the effect that the more supplies at the farm level, the better.

Wholesalers and truckers mentioned to the USU Team that export prices are a substantial influence on domestic prices. And, in fact, a great deal of non-traditional crop production is being exported, especially through Guatemala City. Statements made to the Team indicate that wholesale prices are increasing quite rapidly and that a strong export market is responsible for this. (There was little or no evidence provided to support these claims during the farm gate visits of the USU Team.)

Higher wholesale price trends would be consistent with the real exchange rate differentials with Mexico and El Salvador. In the face of these differentials moving by as much as 200 percentage points in 1985, vegetable supplies ought to tighten inside Guatemala. Yet in official statistics there are no recorded real price increases for non-traditional crops. In general, the real prices for crops of the type produced in the M.R. projects seem to have been constant, or even declining, during recent years.

One may suppose that either national production increases have been substantial over the past few years, that published price statistics are not an accurate reflection of real prices, or that truckers/exporters are obtaining enormous profits by shipping to other Central American countries. Some additional data would be necessary in order to sort this puzzle out. The operating methods of the Almolonga group, augmenting their own vegetable output with purchases from various sources, might give some credence to the theory of large profits to the middleman/Central American exporter.

In summary, there is some evidence that the concentration of M.R. projects in the San Marcos area might be putting some pressure on local non-traditional prices. A more important conclusion is that the overall, national, market for non-traditional crops is not very sensitive to the small increases in supplies originating in M.R. sales.

It is difficult to escape the conclusion that vegetable markets in Guatemala are so well supplied that prices are very sensitive to quantity movement. It is obvious that not every farmer can solve his income problem by raising vegetables for sale. A lot of success in this type production cannot be replicated--indeed, it is the very narrowness of markets for high value crops that means that "successful irrigation projects cannot be replicated" in the same country (in the absence of export markets for growth in output) (LeBaron, 1983, p. 6).

BENEFIT EVALUATION

The main benefits of the M.R. program accrue directly to the small groups of subsistence farmers who are able to crop at least part of their land for twelve rather than six months per year. To the degree that the net returns to the projects more than cover their social costs, society in general obtains a value added increment to gross domestic product.

In fact, as we have seen, the M.R. projects are not fully auto-financed because the social costs of technical assistance and subsidized project construction loans are not borne by the farmers. Thus, the calculations of primary benefits, as tabulated below, are shown with and without an adjustment for TA subsidy and donated labor costs, as shown in DIGESA records. By and large, the rates of return appear ample to cover both the TA costs and a "market" rate of interest. In addition to internal rate of return values, several other indicators of M.R. program performance are available which, taken in total, suggest good economic success.

Workability of the Technology

Pressurized sprinkler systems allow farmers to irrigate irregular surfaces that would be out of the question employing traditional furrow methods. On-farm water management is learned quite rapidly, and small children can be taught to move the hoses in the proper pattern and keep the nozzles unclogged. Uniformity of water application goes up, and this improves yields. (This aspect of application efficiency is the big benefit of the technology.) Another important advantage is that even quite small water sources can be turned into effective irrigation supplies: Mainlines can be swung across small gorges, for example. This technology is pretty much scale neutral--a certain minimum threshold investment such as for a center pivot is not a major requirement. The particular version of sprinkler technology being introduced in the Western Highlands of Guatemala is adapted to micro-scale applications; all the aluminum piping normally encountered in sprinkler installations is missing.

The older systems visited by the WMS II Team have been in service six to seven years, and ample time has elapsed to reveal weaknesses in design and operation. The systems appear easy to operate and maintain. None of the user groups interviewed complained of inability to keep them clean and functioning. The main equipment items that have to be replaced are rubber garden hoses and brass fittings that are individual farmers' responsibility. The most difficult maintenance problems uncovered by the survey were in the projects that rely on pumps. They are inherently more expensive in the first place, and more demanding of careful day-to-day operation. Sometimes, of course, lifting is the only way to get at a water source, but the machinery adds complications.

Reduction in Migration and Off-Farm Employment

During the course of various interviews, respondents commented that they were happy they no longer had to migrate to the South Coast seeking employment during the dry season. This is regarded as one benefit of being able to work part of their own lands on a year-round basis. Some of the complaints about former annual migration are that overseers (Majordomos) on the large plantations treated the migrant workers almost like cattle, and supplied scant amounts of food and shelter. Other complaints were of long hours and threat of disease. Some persons interviewed claimed that their net rates of pay on the South Coast sometimes did not equal what a day laborer earned in the Highlands. However, during the dry season they had been forced to find something to do in order to support their families, and migration was the best choice.

All seasonal migration has not ceased among members of M.R. groups. However, in almost every M.R. community surveyed, a much smaller percentage is involved. In a similar fashion, all local off-farm employment has not ceased, but it has fallen a lot. In 85 percent of the communities visited, a majority of the members used to migrate or work outside their farms in the local area. Now a majority of members continue to work off-farm in only 23 percent of the sample communities. A majority no longer migrates in any of the communities visited.

What has happened is that M.R. farmers may work far less for other persons than formerly, but themselves hire more day laborers. The interrelationship of M.R. irrigation activities and increase in local agricultural employment has been estimated for the San Marcos area. In 1978, prior to having irrigation water, the Santa Rita water users group contributed or paid for 427 man days of agricultural labor on the lands they controlled. Two years later, during the second season operating their pressure system, the same families contributed or paid for 972 days of labor on the same plots (Samayoa V., tbl. 7). Although this suggests a good impact upon job creation, the significant point is that the average project family continued to obtain most annual income from off-farm activities (about 80 percent). In the same study Samayoa V. includes a comparison with some village families that did not participate in the project. She found that the per capita incomes were about 10 percent higher for families with access to irrigation water, and that the difference was totally accounted for by benefits from use of the pressure facilities (tbl. 13).

The 1983 survey of 10 M.R. projects by the student members of the Agronomy Seminar from the Centro Universario de Occidente, Universidad de San Carlos, showed that sample families spent 43 percent of their working effort (mainly during evenings and on weekends) caring for their own plots. Fifty-seven percent of their working hours were devoted to off-farm activities, driving trucks, building roads, etc. The average family size was 7 and the equivalent of 2 persons regularly helped with field chores (Seminario, tbl. 5).

Some Other Impacts on Family Well-Being

Members of M.R. families feel less economic pressure to migrate during the dry season, can be together as a family (although some families used to migrate as a group), eat better and have more money to elevate their standard of living. A potable water supply is a by-product of many installations (Embry, 1983 a&b). Obviously, not every favorable economic or social change that has occurred within M.R. water user groups can be attributed to the pressurized system program. However, some of them can be, and they were mentioned by survey respondents. The USU Team observed many signs of improved lifestyles. In almost every community, modern durable goods were seen in the homes. Radios, stoves, typewriters, books, furniture and many other amenities were being used. The Survey Team was told that increased income from M.R. was responsible. Several women mentioned that, at last, they had been able to obtain sewing machines.

In at least two projects visited by the USU Team, small pickups are now owned by several individuals (there are four in Rincon Grande alone). In some projects, up to 75 percent of the members had built new houses since installation of their pressure systems. In Santa Rita, six out of seventeen families have new homes. The group has installed their own potable water system, and several TV sets were observed. One farmer in La Grandesa has terraced the ground he irrigates and has moved into high value crops, namely carnations and strawberries. He nets Q2,000 per year from under one-third hectare, an amount he says is twenty times what he earned previous to having irrigation supplies. Potatoes have also been a good diversification crop for some M.R. project farmers.

Even though in most cases women were not seen in the fields, their lives have changed to some degree. More often than not, they have taken on any added tasks of selling the M.R. production in the community or local markets. Discussions with farm wives suggest that while they no doubt have a higher allowance for household purchases, it does not appear that they have much more control of the household money than before (at least they would not admit it).

Small children help in the fields. Since the dry season occurs during the normal school year, the USU Team asked whether irrigation activities had any impact upon attendance. The adults claim there has that children would not attend school was a lack of schools. If there is no school, or if it is too full, they do not attend elsewhere.

Apparent Impact on Land Values

Obviously, irrigated land is worth more than adjacent dry land. So farmers who have become part of a M.R. project have experienced an increase in their wealth positions. The problem with determining the amount of increase lies in two elements. First, many project groups have not sold any land at all and have no idea how much it is worth with water on it. Second, a big reason why land has not changed hands too often is that land is always sold for cash--100 percent down. The idea of time payments for land in this area of Guatemala is relatively nonexistent. This in itself lowers the price of land because if the occasional M.R. farmer needs some cash and wants to sell, it can be difficult for the buyer to come up with 100 percent of the price that the seller might originally have in mind.

During the survey the farmers were asked for the difference in price of dry land and land with water. Their estimates fell somewhere between $4,000 and $7,000/ha for land with a pressure system, and $1,200 to $2,000/ha for land without. Since a pressure system, of the design generally being implemented, can be put onto the land for about $1,000/ha on average, there is still quite a sizable gap between estimated dry and irrigated values. Although these data are not definitive, they do lend some support for thinking that the farmers probably have obtained windfalls through project participation.

Estimating the Value of Incremental Production

Data, Assumptions and Method

Our assumption was that experience from the oldest pressurized water installations formed the relevant data base. Most survey efforts therefore were concentrated on visiting as many projects that fitted this definition as possible. Unfortunately, it was necessary to visit several projects newer than 1981-82. The individual sampling unit was the entire user group, not individual members. The irrigated lands of each community were assumed to be a single farm.

The questions asked by the USU Team covered patterns of land use, quantity of crops produced, prices and sales in average years prior to installation of the pressure systems and afterwards. Responses to such questions formed the basis for estimating gross revenues from the group's irrigated area during an average dry season. Prices used are those most recently received (mainly in the Fall of 1985). A large volume of up-to-date crop budgets prepared on a regional basis and for different technology levels are available (MAGA 1984). Various studies by DIGESA technicians or as made by ICTA were also reviewed and incorporated. These data formed the basis for estimating costs as a percentage of returns. All cost estimates are indexed for inflation to 1985-86 levels where necessary.

In a large share of the projects, prior to constructing the pressure systems, no farming activities were carried out during the dry season. Our assumption is that this lack of agricultural activity would have continued indefinitely had there not been a switch to controlled irrigation. Therefore, a before and after benefits calculation is adequate.[4] The "after" data represent what community leaders feel is possible in the dry portions of an average year with the systems now in place. Only in the cases of four of the projects visited was an adjustment made for any foregone "before" production (see Annex Table B.1). All calculations are in real terms as of 1985-86.

Computed differences in before and after real net returns to irrigated land (incremental project benefit) is assumed to be the expected average annual level benefit value for 20- and 30-year project lives. Actual calculations of project benefits only utilize the data pertinent to the dry season; any additional benefits obtained from availability of irrigation during other parts of the year are ignored. This introduces a conservative bias. No allowance is made for improved yields or prices in the future, or for any wind-up salvage values, etc.

This (implied) level series of realized incremental benefits was then adjusted by a constant average annual allowance for project O&M expense. Generally, this allowance amounted to Q50 or less per family except where pumps are involved. The results are the "average" real incremental benefits of any year of a project's life. Cash installation costs and total costs, including allowance for the value of donated labor and technical assistance, were taken from DIGESA records. These costs were then indexed for inflation during the period since the individual projects came on line (see Annex C). The installations are completed within a matter of months, so the calculations ignore the construction period prior to start-up. Any years of low harvests while the projects have been maturing are also ignored. These assumptions all introduce liberal biases.

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[4]Technical note: Only out-of-pocket production costs were taken into account. This has no effect upon calculation of the level of incremental benefits as long as after project fixed costs, excluding irrigation features, are about the same as "before project." If fixed costs rise somewhat following the investment, then the IRR results are biased upward. IRR values must cover some unknown allowance for required greater returns to family labor and management to offset the increased intensity of irrigated farming.

Calculation of "Realized" Internal Rate of Return for Surveyed Projects

Arrangement of data:

With project irrigation crop values - production costs = after net benefit.

Without project irrigation crop values - production costs = before net benefit.

Average annual net incremental project benefit (R) = (A) - (B + estimated real seasonal O&M expense).

The life cycle level stream of average incremental benefits (R) can be related to the initial costs of the project (C) to obtain an estimate of the potential internal rate of return (IRR).

Based on all the simplifications mentioned above, IRR = the rate of interest (i) that is associated with a known present value of annuity factor (F) and project life (n).[5]

n = estimated project life or time horizon selected;

F = present value of an annuity $\frac{[1-(1+i)^{-n}]}{i}$ = C/R;

C = Amount of initial system investment (1985 Quetzales);

R = Average annual return (net incremental project benefit).

Values for C, R, and results of the calculations outlined above are shown in the Abstract Table and in Table 3. The basic before and after project net farm income data are in Annex Table B.1.

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[5]Given the simple assumptions and data arrangement described, the quickest way to obtain the IRR estimates shown in Table 3 is to force out values for F, (C/R) then enter a present value of annuity table that includes high levels of interest rates (i.e. over 50 percent), at the expected live(s) of the projects and move left to right across the columns of factors until each calculated "F" is located close enough. The interest rate shown at the top of the associated column is the IRR.

Discussion of Results

Calculations for both 20- and 30-year time horizons are shown in Table 3 because expected physical lives are unknown, whereas the financing period is for 20 years. Agricultural engineers familiar with such systems feel that the operational lives are indefinite, as long as the required maintenance is carried out (Embry, 1986). Some of the IRR estimates in Table 3 look too good to be true. However, for our purposes, these results mean that biases in our basic data are not critical. In any case, strict accuracy in IRR calculations is not very important. All that is necessary is to be able to decide whether the small farmer program is basically sound as measured by reasonable economic criteria.

There seems to be little reason not to take an affirmative stand on this question. Even those systems that are quite expensive to build and operate (Rincon Grande, for example) can be made to look quite viable if the crops produced are valuable. As mentioned earlier, emphasis is given to strawberries in this pump project. The USU Team sample included many of the pressurized systems that have had a chance to become well established, plus some younger projects, and the IRR results are positive in every instance (see Annex Tables A.1 and A.2). There is a lot of variance, of course, but that is no doubt due mainly to their wide construction cost differentials.

Two of the reference documents available to the USU Team contain some estimates of the benefits from the MR program. Smith illustrates a "worst case" example involving production of snow peas, and estimates a 20 percent improvement in average farmer incomes due to better yields under irrigation, etc., (Smith, p. 30). Samayoa V. estimated the expected flow of expenses and incomes for the Santa Rita projects for a 9 year period through 1986, and projected an internal rate of return = 10.1 percent (Samayoa V., tbl. 12). Both of these examples, to the degree they are compatible with the present study, put benefits at the lower end of the variability range shown in Table 3.

Some comparative per family financial costs and benefits have already been given in the Abstract Table. In Table 3, per hectare costs for 24 projects are combined with some additional calculated IRR values based on 20-year time horizons. Once the IRR gets above 15 percent, of course, the assumed length of life does not make much difference, unless it is quite short. (Inadequate production information was recorded on two of the 26 projects visited.) Now the data are arranged according to rough geographical proximity of one project to another, rather than according to size of average irrigated land holding. There appears to be no pattern in the IRR values in either table. Rearranging the results according to per hectare construction costs leads to the same result: no pattern emerges. For example, there are one or two cases where gravity systems cost more on a per hectare basis to install than some of the four pump systems visited. Farmers do not all raise the same crops so the assumed correlation between IRR and materials installed per ha will only explain part of the variance.

TABLE 3. CALCULATED IRR FOR SAMPLE OF MINI-RIEGO PROJECTS, GROUPED BY GEOGRAPHIC PROXIMITY

Name	IRR % 20 Year Life Cash Cost	IRR % 20 Year Life Total Cost	IRR % 30 Year Life Cash Cost	IRR % 30 Year Life Total Cost	Construction Costs $/ha Cash Cost	Construction Costs $/ha Total Cost	O&M per $/ha
Region V							
Cauque (P)	51	34	52	36	1250	1805	96
Santiago (P)	16.5	11	17.0	12	1500	2125	123
Xenacoj (P)	10	7.5	13	9	5384	6795	119
Saraya	17	10	17.6	11.3	857	1357	17
Pacul	62	35	62	35	417	775	20
Rincon Grande (P)	30	20.5	30	21	1925	2160	424
Lo De Silva	68	46	68	46	613	957	16
Los Mixcos	32	23	32.5	23.3	1167	1567	25
Region I							
Los Encuentros	69	45.5	69	45.5	1489	2393	46
La Estancia I	19	14	19	14	213	325	27
Quiajolo	24	17.2	24	17.8	1058	1439	14
Pueblo Viejo	12.0	8.5	14.5	10.2	946	1232	20
Los Alisos Tzaley	24.5	17.8	24.5	18.5	1200	1620	43
Region I, San Marcos							
Esquipulas	11.6	6	12.8	7.5	600	995	12
Rosario II	37.5	28	37.5	28	1037	1400	35
Los Frutales	17	14	18	15	1850	2226	29
Las Hortencias	58	40	58	40	2442	3662	61
La Estancia	52	36	52	36	1963	2945	76
Pasal II	24	16.8	24	17.5	1389	1875	50
San Isidro Chamac	25.5	18.5	26	19	1916	2587	280
Sta. Rita	100	64	100	64	333	450	44
San Ramon	100	85	100	85	700	945	63
S. A. Chapil I	45	33	45	33	520	702	19
S. A. Chapil III	90	37.5	90	37.5	392	149	27

Finally, it may be noted that the type of primary field data utilized in the economic analysis implies something about realized benefits since, in many cases, the projects have been on line for several years. The computed internal rates of return are based on an "average" year and, to the degree they are accurate, they reflect what is being achieved at present, even though the calculations are made over an assumed project life-span of 20 or 30 years.

Status of Loan Repayments

An indirect measure of the M.R. program success might be the willingness or ability of the borrowers to repay the construction loans made on their systems. Some of the older project groups liquidated their loans within a few years, but at present quite a few M.R. groups are behind in their payments.

At the time institutional arrangements were made with USAID/Guatemala and the Government of Guatemala for BANDESA to set up a revolving fund mechanism for the newly established M.R. program, one of the elements included was subsidy of construction loans at the concessionary rate of 2 percent. This rate is still used when arranging financing for the newest projects. And, although some M.R. groups have paid in full, ahead of schedule, there is little incentive to do so.

A more important subsidy, possibly unintended, has crept into the financing picture, however. The Guatemala economy has inflated during the past four years. Since the earliest M.R. projects came on line, the value of the Quetzal has dropped by a factor of three relative to the US dollar. None of BANDESA's loans are indexed. A senior staff member stated that he is not aware of any plans by Bank management to introduce an indexing or equivalent policy to maintain the value of the Bank's portfolio consistent with the nominal value of the original trust funds. Consequently, the M.R. (and other agricultural program) loans are being repaid in very cheap Quetzales, and the real debt burden on the M.R. groups has been sliced. Meanwhile, real net incomes from farming (on a per hectare basis) have more or less held their own, although costs of purchased inputs are sharply up.

At the request of the USU Team, a senior officer in BANDESA asked the Bank's agents in charge of regional branch offices (Caja-Rurales), to report the status of any M.R. group loans on their books. Data covering all AID loan finance projects were obtained from DIGESA Region I, according to percentage totals for each sub-zone and particular USAID loan. All the newest projects (loan 037) were still in the grace period. Under loan 034, 0.6 percent have prepaid, 3.5 percent are on time, 72.2 percent were in their grace periods, and 24.7 percent were behind. The situation for the oldest projects, those built under loan 026, reveal the relationships of most interest. Over one-third the loan values (34.5 percent) have been prepaid, whereas 50.6 percent of the loan values are in arrears and 14.9 percent are up-to-date.

The financial data received from Region V offices were incomplete and there was no way to work with total M.R. project loan values. However, a few individual projects were reported and it was possible to calculate some percentages as follows: Xenacoj, built in 1984, 9 percent of the users in arrears, and 27 percent were late with the current payment; Lo de Silva, 12 percent in arrears; Los Mixcos, 9.2 percent; Rincon Grande, 2 percent; Saraya, 3 percent. Based on this skimpy evidence, it appears that a smaller percentage of farmers are in arrears relative to Region I.

The Bank's representatives report that 40 percent currently are in arrears in their payments. According to DIGESA engineers, the overall percentage is about 5. It seems that the engineers may be thinking in terms of total failure, whereas the Bank personnel see few if any of the loans as seriously delinquent. Being in arrears is not a bad strategy if there are no penalties, and more and more devalued currency can be used eventually to catch the payments up.

Several systems in Region I have been paid off by the water users, but no instances were recorded in the incomplete documentation forwarded from BANDESA operation in Region V. Pasac II is a single family system that never required a loan. The materials were paid for directly by the owner. In Region I, at least two small-scale systems were not financed through BANDESA: grants or loans from other sources are involved. Fourteen or more of the 33 projects constructed in Region V were not financed through USAID lines of credit.

Thus, a clear-cut judgment on the worth of the projects as measured by loan repayment performance, is not possible. Some BANDESA officers discussed the bank's policies with respect to conventions of loan administration, grace periods, and interest rates in terms that suggested strong paternalistic bias, but in the case of the Small Farmer Program, the USU Team uncovered no evidence that the Bank cannot get its money if it wants it.

LESSONS FROM THE GUATEMALA MODEL

Financial Feasibility

USAID/Guatemala technicians continue to support the program. A third loan is now involved. DIGESA Engineers have various projects on the drawing board or submitted for approval. This suggests that there is considerable truth in the often repeated claims that the farmers want the systems and will pay for them. Generally, as we have shown, the farmers do pay for the installations; at least, they pay a greater proportion of the initial social costs than is usual. They also pay for all subsequent operation and maintenance. There is subsidy in concessionary financing arrangements. There is a relaxed policy of dealing with the groups that fall behind in payments. However, there is no evidence that the groups will not pay. This leads to the main subsidy that occurs in cost recovery projects everywhere: the actual payback in low valued Quetzales. In the Guatemala situation there be some added social cost somewhere in the financial structure (not accounted for by direct rural sector subsidy) if the agricultural bank (BANDESA) constantly decapitalizes. It is possible that water user groups may be able to pay higher interest rates (this would not be much of an overall cash flow burden if the loans are written for short periods or the users close the books ahead of schedule).

Generally speaking, the per hectare installation costs are not excessive. In fact, by modern water project experience, the costs per hectare are quite low. At the same time, the technology is relatively advanced. Only one of the sampled projects (Xenacoj) is very expensive. Yet, as we have shown, even in this case, the IRR is estimated to be positive. Recurring costs for all the non-pump projects are very low. On average these are estimated to be about $10.00 per family/year in 1985/86 dollars.

Tranferability

In general the model is easily transferred, both in a technical and logistical sense. The project beneficiaries themselves can do most of the construction. Farmer trainees from one village can show neighboring villages how to work with program engineers and install the designs. In Guatemala this feature of the model has taken the form of hiring full-time a few of the farmers from the very earliest projects. These persons act as construction foreman, who are shifted from group to group, as successive system installations are approved. Qualified technical design assistance is required. This can be taught to other engineers, as has been shown in Ecuador starting in late 1986. In Guatemala the technical assistance component equates to about 11 percent of average project per hectare cost (Annex, Table 2). Probably this percentage could be reduced if the techno/bureaucratic support units always function effectively. Based on the USU survey results, the farmers also could repay the value of technical assistance, so even this cost might be built into the BANDESA loans, and be recovered by society.

The genius of the irrigation component of the Small Farmer Program is that the techniques utilized, though relatively advanced, are suitable for little, scattered plots that may not lay out level enough for surface irrigation, yet they often permit utilization of what otherwise might be unlikely supply sources. The self-help, auto-financed features appeal to the farmers because they really own and manage the installations. They can assess for themselves if a change in operations is likely to generate adequate rewards. Operation cost is not a major issue since gravity provides the necessary energy.

The actual on-farm agronomic and water management practices that will be most effective in another country such as the Andian zone of Ecuador, can be transferred only to a partial degree. The Guatemalan program itself is weak on that score, because not much technical information has been specifically generated. However, the Guatemalan construction foremen have watched a lot of these small systems develop and are practicing farmers themselves, so they have some practical knowledge to pass on about on-farm water management on hillsides. The amount of irrigated land per family will be considerably larger in Ecuador and, presumably, there will be enough additional chores to keep family members more fully occupied with their own plots than has been the case in the Guatemalan experience thus far. However, the financial benefits are problematic unless there is some emphasis upon moving the Ecuadorian water users into higher valued crops, other than simply potatoes. Here again, market outlets hold the final key to economic success.

The social acceptance of the technology, and its attendant pressure to adapt to its demands may or may not easily transfer. Farmers experienced with rainfed (dryland) farming techniques, when introduced to irrigation, often are unprepared for the discovery that they are actually members of a collective. A benefit of demand or semi-demand systems such as have been described above, is that they preserve a maximum of individual family freedom in day-to-day group interaction for system operation but, inevitably there is some loss of freedom involved.

In dollar terms, the real construction costs in other regions should be about the same as in Guatemala, but actual results are not yet available (LeBaron, et al., sec. IV.B). The pilot trials of the Guatemala model in Ecuador have not relied on the important auto-financing feature, although it might be possible to include this feature if a continuing hillside sprinkler program is fully developed for the Sierra zone. It is the auto-financing aspect that takes the pressure off the public treasury, and reserves a lot of private initiative to the water user groups. Samayoa V. argues that one of the benefits she detected in her comparative study was "an increase in group solidarity" (p. 31).

Some Caveats

One reason why the Guatemalan program has enjoyed considerable success is that the systems, and therefore the marketable output, are small. This has allowed the participating community members to penetrate an already well developed vegetable marketing system that has potential export outlets built in. In turn, this has made the socially attractive auto-financing features viable. This combination of factors might be hard to duplicate in another country. Thus, we have to ask ourselves the fundamental question: can these systems pay for themselves with the most common ordinary crops if markets for high valued crops are not available?

The actual, not imagined, relation between costs and value of yields tell the tale. Currently, in Guatemala, the answer is a tentative yes. As we have seen, some groups are doing very well from their diversification activities and they probably could pay for their systems from earnings of a traditional crop such as beans, even though their overall incomes might fall. Readers should bear in mind that it might not be easy to get dry season irrigated yields of any crop much above what is achieved during the wet season. So, while it is true that year-round production is made possible by the irrigation supplies, in this particular situation dry season production benefits must bear the additional burden of paying for a system, with little or no corresponding jump in yields. This brings out the importantce of higher off-season prices as the means to hold net benefits up.

In a more general situation, the technology pushes up yields and this reduces unit costs. Also, the systems are not as expensive as might be imagined, given the technology. They are cheaper to build where hillsides and fragile lands are involved than open ditch systems. In the Ecuador technology transfer experiment, the volcanic soils are so light that only these buried systems and controlled deliveries make sense. Nevertheless, this does not guarantee that the ordinary, traditional crops being grown on the Ecuadorian pilot projects will be valuable enough to cover social costs -- this aspect needs to be evaluated. In Annex C we show some estimates for the Guatemala situation, based on production of maize.

Little has been done in Guatemala to develop on-farm sprinkler management techniques in a formal way. General knowledge about how to raise vegetables was, of course, widespread in the areas where the micro-sized projects have been built. This knowledge has been adapted to the sprinkler regime through experience. The technical assistance furnished by foreign experts in the early days of the program and since involved some rules of thumb based on sprinkler irrigation experience from the U.S.A. Later, other suggestions have been made by Extension Service personnel. However, these engineers told the USU Survey Team that they wished they had the budget to do some specialized research directed to the special requirements of the hillside situations.

Groups planning to put in such systems do have to be warned about sources of potential conflict and the need to control that potential. There does not seem to be very much difficulty involved in getting the individual members of a group to work together to install the systems, even in cases where a tremendous amount of group labor has been involved. The need for continuing cooperation and putting group interests ahead of personal interests once the system is in place is a harder lesson. Fortunately, compared with other irrigation programs, even right in Guatemala, the problems seem minor (IDB, Conclusions).

The pressurized systems are run on a demand or semi-demand basis, and thus confer a measure of freedom for individual initiative to be exercised by each farmer. Yet, as with all group irrigation situations, some freedom must be given up in order to obtain the benefits of a controlled water supply.

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ANNEXES

A. Mini-Riego Projects Vistited by the USU Team

Although the aim of the field survey was to visit only the oldest systems, this was not always possible to do since the Team's movements had to be coordinated with work schedules of the engineers in various DIGESA offices and sub-offices who had to take the team to all the hard-to-find sites. Eleven out of 24 usable interviews were obtained from projects 1982 or newer. The two unusable interviews came from 1984 projects where the Team had difficulty with dialects. The visits and sites are listed in Annex Tables A.1 and A.2.

ANNEX TABLE A.1. SHARE OF OLDER M.R. PROJECTS VISITED

	1978	1979	1980	1981	1982	1983	1984	1985
Region V								
# Built	2	4	3	2	8	1	1	?
# Visited	-	2	2	1	2	1	1	
Region I								
# Built	2	6	12	5	6	7	20	23
# Visited	2	2	5	1	2	1	3	1

B. Dry Season Crop Sales and Production Costs, Recurring Costs, and Project Investment Costs

All the values shown in Annex Table B.1 are in terms of 1985-86 Quetzals. The irrigated total crop sales reported to the Survey team are for 1985 dry season. Production costs for each crop are a percentage of sales values as obtained by study of recent crop budgets from estimates by various sources. Costs shown are the sum of the proportionate share of the amount of each crop reported sold. Operation and maintenance costs are estimated for an average year as reported by the user groups, allowing for on-farm as well as group expenses. (The reported O&M values tend to be low for the groups on newer projects.) The real materials investment costs are the amounts as recorded in DIGESA records and the real total costs add in DIGESA estimates of the values for contributed manual labor and the value of technical assistance related to construction. This total is more or less the social value of each project if labor is shadow priced at going rates. This might be a little high, but the shadow price of farm labor in the Western Highlands is not zero.

ANNEX TABLE 2
LIST OF MINI-RIEGO PROJECTS VISITED (1986)

	Number of Visits	Usable Survey	Type	On-Line Year
REGION V				
Cauque	1	yes	pump	80
Santiago	1	yes	pump	81
Xenacoj	1	yes	pump	84
Saraya	1	yes	gravity	79
Pacul	1	yes	gravity	79
Lo de Silva	1	yes	gravity	82
Los Mixcos	1	yes	gravity	82
Los Enquentros	1	yes	gravity	83
Rincon Grande	2	yes	gravity	80
REGION I				
La Estancia I	1	yes	gravity	80
Quiajola	1	yes	gravity	82
Pueblo Viejo	1	yes	gravity	81
Los Alisos Tzaley	1	yes	gravity	80
Esquipulas	1	yes	gravity	79
Rosario II	1	yes	gravity	83
Los Frutales	1	yes	gravity	80
Las Hortencias	1	yes	gravity	85
La Estancia	1	yes	gravity	84
Pasac II	2	yes	gravity	82
San Isidro Chamac	1	yes	gravity	80
Santa Rita	2	yes	gravity	78
San Ramon	1	yes	gravity	78
Chapil I	2	yes	gravity	79
Chapil III	1	yes	gravity	80
San Pedrito	1	no	gravity	84
Nimasac I	1	no	gravity	84
Total:	26			

ANNEX TABLE B.1. BASIC DATA FOR CALCULATING INTERNAL RATE OF RETURN (Quetzals)

	With Project			Without Project									
	Σ Sales	Σ Costs	Net	Σ Sales	Σ Costs	Net	Incremental Benefits	O&M Costs	R Adjusted Increm.	(Q) Real Cash Costs	F = Cash Costs/ Adjust. Increm.	Real Total Costs (Q)	F = Real Total/ Adjust. Increm.
Cauque	80,000	33,600	46,400	2,400	1,030	1,320	43,080	5,750	39,330	75,000	1.91	108,000	2.75
Santiago	46,125	23,524	22,601	0	0	0	22,601	6,970	15,631	90,000	5.76	127,500	8.16
Xenacoj	46,738	20,368	26,370	0	0	0	26,370	4,193	22,177	189,000	8.52	226,500	10.21
Saraya	24,925	11,500	13,425	11,440	5,148	6,292	7,133	710.5	6,422.5	36,000	5.61	57,000	8.87
Pacul	35,955	23,371	12,584	3,950	1,975	1,975	10,609	708.5	9,901	15,000	1.51	27,900	2.82
Lo De Silva	26,400	82,464	43,936	0	0	0	43,936	1,452	42,484	37,000	1.38	91,848	2.16
Los Mixcos	77,050	31,570	45,430	17,870	7,618	10,246	35,164	2,256	33,926	105,000	3.19	141,000	4.28
Los Encuentros	43,645	19,640	24,005	0	0	0	24,005	972	23,033	31,266	1.36	50,216	2.18
La Estancia I	16,200	8,343	7,857	0	0	0	7,857	1,212	6,645	34,800	5.24	46,980	7.07
Guiajola	60,720	29,284	31,436	0	0	0	31,436	2,465	28,971	120,000	4.14	162,000	5.59
Pueblo Viejo	40,368	17,354	23,014	0	0	0	23,014	2,602	20,412	126,000	6.17	169,000	9.26
Esquipulas	30,100	10,535	19,565	0	0	0	19,565	2,573.5	16,991.5	129,606	7.63	194,100	11.42
Rosario II	54,180	23,872	28,308	0	0	0	28,308	2,335.5	25,972.5	68,424	2.63	92,370	3.56
Los Frutales	15,064	6,948	8,116	0	0	0	8,116	636	7,480	41,958	5.61	49,410	6.61
Las Hortencias	49,888	19,405	30,483	0	0	0	30,483	1,195	29,288	47,610	1.63	71,415	2.44
La Estancia	49,852	19,730	30,122	0	0	0	30,122	1,981	28,141	51,180	1.82	76,223	2.73
Pasac II	1,505	667	828	0	0	0	828	107	721	3,000	4.16	4,050	5.62
San Isidro Chamac	6,030	2,616	3,414	0	0	0	3,414	1,235	2,179	8,451	3.88	11,409	5.24
Santa Rita	30,090	11,982	18,108	0	0	0	18,108	918	17,190	24,000	1.40	32,400	1.89
San Ramon	17,053	6,255.5	10,797.5	0	0	0	10,797.5	945	8,852.5	10,500	1.07	14,175	1.44
Chapil I	21,212	9,816	11,396	0	0	0	11,396	846	10,550	23,400	2.22	31,590	2.99
Chapil III	21,460	9,613	11,847	0	0	0	11,847	684	11,163	14,712	1.32	29,424	2.64
Rincon Grande	112,500	5,962.5	52,875	0	0	0	52,875	25,460	27,415	91,500	3.34	129,600	4.73
Los Alisos Tzaley	88,055	47,311	40,744	0	0	0	40,744	5,200	25,544	144,000	4.05	194,400	5.47

C. Reasons for using 1986 as a Base Year for IRR Calculations

The commitments of initial human and capital resources were actually made in various years prior to 1986, depending upon the project in question. Since the data arrangement procedure described in the main text reduces the expected flow of incremental benefits (R) to a series of annual level values, i.e., an average year, it would be possible to discount calculated values of "R" from 1986 back to the date of each initial investment, assuming some given social discount rate. The easiest and best next step is to assume future price levels constant as of the base year, and treat the resultant calculations as being in real terms. The reverse of this is to re-flate the initial investment amounts to 1986 values, taking care to introduce any necessary adjustments to keep the results in real terms, and the calculated IRR values will be exactly the same as before. In the main text, an approximation of the latter method is used.

Roughly 60 plus percent of the initial investments involved materials that were either imported or could be denominated in U. S. dollars. At the time of construction the Quetzal exchanged 1:1 with dollars. By 1986, the Quetzal had been devalued to approximately 3:1. This seems to be the big factor to take into account, since the materials costs for the same project in 1986 would have cost at least 3 times as much in 1986 as in the late 1970's and early 1980's. All the materials costs (cash costs) in Table B.1 have been multiplied by 3. In effect this is a proxy for a GDP deflator and keeps the costs in real terms. No allowance is made for interest on the social value of the investment between the construction date and 1986. This means that the IRR values (listed as cash costs) are biased upward to the degree that the social value of the committed resources, viewed as of 1986, are undervalued.

On the other hand, that part of the overall investment represented by DIGESA technical assistance and the construction labor contribution made by the villagers is also multiplied by a factor of 3, even though there is no evidence that wage rates have moved anywhere near an amount to offset the amount of currency devaluation that has occurred. The great probability is that real wages have dropped. These latter costs are assumed to have been over-valued, thereby biasing the IRR values for total project costs downward. Thus, the biases in the proceuure tend to cancel, at l-ast in the case of the total cost calculations.

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Executive Summary
Appendix A: The Indian Subcontinent
Appendix B: East Asia
Appendix C: Near East and Africa
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WMS 2 Nepal/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 3 Bangladesh/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 4 Pakistan/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 5 Thailand/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 6 India/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 7 General Asian Overview

WMS 8 Command Area Development Authorities for Improved Water Management

WMS 9 Senegal/USAID: Project Review for Bakel Small Irrigated Perimeters Project No. 685-0208

WMS 10 Sri Lanka/USAID: Evaluation Review of the Water Management Project No. 383-0057

WMS 11 Sri Lanka/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 12 Ecuador/USAID: Irrigation Sector Review

WMS 13 Maintenance Plan for the Lam Nam Oon Irrigation System in Northeast Thailand

WMS 14 Peru/USAID: Irrigation Development Options and Investment Strategies for the 1980's

WMS 15 Diagnostic Analysis of Five Deep Tubewell Irrigation Systems in Joydebpur, Bangladesh

WMS 16 System H of the Mahaweli Development Project, Sri Lanka: 1980 Diagnostic Analysis

WMS 17 Diagnostic Analysis of Farm Irrigation Systems on the Gambhiri Irrigation Project, Rajasthan, India: Volumes I-V

WMS 18 Diagnostic Analysis of Farm Irrigation in the Mahi-Kadana Irrigation Project, Gujarat, India

WMS 19 The Rajangana Irrigation Scheme, Sri Lanka: 1982 Diagnostic Analysis

WMS 20 System H of the Mahaweli Development Project, Sri Lanka: 1983 Diagnostic Analysis

WMS 21 Haiti/USAID: Evaluation of the Irrigation Component of the Integrated Agricultural Development Project No. 521-0078

WMS 22 Synthesis of Lessons Learned for Rapid Appraisal of Irrigation Strategies

WMS 23 Tanzania/USAID: Rapid Mini Appraisal of Irrigation Development Options and Investment Strategies

WMS 24 Tanzania/USAID: Assessment of Rift Valley Pilot Rice Project and Recommendations for Follow-On Activities

WMS 25 Interdisciplinary Diagnostic Analysis of a Work Plan for the Dahod Tank Irrigation Project, Madhya Pradesh, India

WMS 26 Prospects for Small-Scale Irrigation Development in the Sahel

WMS 27 Improving Policies and Programs for the Development of Small-Scale Irrigation Systems

WMS 28 Selected Alternatives for Irrigated Agricultural Development in Azua Valley, Dominican Republic

WMS 29 Evaluation of Project No. 519-0184, USAID/El Salvador, Office of Small-Scale Irrigation - Small Farm Irrigation Systems Project

WMS 30 Review of Irrigation Facilities, Operation and Maintenance for Jordan Valley Authority

WMS 31 Training Consultancy Report: Irrigation Management and Training Program

WMS 32 Small-Scale Development: Indonesia/USAID

WMS 33 Irrigation Systems Management Project Design Report: Sri Lanka

WMS 34 Community Participation and Local Organization for Small-Scale Irrigation

WMS 35 Irrigation Sector Strategy Review: USAID/India; with Appendices, Volumes I and II (3 volumes)

WMS 36 Irrigation Sector Assessment: USAID/Haiti

WMS 37 African Irrigation Overview: Summary; Main Report; An Annotated Bibliography (3 volumes)

WMS 38 Diagnostic Analysis of Sirsia Irrigation System, Nepal

WMS 39 Small-Scale Irrigation: Design Issues and Government Assisted Systems

WMS 40 Watering the Shamba: Current Public and Private Sector Activities for Small-Scale Irrigation Development

WMS 41 Strategies for Irrigation Development: Chad/USAID

WMS 42 Strategies for Irrigation Development: Egypt/USAID

WMS 43 Rapid Appraisal of Nepal Irrigation Systems

WMS 44 Direction, Inducement, and Schemes: Investment Strategies for Small-Scale Irrigation Systems

WMS 45 Post 1987 Strategy for Irrigation: Pakistan/USAID

WMS 46 Irrigation Rehab: User's Manual

WMS 47 Relay Adapter Card: User's Manual

WMS 48 Small-Scale and Smallholder Irrigation in Zimbabwe: Analysis of Opportunities for Improvement

WMS 49 Design Guidance for Shebelli Water Management Project (USAID Project No. 649-0129) Somalia/USAID

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WMS 57 Diagnostic Analysis of Parakrama Samudra Scheme, Sri Lanka: 1985 Yala Discipline Report

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