# Small-Scale and Smallholder Irrigation in Zimbabwe: Analysis of Opportunities for Improvements

WATER MANAGEMENT SYNTHESIS PROJECT

WMS REPORT 48

# SMALL-SCALE AND SMALLHOLDER IRRIGATION IN ZIMBABWE: ANALYSIS OF OPPORTUNITIES FOR IMPROVEMENTS


by

Terence H. Podmore, Richard J. McConnen and Alois Hungwe



WMS Report 48

Prepared in cooperation with the United States Agency for International Development, Contract AID/DSAN-C-0058. All reported opinions, conclusions or recommendations are those of the author (contractor) and not those of the funding agency or the United States government. Mention of commercial products in this publication is solely to provide information. It does not constitute endorsement by AID over other products not mentioned.

WATER MANAGEMENT SYNTHESIS PROJECT

University Services Center
Colorado State University
Fort Collins, Colorado

in cooperation with the
Consortium for International Development

November 1986

TABLE OF CONTENTS


| Section | | Page |
|---|---|---|
| | ACKNOWLEDGMENTS | iv |
| I. | EXECUTIVE SUMMARY | 1 |
| II. | PRINCIPAL CONCLUSIONS | 4 |
| | A. High level of development | 4 |
| | B. Small-scale irrigation related to total water resources | 4 |
| | C. Irrigation development related to development objectives | 5 |
| III. | ACTIVITIES TO CONSIDER | 8 |
| | A. Monitoring and evaluation | 8 |
| | B. Farmer organization | 10 |
| | C. Allocation of water | 13 |
| | D. Coordination with the Department of Water Resources and Development | 19 |
| | E. Pumping | 22 |
| | F. National Farm Irrigation Fund | 24 |
| | G. University and technical training | 25 |
| | H. Support for schemes | 26 |
| IV. | SOURCES OF INFORMATION | 28 |
| | A. Published material | 28 |
| | B. Field trips | 30 |
| | C. WMSII experience | 33 |
| V. | REFERENCES | 42 |
| VI. | APPENDICES | 43 |
| | A. Some Aspects of Irrigation Agronomy for Communal Irrigation Schemes | 44 |
| | B. Itinerary - Zimbabwe | 47 |

# ACKNOWLEDGMENTS

When a Technical Assistance team arrives in a country, the best welcome they can have is the enthusiastic support and assistance of the in-country personnel. This was especially true in Zimbabwe. The cooperation, assistance and support of the USAID mission staff, in particular Mr. Eric Witt, Agricultural Development Officer, are greatly appreciated.

The Ministry of Lands, Agriculture, and Rural Resettlement has the primary responsibility for irrigation in Zimbabwe. The strong positive support for irrigation is very encouraging for the future development of the country. The advice and assistance of Mr. Simon Pasvakavambwa, Assistant Director, Mr. Johannes Makadho, Chief Irrigation Officer, and Mr. John Graham, Irrigation Officer, were extremely helpful.

The University of Zimbabwe and the Ministry of Lands, Agriculture, and Rural Resettlement are to be congratulated on their close and productive relationship. In the Faculty of Agriculture at the University of Zimbabwe, Dr. Malcolm Blackie, Dean of Agriculture, and Dr. Mandi Rukuni, Assistant Dean of Agriculture, were particularly helpful. Dr. Rukuni's experience of irrigation in Zimbabwe was very useful to the team.

This report is dedicated to the people of Zimbabwe. We hope that the findings are beneficial, and will aid in the development of Zimbabwe's irrigated agriculture.

Terence H. Podmore
Richard J. McConnen
Alois Hungwe

# I. EXECUTIVE SUMMARY

1. The general level of irrigation development in Zimbabwe is impressive. There are a limited number of small-scale irrigation schemes that appear to have serious problems, however. If these schemes are analyzed, along with the other schemes whose performance is generally good, the GOZ will be able to strengthen its knowledge base. Such a base is required to build a strong and significant small-scale irrigation sector in Zimbabwe.

Appropriate irrigation assistance should recognize both the current level of development and the considerable capabilities of the people involved. Such an assistance program should concentrate on the opportunities which exist in Zimbabwe to build in-country analytical capabilities related to the effective use of water resources and to strengthen relevant in-country training programs.

2. Assistance programs need to deal with the interrelated potential of expanded irrigation development based on the effective use of Zimbabwe's water resources. Efforts could be initially concentrated on small-holder irrigation development based on a) communal lands, b) resettlement schemes, and c) the use of groundwater from at least three aquifers which have potential for irrigation development.

3. The potential for water resources to contribute to the development of Zimbabwe is considerable. In order for this potential to be realized, each irrigation scheme must be planned and evaluated in terms of the scheme's contribution to the accomplishment of Zimbabwe's development objectives.

4. The opportunities the WMSII team sees for the next steps in the development of Zimbabwe's irrigation sub-sector which would increase both the rate of irrigation development and the magnitude of irrigation's contribution to Zimbabwe's development progress are summarized below.

a) Develop and extend an active monitoring and evaluation program to measure and analyze irrigation water use as well as other scheme characteristics as they relate to previously determined irrigation development objectives. The information gathered should be used both as a basis for learning better ways to design, implement and operate irrigation schemes and be incorporated into irrigation training programs.

b) Develop activities to enhance existing programs to help build more effective irrigation associations and irrigation management committees.

c) Improve abilities to analyze the intra- and the inter-year allocation of water and to determine the implications for contribution of irrigation schemes to the development objectives of growth, equity and stability.

d) Assist in the building of institutional structures and the design of operational procedures at the field level which will increase the potential of small-holder irrigation schemes to contribute towards the achievement of Zimbabwe's development objectives. Of particular importance is the coordination between the Irrigation Department and the Ministry of Water Resources and Development at all levels - national, regional, and local.

e) Help develop a training activity which would lead to improvements in the design, implementation, operation and maintenance of water pumping systems with emphasis placed on increased system reliability and decreased recurrent costs.

f) Utilize the National Farm Irrigation Fund. The creation of the National Farm Irrigation Fund is a potentially important source of investment capital which can be used to promote the development of irrigation schemes. However, the Fund has not been utilized for the development of small schemes. In order to better utilize this Fund to promote the development of small-scale irrigation schemes, several issues must be dealt with, including: 1) recognition that most capital investments in small-scale schemes serve a group of farmers rather than an individual farmer, 2) the Irrigation Management Committees (IMCs) for the schemes need to be better informed about the Fund, 3) IMCs need a source of income which will make them suitable applicants for loans from the Fund, and 4) AFC personnel responsible for the Fund must not only be capable of evaluating loan applications, but they must also have the ability to generate more successful loan applications. There are operational methods for dealing with the problems associated with these issues.

g) Develop full fledged training programs at both the technical and university levels to sustain the long-term effort required for both the development and the operation of an interrelated set of irrigation schemes.

h) Assist in the development of individual schemes when such a development will serve as a field trial of ideas and techniques developed in the activities presented above. Incorporated into any such development schemes need to be adequate monitoring and evaluation activities as well as adequate analysis in order that the effectiveness of the ideas and techniques can be determined.

NOTE 1: Many other factors will influence the effectiveness of irrigation including timely availability of inputs, access to markets, the conservation state of catchment areas and the management of grazing of livestock belonging to local farmers. These important factors must be recognized, but they are not dealt with in detail in this report.

NOTE 2: The WMSII team believes that much of the rest of Africa can profit by knowing more about irrigation in Zimbabwe.

## II. PRINCIPAL CONCLUSIONS

### A. High Level of Irrigation Development

The general level of irrigation development is impressive. The large estates and commercial farms are diverse, most often financially successful and technically sophisticated. The schemes found on communal lands are more diverse in terms of apparent success. Some are as impressive as the irrigated agriculture found in the commercial sector, while some others show evidence of serious problems and both their economic and social viability must be questioned. What Zimbabwe has, and so many developing countries do not have, is a significant number of successful irrigation schemes which can provide a knowledge base for future irrigation improvement and expansion. However, this knowledge base cannot be exploited unless there is a systematic comparison of the successful and not too successful schemes. Based on such a comparison, it will be possible to determine those scheme characteristics which are likely to lead to success and those which are likely to result in failure.

Zimbabwe also has a limited number of good, capable irrigation professionals in both the public and private sector. The number of well-trained professionals could be increased by developing degree programs at the University of Zimbabwe and by strengthening the existing irrigation training programs at Chibero and Gwebi. The capabilities of Zimbabwean professionals could also be enhanced by both short-term and long-term out-of-country training programs. In addition, existing Zimbabwean professionals could gain valuable on-job experience by participating in joint efforts with selected expatriate irrigation professionals.

The diversity of irrigation schemes and the existence of a limited number of well-qualified irrigation professionals provides an excellent opportunity to build a sound foundation for an effective irrigation development program for communal lands in Zimbabwe. This is particularly true since models for successful development can be found within the diversity of existing schemes in Zimbabwe.

### B. Small-Scale Irrigation Related to Total Water Resources

Since the original scope of work for this activity placed the emphasis on small-scale irrigation development, this has been the major focus of the study. However, the WMSII team needs to point out that to consider small-scale irrigation in isolation without regard to the total water resources development and utilization program of Zimbabwe would be erroneous.

Two points need to be made in this regard. First, the terms "small-scale" and "small-holder" irrigation are difficult to define since the size of the scheme or of the landholdings within that scheme do not give the complete picture. Generally, it is the type of management that is more characteristic of the type of scheme. For example, "locally managed" as opposed to "centrally managed." In WMSII experience, the small-scale schemes are locally managed, whereas the large-scale schemes are centrally managed. The large-scale commercial irrigation schemes in Zimbabwe are somewhat unique, since they include large landholdings under local management. Consequently, to refer to system type solely in terms of size is incomplete. The WMSII team was fortunate to be able to visit a number of different types of schemes during the activity (see Appendix B).

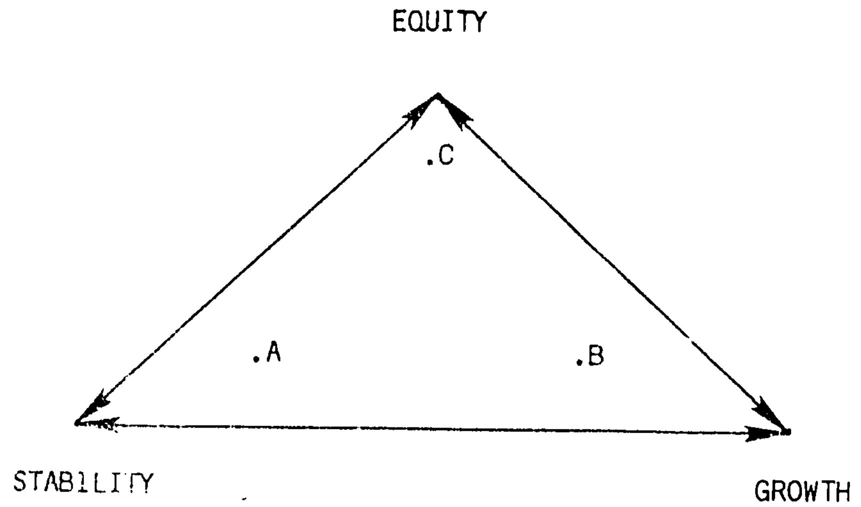
Second, changes in the large-scale or commercial sector can significantly affect the small-scale sector. Small-scale irrigation on communal lands has been estimated at 13,375 ha, while the large-scale commercial farms occupy 119,375 ha (GKW et al., 1985). Therefore, if water management on the large-scale schemes could be improved to save 10% of the water currently used, and the water could be directed to small-scale outgrown schemes on irrigable land in the same area, it has the potential to approximately double the current small-scale irrigated area. Such an example is very simplistic, but it illustrates the need to look at the whole picture of Zimbabwe's irrigation development.

## C. Effective Irrigation Development: Relating Irrigation Programs to Development Objectives and Constraints

The GOZ has the clearly pronounced goal of "Growth with Equity." The potential conflict in these dual goals is recognized in the statement by the Minister of Finance in 1982, "Growth without equity is unacceptable -- Equity without growth is disaster." The government has focused on "redistributing opportunity" rather than the politically more popular, but economically troublesome act of relying solely on redistributing assets and wealth. For example, land reform and rural development programs in communal areas have been pursued aggressively. In the more isolated communal areas, the GOZ has pursued a policy aimed at food security.

The potential for irrigation development to contribute towards the achievement of the more general objectives appears to be considerable, especially those objectives aimed at communal land. However, this potential does not seem to have been realized. The apparent lack of success in developing vigorous irrigation development programs for communal lands has been a source of concern among those responsible for such programs. While they want immediate achievements, that may not be possible until the relationships between the objectives for such programs and national development objectives and constraints can be better understood. The key to such an understanding is probably based on the nature of the trade-offs among development objectives.

A highly simplified example of the trade-off among the objectives of equity, growth and stability is demonstrated below. The objective of stability in this case is in terms of the year to year stability in food production and farmer incomes. For example, point C could represent an irrigation development program based on very small plots and a large command area. In such a case, there will be little stability in drought years and the variability of both production and marketing costs are apt to be high. The program represented by A would be a program based on a command area which was limited in order to emphasize the year to year storage of water. Equity would be sacrificed because few farmers would be given the opportunity to farm irrigated land. The command area under the program represented by B would be large relative to the supply of water, and the farms would be at least of moderate size. There is no clear indication which of these three programs would be "best."




The selection of which alternative to implement must be the responsibility of the officials in charge of the programs, and that selection should be based on the relative importance of the objectives they want to achieve. In an area highly susceptible to drought, program C may be "best." In an area where the level of precipitation is relatively stable and other job opportunities exist, program A may be "best." In an isolated area with high population density and few job opportunities in the immediate area, the program represented by C may be "best." Generally, it will be easier to make and to defend such decisions if the decision maker has explicit information about the trade-offs involved. An example of the tradeoffs between risk and production is discussed in Section III A.

The appropriate program to select for a specific scheme will also depend on the constraints to development. Zimbabwe suffers a chronic shortage of foreign exchange. The GOZ is attempting to control government budget deficits while at the same time dealing with the need for the expansion of social programs for health and education. The competition for government funds is, therefore, severe. Communal lands still suffer from the low-level of pre-independence investment in infrastructure. If irrigation development programs are to be successful, they must not only be viable, they must also compare well with many other development programs in the achievement of a broad range of development objectives.

In generating alternatives for the development of a potential irrigation scheme on communal lands and in the selection of that alternative put forward for implementation, particular attention needs to be paid to (1) the expected contribution to achievement of a broad range of development objectives, (2) the trade-offs between objectives if other alternatives can be considered, and (3) the relationship to significant development constraints. For example, alternatives which have significant foreign exchange requirements and high levels of recurrent costs for government would generally be less competitive than alternatives having lesser requirements for foreign exchange and on future government budgets unless it could be demonstrated that the first alternative had over-riding benefits in terms of equity, stability or growth.

There is no easy recipe for dealing with these problems. However, the issues must be dealt with. It is unlikely that the GOZ will implement a significant irrigation development program for communal lands unless the relationship of such a program to a broad set of development objectives and constraints can be made in an authoritative manner. The ability to deal with such issues will be greatly enhanced as the analytical work on irrigation schemes is expanded in terms of its impact on these objectives and constraints.

## III. ACTIVITIES TO CONSIDER

### A. Monitoring and Evaluation

During the visits to the various irrigation systems it was noted that there was an absence of data on water utilization, or that the data being collected was incomplete. Even at Nyanyadzi, where considerable work on flow measurement was being carried out with the assistance of Hydraulics Research Ltd. of Wallingford, England, the data being collected were limited to water application.

In contrast, water measurement structures were in place on many of the schemes visited. Consequently, whether the measuring structures are currently in use or not, the opportunity exists to develop reliable data on water utilization. It was observed that the majority of measuring structures were in place at the points of delivery to the systems, with additional structures at various locations in the larger schemes. There was little evidence of water measurement at the point of supply. Consequently, information on delivery losses between the supply and the system was not available. In addition, no cases were observed where excess runoff or tailwater was being or could be measured. As a result, such limited data on water utilization and application efficiency that was available was suspect.

While it is recognized that such data is time-consuming and sometimes difficult to obtain, it would be extremely valuable to evaluate system performance. However, it must be noted that a complete and permanent program of data collection is not recommended. Sample data, while it must be complete in order to determine system performance, would be adequate to establish performance indicators.

In another context it was apparent that there is some confusion over irrigation system objectives. The Policy Paper on Small-Scale Irrigation Schemes (Ministry of Lands, Resettlement and Rural Development, 1983) refers to Supplemental Schemes as being "food security" objectives, in addition to minimizing the use of a limited water resource and providing employment. Other schemes are to increase agricultural production, to generate employment and to reduce population pressure on the land. On inquiry it was usually not possible to determine which objective held primary importance for an individual scheme. Also, there was a lack of information on whether any or all of the objectives were currently being met.

In attempting to develop a structure whereby these differences could be resolved, it was found that all new irrigation schemes are designed on the basis of a 10 percent risk factor (Kabell, 1984). This risk factor can be interpreted to be a failure to supply the quoted yield in one year out of ten on average. Kabell points out that a 4 percent risk factor is generally accepted for urban, industrial and mining uses. In his section on guidelines for development planning, Kabell recommends that a 20 percent risk factor for agricultural applications would yield about 25 percent more water than for a 10 percent risk factor from the same source. The recommendation stated is that a 20 percent risk factor greatly improves the utilization of water resources for agriculture, and that the economics are correspondingly more favorable.

An example will serve to illustrate the advantages. Let us suppose that a 10 percent risk factor (that is, failure in one year in ten on average) is adopted as an appropriate criterion for irrigation systems whose primary objective is food security. Also, let us suppose that a 20 percent risk factor (that is, failure in two years in ten on average) is an appropriate criterion for a scheme where increased productivity is the principal objective. [Whether or not these suppositions represent a truly realistic set of options remains to be determined.]

Let us assume that a system of 100 ha is being operated at 10 percent risk, and that under the existing management the crop yields Z$100/ha. Assuming that the risk factor is increased from 10 to 20 percent, there will be 25 percent more water available for irrigation, according to Kabell (1984). If we can assume that additional land area is available to utilize the additional water at the same level of management, then the scheme can now support 125 ha under production. However, before we can complete the analysis, an assumption must be made about those years in which failure occurs. It is unlikely that zero water will be available for irrigation, although the amount will be insufficient for complete irrigation. Let us assume that, on average in years of failure, 75% of the water required for irrigation is available. [This figure is derived from a statement by Kabell that on average 18 percent more water is utilized over a period of years by increasing the risk factor from 10 to 20 percent.]

Now a comparison can be made:

A) Food security system (10 percent risk)

| | | |
|---|---|---|
| 100 ha yielding Z$100 per ha for 9 years | = | Z$90,000 |
| 75 ha yielding Z$100 per ha for 1 year | = | 7,500 |
| Total | = | 97,500 |

B) Production system (20 percent risk)

| | | |
|---|---|---|
| 125 ha yielding Z$100 per ha for 8 years | = | Z$100,000 |
| 75 ha yielding Z$100 per ha for 2 years | = | 15,000 |
| Total | = | 115,000 |

Consequently, over the ten year period, production is increased, although at greater risk, by Z$17,500, which is an 18 percent increase in production. These numbers are only intended as an illustration, but

A and B above are indicative of the possible alternatives related to the conceptual issues of stability, equity and growth discussed in Section II C.

What is presented here is a method of quantifying irrigation system objectives on the basis of the assigned risk factor. In addition, while the 10 percent risk factor is being applied to new schemes, the current risk factors on existing schemes are not known. Changes in irrigation systems, such as increasing the area under irrigation, could have a significant effect on system performance. In the case of Duncal, this change has proved disastrous to the point where the risk factor approaches 100%. An investigation of existing schemes, with the expertise already available, would enable risk factors to be assigned. If they are not in accordance with the desired objectives for that scheme, alternatives could be developed to modify the scheme (for example to increase or decrease the area under irrigation) in order to realign the risk with the objectives.

Courses of Action

- For new schemes: determine the system objectives and relate them to the risks incurred.

- For existing schemes: determine the current level of risk and compare to the existing system objectives. Develop system modifications to resolve risk/objective conflicts.

- For existing schemes: determine water use efficiency and check on current operation of selected schemes. Develop criteria for system operation and efficiency.

B. Farmer Organization

In Zimbabwe, there is a total of 74 communal area irrigation schemes belonging to two categories in terms of their management and organization. These are government-managed and community-managed schemes.

There are other smallholder irrigation schemes in communal areas of Zimbabwe where the smallholdings are part of large centrally-managed estates of the Agricultural and Rural Development Authority (ARDA), a parastatal. At these schemes, the smallholders receive management and extension services from the central estate and market their produce through the estate. These deliveries, although in communal areas, are not strictly communal. Examples of such schemes are Chisumbanji and Tshovane. The latter scheme was established recently and the smallholders were recruited and trained in a novel and interesting way. In the first season of irrigation, the would-be smallholders were recruited as employees of the estate to provide them with the necessary training in the practice of irrigation. After the first six months the recruits were allocated holdings and started farming but continued to receive management and extension advice from the central estate.

There are 56 government-managed schemes, and at each, government has staff on site to supervise the irrigators, maintain and repair physical structures on the schemes, and negotiate with the Ministry of Water Resources and Development on the supply of water and maintenance of pumping and conveyance works to field edge. In their turn, the farmers pay maintenance fees to government (currently set at $145/ha/year of all-year-round irrigation, for all schemes throughout the country, irrespective of the local cost of water delivery or capital cost recovery).[1]

On government-managed schemes the farmers elect a committee consisting of irrigators whose responsibilities have been outlined in the DERUDE Policy paper (1983) as:

> "The maintenance of discipline amongst irrigators, control of water distribution, recommendation of eviction of ill-disciplined irrigators, collection of maintenance fees, assessment of applicants intending to join the scheme."

The eight community-managed schemes in Zimbabwe are not provided with government staff and, as their name implies, the community of irrigators takes charge of management of the scheme and maintenance of physical structures. They only receive extension service from the government. The farmers elect a committee which has all the responsibilities of similar committees on government schemes and, in addition, oversees all repair and maintenance work on the schemes and negotiates directly with the Ministry of Water Resources and Development about water supply issues. Because community schemes do not get service from government, they do not pay maintenance fees to government.

The idea of management committees is not new in Zimbabwe. What is new, however, and appears to underline their performance today, is that the committees are elected by irrigators and not imposed on them by agents of a central government. It is important that the role of the committee as a representative of the farmers be strengthened.

Stated government policy is that all communal irrigation schemes should eventually be handed over to farmers for management and maintenance (DERUDE, 1983). While the policy is commendable, and has been in existence for a fairly long time, it does not appear that the farmers are being prepared for the transfer. The handover process

---

[1]Government argues that at 1982 costs, the annual operation and maintenance costs of communal irrigation schemes was in excess of $600 and the subsidy was justified on the basis of the gross margin of the crops the farmers are able to grow on the schemes. World Bank (1984) has heavily criticized the subsidy as "The use of one and one half ears of corn to grow one."

should be a gradual one in which the farmers, through their committees, gradually take over responsibilities of managing the schemes from government in a step-by-step process. The performance of the farmers can then be assessed at each step and corrective measures taken promptly. For example, from the maintenance fees the GOZ is collecting, the farmers could be allowed to withhold a certain proportion and use the funds to carry out some of the maintenance required on the scheme. The proportion of fees withheld could be increased gradually each year until the farmers control all the fees. There is, however, a problem arising from the present level of subsidy awarded to the schemes by GOZ. The question of how the currently subsidized schemes can be run by farmers without assistance from government remains unanswered.

During our tour of irrigation schemes in Zimbabwe, we had the opportunity of visiting both government-managed and community schemes and of speaking to farmers and committee members. All farmers interviewed were, invariably, in favor of their committees, and it was notable that they were familiar with the responsibility of their committees. Similarly, committee members interviewed appeared to understand their responsibilities.

Although both the farmers and committee members interviewed appreciate their duties, the performance of irrigation schemes and their committees varied immensely across the country.

Some committees were observed to be very effective and to have strong control over their farmers and to administer a strict but fair code of discipline among their members. At such schemes, agricultural production and water use efficiency was found to be high. Examples of such schemes are Nyanyadzi in Manicaland Province; Charandura[2], Mhende and Mkoban[2] in Midlands Province and Mzinyatini[2] in Matabeleland. The following schemes were judged to be unsuccessful (in terms of agricultural production and efficiency of water use) mainly because of poor farmer organization and ineffective committees: Mutambara[2] in Manicaland, Shagari in Midlands and Silalabuhwa in Matabeleland. Of all three schemes, the soils and availability of water were not limiting.

Mkoba irrigation scheme is a good example of the effectiveness of a strong committee. The soils under irrigation are sandy, of low inherent fertility and low waterholding capacity and are of poor suitability for irrigation. The farmers have 0.1 ha plots and achieve high yields of about 10 bags maize grain per plot (9 tons per ha). A farmer is not allowed to abstract water from the canal to plant a crop unless he/she has purchased (and shown to the committee) his/her season's requirement of seed, fertilizer and any other inputs recommended by the extension worker. Each farmer at the scheme is

---

[2]Indicates community scheme. Other schemes are government.

responsible for the repair and maintenance of his section of the in-field canals.

The Ministry of Lands, Agriculture and Rural Resettlement is currently running training courses for irrigation committees and irrigators at several centers in all provinces. The course programs vary between centers and depend on the problem encountered or observed by the extension and irrigation management workers in each province. Generally, however, the programs teach the irrigators (in venacular languages) irrigation water management, the need for field leveling and timely irrigation, and clearing canals of debris and grass. Committee members are taught how to enact discipline, the channels for forwarding complaints and problems of farmers and recordkeeping.

The idea of running the training courses especially in vernacular languages is commendable. Such efforts could be enhanced by the availability of:

a) more funds to run them

b) more staff to run them

c) the production of training aids (pamphlets and film materials) in venacular languages.

There is considerable scope for improvement in this effort.

It must be emphasized that if irrigation in communal areas is to be successful, the committees must be strengthened and assisted. One obvious way of strengthening them is through training, as pointed out earlier.

## C. Allocation of Water

### 1. The Basic Issues: Uses, Users and Time of Use

The social value of irrigation water will depend on how the available supply of irrigation water is allocated among uses, users and time periods of use. In Zimbabwe, the sources of irrigation water are from either groundwater or streamflow. Groundwater is a "stock resource" and decisions will be made about how that water is allocated among different time periods as well as among uses and users. Streamflow is primarily a "flow resource" and is derived from either runoff which becomes available during Zimbabwe's single rainy season or from a base flow during the dry season which results from natural storage of seasonal runoff. Flow resources must be allocated among uses and users during the time interval when they become available. However, flow resources can be stored and converted into a stock resource. The man-made storage reservoirs in Zimbabwe are, in fact, used to convert flow resources into stock resources. These reservoirs presently have a storage capacity of about 5.8 billion $m^3$, of which 2.5 billion $m^3$ are available for use. The social value generated by the use of groundwater and streamflow in Zimbabwe for irrigation waters will depend on how they are allocated among (a) water users, (b) water uses and (3) time periods when the water will be used.

2. The Initial Work Should Relate to Micro Issues

There are macro issues relating to the allocation of water, but an irrigation agency should place initial emphasis on the analysis of micro or single scheme allocation of irrigation water. This emphasis is necessary in order to establish an empirical basis for understanding the principal issues which are involved in the allocation of irrigation water in Zimbabwe. Once some level of understanding is gained at the scheme level for a representative sample of schemes, it will be possible to deal with higher level or macro water allocation issues. While there apparently are broad principles which guide water allocation in Zimbabwe (for example, domestic water for urban areas takes priority over irrigated agriculture), the Team was not aware of empirical information about the impact of alternative allocations of irrigation water. In Zimbabwe, the base flow of streams is fully committed, reservoir storage capacity is expensive to increase and limited, and groundwater is generally expensive to pump. Therefore, the way in which irrigation water is allocated will have a significant impact on the ability of irrigation to contribute to the achievement of Zimbabwe's development objectives.

The rules and guidelines for the allocation of irrigation water varies greatly from country to country. In the case of some of India's large-scale systems, as little as one-third of the command area may actually be irrigated in any one year. The goal is apparently to provide some water to as many farmers as possible, even though total production is diminished because of the high conveyance losses and depressed yields resulting from inadequate water. On the other hand, in Sri Lanka during years of drought, property rights to land are temporarily modified so that all farmers have the right to farm some land near the head of the irrigation scheme. In this case, emphasis is placed on the efficient use of water and the recognition of equity concerns even if some property rights for land are sacrificed. In the Western United States, the doctrine of prior appropriation (water rights are based on "first in time - first in right") usually applies to water in order to encourage irrigation development by lessening the impact of drought for the earliest developers of irrigation. There is obviously no one correct method for allocating irrigation water, but there are many cases in the world where the allocation rules seriously compromise the ability of irrigation to contribute to the development process. The allocation rules should be designed to ensure that it is possible to realize the potential of irrigation to contribute towards the achievement of development objectives. Until recently, irrigation development in Zimbabwe has taken place under conditions where the overall supply of water was adequate relative to demand and lack of well-defined water allocation rules has not imposed a hardship. This situation has changed.

It is recommended that the initial investigation of the issues of the allocation of irrigation water in Zimbabwe be carried out using an efficiency -- cost-effectiveness approach. This is not to argue that Zimbabwe must develop efficiency-related water allocation rules. This approach is recommended because the models are well understood, they can usually be computerized, and, most important, they can provide a basis for generating trade-off information which will be helpful in evaluating non-efficiency-related development objectives such as equity and food security. Computerization is not an end in itself, but it does make it much easier to try alternative sets of data, scheme designs and assumptions. When the amount of available information is not high, allocation studies should be designed to improve understanding rather than to produce unique answers. Therefore, the methods of analysis need to encourage the analysis of a broad range of alternatives.

3. One Method Among Many: Linear Programming

One of the simplest and most widely used efficiency models is linear programming (LP). LP will be used as the basis for the following discussion of the allocation of irrigation water issues in Zimbabwe.

The LP approach is based on evaluating alternative allocations of irrigation water in terms of the impact on some objective function such as "gross farm profits" or "net social benefits." These alternative allocations of irrigation water are defined in terms of either an activity of a set of related activities as defined in an LP tableau or matrix. The basic approach to the solution of an LP problem is to select that set of alternatives which will generate the most favorable value of the objective function, while not violating either the constraints or relationships specified in the model. The relationships which must be specified in the LP model include (1) water requirements for relevant farmer systems, (2) the impact of irrigation on production levels, and (3) other inputs required -- all by (a) user, (b) uses, and (c) time of use. The constraints involve available irrigation water by season, available land and sometimes seasonal availability of labor. In addition, a relationship must be specified in the model which specifies how the amount of irrigation water available for use will be influenced by evaporation, seepage, conveyance loss, as well as any change in the effectively available irrigation water.

4. A Simple LP Example

A simple LP example is described below which will be used to demonstrate how LP can be used to increase the understanding of water allocation issues in Zimbabwe. The example involves (1) a rainy and a dry season, (2) two crops or farming systems for each season and an estimate of both water requirements and the gross profits from each crop or farming system, (3) a specified land area which can be irrigated, and (4) a fixed amount of irrigation water available during the rainy season which can be stored at a cost for use during the dry season. This simple example involves four rows for constraints and five columns, one for each of the five activities.

Activity X1 allows the storage of one unit of irrigation water from the rainy season (the +1.0 in Row 1) for use in the dry season. The -.7 in Row 2 of X1 means 30% of the stored water has been lost by the dry season, and the -5.0 in Row 5 is the cost (i.e., the gross profit, the objective function to be maximized, will be reduced by 5) for each unit of water stored for use in the dry season. Activity X2 is the "recipe" for Crop 1, and this "recipe" calls for 8 units of water during the rainy season, one hectare of land and the other associated inputs. This "recipe" will result in 1200 units of gross profit per hectare. These "recipes" can be written in much more detail if information is available and the added detail is needed for appropriate analysis. The activities X3, X4, and X5 can be read in a similar fashion. The Constraint column shows that 1200 units of irrigation water are available for use during the Rainy Season (Row 1), no irrigation water is available during the Dry Season (Row 2) unless it is stored using Activity X1, 75 ha of land can be commanded by the scheme in both the Rainy (Row 3) and Dry (Row 4) seasons. Row 2 is a "material balance" equation which states that the amount of water used during the Dry Season cannot exceed 70% of that water which is stored from the Rainy Season. Activity X1 is a "transfer activity" which permits the transfer of a resource from one time period to another time period. Row 5 is the objective function, gross profits in this case, which is to be maximized subject to the constraints and relationships specified in the model.

Allocation of Irrigation Water
A Simple Zimbabwe LP Model

| | Activities | | | | | |
|---|---|---|---|---|---|---|
| | Storage Rainy to Dry | Rainy Season Crop 1 | Rainy Season Crop 2 | Dry Season Crop 3 | Dry Season Crop 4 | Constraint |
| | X1 | X2 | X3 | X4 | X5 | |
| Row | | | | | | |
| 1 | +1.0 | 8 | 6 | | | ≤1200 units |
| 2 | - .7 | | | 10 | 14 | ≤ 0.0 |
| 3 | | 1.0 | 1.0 | | | ≤ 75 ha |
| 4 | | | | 1.0 | 1.0 | ≤ 75 ha |
| 5 | -5.0 | 1200 | 1050 | 2000 | 2600 | = Z (Max.) Gross Profit |

## 5. The Merits of an LP Analysis of Water Allocation in Zimbabwe

The optimum solution to an LP problem will find that combination of activities which would maximize gross profit subject to the constraints imposed by Rows 1 through 4. While the solution of such a problem is in itself useful, experience with other such problems have shown that there are at least three other "outputs" from such an approach which may be of equal or of greater significance than the existence of an optimum solution. First, the multi-disciplinary task of building such a model and generating the empirical estimates of the coefficients is a team building exercise in itself and usually results in a great deal of insight into the nature of the issues being considered. Second, associated with the optimum solution is a set of supplementary information such as "shadow prices", which would show, for example, the value of having one more unit of irrigation water during the dry season. Such information could be used to examine alternatives, such as a comparison with pumping costs in order to evaluate the economic viability of a pumping scheme. Third, the LP model lends itself to sensitivity analysis which means that "what if" question can be asked. For example, "What would be the value of decreasing the conveyance loss during the dry season so that diversion requirement for Crop 4 would change from 14 to 11.2 units of irrigation water?" All three outputs would be of value in dealing with the issues of water allocation in Zimbabwe.

A criticism made of irrigation on communal lands by people within Zimbabwe and outside reviewers is that much of this irrigation is not economical. The clinical evidence for some schemes gathered by the Team supports these kind of conclusions. However, there is little empirical evidence to support such conclusions with regard to the potential for the expansion of irrigation on communal lands. One approach to gathering this kind of information is to conduct detailed feasibility studies while another approach, and the one recommended here, is to evaluate present schemes. If a decision is to be made on a particular proposed scheme, a site-specific feasibility study should by all means be conducted. However, to deal with the policy issue of the potential expansion of irrigation on communal lands, it is probably best to estimate the value and cost of water on present schemes. It is almost certain that the estimates will be highly variable over a number of schemes. However, with such variability, it is possible to look for relationships between value of water and other parameters of the schemes. Because little emphasis has apparently been put on cost control in the past, the estimated costs for existing schemes may not be highly useful as a basis for estimating the economic viabilty of future schemes. However, the information about the value of irrigation, especially for those schemes which are viewed as "good" or potential "model" schemes will be useful. This kind of information can be provided by an LP model. The marginal value of water (the shadow price) in Zimbabwe will be an explicit output, while the average value of water for the set of Zimbabwean schemes examined will be easy to calculate.

## 6. Asking the Right Questions

The LP model presented above is obviously very simple, but even such simple models can yield useful results in the early stages of investigating the allocation of irrigation water in Zimbabwe. Complex models which are not easily understood, and for which reasonable estimates of empirical coefficients cannot be provided, are sometimes more dangerous in the early stages of such an effort than models which may appear to be too simple. The process of developing such a model should begin with the question, "What are the basic questions which are to be asked?" Once the initial specification of the questions are agreed upon, it will be necessary to determine if there is enough understanding of the empirical relationships which are required to build the appropriate model. At this early stage of analysis, some of the important questions which could be answered by an LP analysis of existing schemes are presented below.

Question 1. What is the value of water?

If answers to this question are generated, a host of relevant secondary questions can be asked and hopefully answered. A sample of such secondary questions follows.

a) If irrigation water has a value of Z$X per 1000 $m^3$, how much are we willing to spend to provide water to a scheme?

b) If it is agreed that proposed scheme A need not be economically feasible, are we willing to subsidize the scheme at the rate of Z$Y for each 1000 $m^3$ of water delivered?

c) If irrigation water has a value of Z$X per 1000 $m^3$, can we develop a scheme design which will result in a cost not to exceed 75% of Z$X per 1000 $m^3$?

Question 2. Should we emphasize supplemental irrigation during the rainy season or provide irrigation for both the dry and the rainy seasons?

Question 3. Should we provide carryover water in order to start rainy season crops early or should there be no planned year-to-year carryover of stored water? Related to this question is the degree to which irrigation schemes should provide drought insurance.

Question 4. How do the regional differences in both the value of water and the cost of developing schemes compare?

These questions do not mean that Zimbabwe's irrigation development policy be based solely on economic feasibility. However, when there are development objectives which are not driven by economic efficiency, such as equity and food security, it is important to have reasonable estimates of the economic costs of achieving those objectives.

7. Why Study the Allocation of Water?

There is little doubt that some presently developed schemes in Zimbabwe are highly productive. There is also little doubt that it would be physically feasible to greatly expand the irrigated area on communal lands. However, what is not clear is when such an expansion would contribute to the achievement of Zimbabwe's development objectives. A backdoor approach to gain greater insight into such issues is to gain a greater understanding of the value of irrigation water used on existing schemes. That value will undoubtedly depend on how the irrigation water is allocated among uses, users and time period of use.

This type of information can be gained by studying existing schemes within an LP model. While other models could also be used for this purpose, the simplicity of the LP approach is a strong recommendation. Such an approach would also be a means of building interdisciplinary teams which will need to be created if the full potential of irrigation on communal lands is to be realized. In addition, such an approach would greatly enhance the understanding of the operational components of small-scale irrigation schemes in Zimbabwe.

The initial work would require some limited expatriate assistance. However, given the skilled people in Zimbabwe and the structured nature of the LP approach, the study of irrigation water allocation issues could soon become a Zimbabwean effort. The results of such a study would have almost immediate implications for Zimbabwean policy makers.

## D. Coordination with the Department of Water Resources and Development

In Zimbabwe, the control of all water resources lies in the Ministry of Energy and Water Resources Development (MEWRD) through the Department of Water Resources Development (DWRD).

Abstraction of surface water from rivers and dams for major uses such as irrigation requires a water right from the DWRD. The right dictates the maximum amount of water the holder of the right is permitted to draw. In issuing the right, engineers of DWRD determine the maximum sustainable level of abstraction the water source can support. Exceeding the water right is an offense.

The DWRD serves all water users: urban, industrial, mining and agriculture. The first three users take priority over agriculture. Thus, in times of water shortage, irrigation water rights tend to be the first to be reduced or suspended.

At every major dam in Zimbabwe, there is a water bailiff whose responsibilities include:

1. Regular recording of water levels of the dam and sending of such records to the Provincial Water Engineer (PWE).

2. Release of predetermined amounts of water for use as per instructions from PWE.

The returns sent to the PWE by the water bailiff assist him in deciding the amount of water available for release to the users. In times of critical water shortage, such records enable the PWE to enact water rationing to users and instruct the bailiff to reduce or cut off water supply.

The DWRD is manned by qualified professional engineers who are capable of designing, constructing and managing all water storage works in Zimbabwe. The department is responsible for the supply of water to large-scale commercial estates drawing water from government-owned dams and to all communal irrigation schemes. With respect to all the schemes where DWRD is responsible for water supply they are in charge of the following:

1. Construction and maintenance of storage works, where water is supplied from a dam.

2. Construction and maintenance of canals to field edge.

3. Pumping water (in the case of a pumping scheme) to field edge and maintenance of pumps.

In cases where the dam is privately owned by a farmer or when the farmer irrigates from a perennial stream on the farm, the farmer takes charge of all the responsibilities listed above, but DWRD retains control of the water right.

The supply of irrigation water to large estate schemes, and the maintenance of pumping equipment and conveyance works by DWRD appears to be proceeding efficiently. However, some problems arise, as discussed later, with regard to small-scale schemes.

The management and agricultural extension services on most communal area irrigation schemes are carried out by the Irrigation and Extension Departments of the MLARR. Bearing in mind that efficient water supply and effective management and extension are three of the most important factors for successful irrigation, the fact that they are controlled by different ministries calls for careful interministry coordination to ensure that:

a) adequate amounts of water are supplied promptly on request or as per agreed schedule,

b) pumps are regularly serviced,

c) pump or canal breakdowns are attended to promptly to avoid crop losses due to water shortage,

d) that, in times of critical water shortage, the farmers are informed well in advance of the sub-normal levels of water in storage. This enables farmers, with the aid of their managers and extension workers, to make decisions, before planting, on ways to best utilize the limited amount of water. Examples of such decisions could be to reduce the irrigated area or to delay planting to a time closer to the rainy season. The important point to note is that the farmers have to be provided with all the information necessary and then left to make the decision.

In discussions with staff of the two ministries concerned it was clear the effective coordination existed at senior and middle levels of the hierarchies. Problems appear to exist at the lower level where:

i) at some schemes, farmers claim that the water bailiff does not release water as required by the farmers with the result that the designed irrigation schedule cannot be achieved.

ii) the farmers are not warned in advance about low stored water levels. In ignorance, the farmers plant all their irrigated land with purchased seed and apply fertilizer. Shortly after crop establishment, and before the next rains, water runs out and farmers lose their entire crop.

iii) pumps break down. Repairs are carried out late causing a substantial portion of the potential yield to be lost.

It would appear that what is required is an increased sensitivity to problems on the part of staff of both ministries. The desirable level of sensitivity can only be achieved by more direct and free communication between the two ministries involved at all levels of their hierarchies.

The bailiff is a critical position with regards to water supply for irrigation. Some of the problems observed or currently experienced by farmers and managers would not occur if the bailiffs were trained sufficiently to appreciate the impact of their responsibilities on farmers. Another way to strengthen the coordination at lower levels of the MWRD and MLARR is to make the bailiff responsible to both ministries or at least to provide formal links between the bailiff and the management of the irrigation scheme.

E. Pumping

Of the irrigation schemes visited by the team, the most common form of pumping encountered was the pumping of irrigation water from a river. In most cases, the irrigation scheme was close to the river, and the transmission distance was short. In these situations, the pumps served as a lifting mechanism for water, which was usually discharged into an open channel delivery system. No cases were observed of water being supplied under pressure for irrigation on small-scale systems.

Less common was the situation of water being pumped from an underlying aquifer for irrigation. In one case, Mutema, water was supplied under pressure by four linked pumps and was used for sprinkler irrigation. From such information as could be obtained, there appears to be a potential for future expansion of groundwater utilization. A necessary step would be determination of the extent and safe yield of the aquifers concerned. There appeared to be three areas -- the Sabi Valley, the area around Bulawayo; and the Highlands north of Harare, where aquifers are located which are worthy of further exploration.

On the small-scale irrigation systems, supplemental pumping to provide water under pressure for sprinkler systems was not common. In one case observed, Devule, water was supplied in an irrigation ditch at an elevation above the land surface. In one part of the scheme, a diesel engine was being used to pressurize the water for a small sprinkler irrigation lateral applying water to a sandy area. The system was not operating properly, in that leakage occurred at most pipe joints due to lack of seals and the sprinkler heads were unable to rotate properly. This application appeared to be totally inappropriate.

Problems that were noted with pumping installations were inlet problems, lack of maintenance, and communication difficulties. With regard to inlet problems, a number of the installations pumping directly out of a river were taking in a considerable quantity of sand from the river bed. An example of this was Tavone, where large quantities of very coarse sand had been deposited in the delivery channel. Wear of the pump impellers was probably very high, although there was no opportunity to check this.

In another location, Musvuugwe, a problem with the design of the intake structure had caused one of the three pumps to be inoperable, since it was choked with sand. It appeared likely that at least one of the remaining pumps would suffer the same problem. From an examination of the intake structure it appeared that a simple design modification would have enabled the structure to be flushed periodically in order to alleviate the problem.

In situations such as Chisumbanje, where care had been taken to design and maintain the intake structures so that the entry of sand was minimized, the systems appeared to be working well. Another interesting aspect of the installation was that a service contract with a private company was in place to maintain the pump station. In conversations with the field manager, and later with private sector personnel, it appeared that the capability for pump repair and maintenance exists in the private sector. An increased level of involvement by the private sector in the repair and maintenance of pumping installations on small-scale irrigation systems would appear to be worthy of investigation.

Another problem area of pumping installations on small-scale schemes appeared to be a lack of maintenance. For example, at Mutema, the pumps lacked any appearance of having been recently lubricated and the oil levels were not visible in the inspection points. Information on the hours of pump operation, frequency of maintenance and the causes and occurences of pump failure were almost totally absent. The need for a regular program of recordkeeping and maintenance is vital for the extension of the operating life of the pump. A measure of the efficiency of the pump, through pump tests to establish performance and costs of operation, would be useful to establish the viability of the pumping operation and the costs incurred.

A problem of communication between ministries was noted in that the pumps on many of the small-scale schemes are maintained by the Ministry of Energy and Water Resources and Development (MEWRD). Instances were reported when pumps were out of action for prolonged periods during the irrigation season. Also, the removal of pump units without warning was cited. The effects of these and similar actions by the MEWRD on the irrigation system operation was apparently not recognized. An improved level of communication between the MLARR and MEWRD on the topic of pump repair and maintenance would be desirable.

Courses of Action

- Review the intake structures on existing installations and redesign when necessary to minimize intake of sand.

- Initiate programs of regular maintenance and record-keeping on existing pumps.

- Investigate the utilization of private sector capabilities to provide repair and maintenance services under contract.

- Perform pump tests at regular intervals to determine efficiency and costs of pump operation.

- Improve communication between MLARR and MEWRD concerning pump operation maintenance and repair.

- Investigate the potential for the utilizational of groundwater for irrigation.

F. National Farm Irrigation Fund

A National Farm Irrigation Fund (NFIF) of Z$6,000,000 was established to provide low cost loans to establish new irrigation areas on communal lands. The situation which gave rise to the NFIF was clearly the desire on the part of the GOZ to reproduce the success of a similar fund used to encourage the development of new irrigated areas which would be used for the production of wheat by commercial farmers. To date, that success has not been reproduced. Much to the disappointment of the GOZ, no applications have been made for such loans.

It is possible to speculate as to why the NFIF has not been used by smallholders on communal lands and four reasons seem reasonable. (1) Most of the capital investments required for smallholder schemes serve a group of farmers and not an individual farmer as is often the case for wheat production on commercial farms. (2) The Irrigation Management Committees (IMC's) which represent smallholders on communal schemes do not appear to be well informed about the NFIF and, in any case, a scheme has to exist before an IMC can come into being. (3) The IMC's would need a source of cash flow before they could be successful applicants for a loan, and IMC's have no source of income under present conditions. (4) The Agricultural Finance Corporation (AFC) responsible for evaluating NFIF loan applications must not only have the capability of doing so, but they must also have the ability to generate successful loan applications. Still, these are speculations. In terms of loan applications under the NFIF, there is a void; there is no experience, good or bad, to learn from.

An alternative approach to learning from experience would be to treat the speculations above as propositions which need to be tested. One way to do this would be to prepare sample loan applications for existing schemes on communal lands and see if such applications would qualify for a loan. This work would have to be done in cooperation with the AFC. It is recommended that such example loan applications be prepared for schemes which at least appear to be viable in economic terms. AFC loan applications must demonstrate the viability of the project if the application is to be successful. The purpose for such a rule is clearly to direct resources toward projects which are efficient in economic terms. The purpose of working on examples of loan applications at this point would be to gain an understanding of the way the NFIF functions rather than determine the economic viability of a particular scheme. The issue of economic viability will need to be dealt with at a later stage, but at this stage, the emphasis needs to be placed on understanding how the NFIF would work for schemes which are economically viable. If the NFIF would not work for such schemes, it needs to be determined what changes would have to take place before the NFIF would be an instrument for irrigation development on communal lands.

It should be noted that the NFIF imposes explicit objectives for irrigation development. The issues of trade-offs between objectives and the impact of development constraints as discussed in Section 2c above is not considered. If the objectives of equity and stability are operative objectives, the NFIF is clearly not an instrument which will contribute towards the realization of those objectives. This does not mean the NFIF should not be used, but it probably means that the NFIF should be viewed as merely one of many development instruments which must be brought into play in the process of promoting irrigation development on communal lands if the objectives of equity and stability are to be considered in making decisions about the development of at least some potential irrigation schemes on communal lands.

## G. University and Technical Training

Although the team did not take an in-depth look at the manpower needs for irrigation and the associated training requirements, the team endorses the findings and recommendations reported by Kay (1985). There appears to be a considerable need for technical personnel with training of an applied nature, which Kay indicates could be provided at the agricultural college level.

At the professional level there is an urgent need for the initiation of a program of education in irrigation. It is the opinion of the team that this education must be a recognized professional qualification in the area of engineering. The rationale for an engineering qualification at the university level is that the professionals produced must be able to operate on a par with other more established engineering professions.

Within the University of Zimbabwe there is a mandate within the Faculty of Agriculture to initiate a program in Agricultural Engineering. Professional level education in irrigation engineering would fit well into the development of such a program. Such a proposal has a model in the Land Grant system of universities in the U.S. Many of the Agricultural Engineering programs have a strong irrigation component and are recognized engineering qualifications. The programs are normally resident in the Colleges of Agriculture but the degrees are granted through the Colleges of Engineering.

Opportunities exist within the Agriculture and Engineering Faculties of the University of Zimbabwe for the joint development of a professional program in irrigation engineering. Informal discussions with faculty indicate a considerable level of interest in such a proposal. A preliminary review of the existing courses indicate that a program could be developed with a minimum number of new courses required. Considerable planning and discussion would be necessary in order to develop such a program, but the need and the opportunity are present.

Another recommendation of the team is the establishment of a Water Management Institute or Center at the University of Zimbabwe. the purpose of such a center would be an opportunity for interdisciplinary research and studies in all areas of water management problems. A particular focus would be the integration of agronomic and technological approaches with the socio-economic aspects of irrigation water management.

No estimates of the numbers of professional and technical staff required for irrigation development in Zimbabwe were developed. It is considered that Kay's (1985) estimates were reasonable. However, should Zimbabwe take the initiative to develop a strong training and evaluation program in the area of irrigation it is likely that it will attract additional participants from other countries in Africa.

<u>Courses of Action</u>

- Develop a professional level irrigation engineering program at the University of Zimbabwe.

- Establish a Water Management Institue or Center for interdisciplinary studies in irrigation.

- Review the recommendations of Kay (1985) and implement where appropriate.

H. Support for schemes

It is the opinion of the team that it is not appropriate for large-scale investment and new small-scale irrigation schemes in Zimbabwe by foreign donors at this time. If significant development in this area is to occur, it must be with the initiative and financial support of the GOZ. However, it is appropriate for assistance to be supplied to assist in the development of new schemes where such a development will serve as a field trial for ideas and techniques. Incorporated into any such development must be adequate monitoring and evaluation together with analysis of data so that the effectiveness of the ideas and techniques can be evaluated.

Such trial schemes would present opportunities for field level testing under actual operating conditions. Topics such as agronomic practices, irrigation water delivery and application techniques, water allocation and use, and alternative structures for IMCs could be evaluated. The level and duration of monitoring would have to be determined so that an adequate test could be carried out. It is considered that such trial scnemes would provide many useful learning experiences and the testing of ideas for possible incorporation on other schemes.

Courses of Action

- Investigate the need for new small-scale irrigation schemes to test ideas and techniques for application in Zimbabwe.

- Develop sources of funding to initiate and operate a limited number of such schemes.

- Incorporate monitoring and evaluation into system operation with the provision for analysis and reporting of system performance.

## IV. SOURCES OF INFORMATION

### A. Published Material

The WMS team was impressed by the quality and quantity of material available on irrigation in Zimbabwe. In addition, information on soils, water resources and land classification is available, together with high quality maps. The Government of Zimbabwe is to be commended on the high standard of these publications.

A substantial amount of information is readily available on the irrigation sector in Zimbabwe. The irrigation sector can be divided into two groups of irrigation schemes which bear a strong contrast to each other with regards to their average sizes, their economies, level of professional management and their contribution of the national economy. The first group consists of commercial irrigation schemes (large commercial estates and individual schemes on private commercial farms) which range in size from about 50 ha to about 13,000 ha per scheme, and account for an aggregate of 133,000 ha in Zimbabwe.

The second group of irrigation schemes consists of 74 smallholder schemes in communal (rural) areas and which have a total area of about 3,500 ha. Plot sizes range from 0.1-2.0 ha, leading to a national total of about 6,000 plot holders (DERUDE, 1983).

Commercial irrigation schemes tend to be efficiently run, highly economic and contribute significantly to the national economy whereas communal schemes are generally less efficiently run and their contribution to national development tends to be of a welfare nature.

Data on the commercial irrigation subsector have always been available through the Central Statistical Office, Government of Zimbabwe. Until about 1980, little was published on the communal subsector.

However, since 1980, numerous studies have been carried out on communal schemes and numerous reports have been produced. It was also noted that some government officials contend that there is no need for further studies to be carried out and that considerable of irrigation development can be carried out on the basis of studies made so far.

Government Publications

The Policy Paper on Small-Scale Irrigation Schemes produced by the Department of Rural Development (DERUDE, 1983) is one of the most compehensive documents on communal irrigation schemes. It was the first document to provide a complete list of all the schemes in the communal areas of Zimbabwe, their real extent and their potential for expansion. The document went further to define the regulations binding the practice of irrigation in these areas.

Staff of the Minister of Water Resources and Development (1984) made a complete assessment of the "Surface Water Resources of Zimbabwe and Guidelines for Development Planning." The surface runoff of all the catchments in Zimbabwe were calculated, thus making it possible to determine the amount of water available for storage and irrigation in Zimbabwe.

Thompson and Purves (1978) produced a soil map of Zimbabwe at a scale of 1:1,000,000. The map shows areas (identifiable at that scale) of potentially irrigable soils.

Consultancy Reports

Numerous studies have been carried out by consultants, mostly with funds provided under cooperation agreements between the GOZ and foreign governments or international organizations. Below is a list of some of the notable ones:

Mashonaland East Province Study (1982)

A broad study of the Mashonaland East Province was carried out by a group of Agricultural Consultants for the Agricultural and Rural Development Authority (ARDA) in 1982. Among other objectives the study was commissioned to identify small-scale irrigation schemes in the province. A number of those identified were implemented.

Midlands Province Irrigation Development (1985)

DANGROUP, a Danish agricultural and engineering consultancy company carried out a study to identify dam sites and possible irrigation schemes in the Midlands Province. The study was divided into three phases. In Phase I, about 150 dam sites were identified by remote sensing methods. Forty of these sites were found to be promising in terms of their possible use for irrigation. In Phase II, 10 of the 40 dam sites were selected for detailed feasibility studies for irrigation development. Out of the 10 sites, three sites were chosen for detailed design of the dams, irrigation schemes, water conveyance and night storage works. In Phase III, it is hoped that Denmark will finance the construction of the three dams and irrigation schemes.

USAID (1982): Irrigation in Zimbabwe

USAID commissioned a local consultancy company to review the irrigation sector in Zimbabwe. The agency possibly wanted to decide which aspects or areas of the sector it could get involved in. The report is essentially a review of the state of the irrigation sector in Zimbabwe at the time, describing the extent of irrigated land under various forms or systems of management. USAID does not appear to have been prompted into involvement in irrigation as a result of the report.

World Bank (1984)

The World Bank carried out a detailed review of the irrigation sector in Zimbabwe. The one unique feature of the study is that it is the only study which took a critical look at the policy issues governing irrigation in Zimbabwe, including the idea of subsidizing small-scale irrigation schemes in communal lands. The report is detailed and appears to be another World Bank "state-of-the-art" report to be used by any agency intending to get involved in irrigation in Zimbabwe.

Blackie, M.J., Hungwe, A. and Rukuni, M. (1984) Irrigation Development and Water Management Strategies in Kenya and Zimbabwe

Report prepared for Ford Foundation, Eastern and Southern Africa Office. As a result of the report, the Ford Foundation has decided to pursue the subject of policy with regard to irrigation in Kenya and Zimbabwe. The foundation is funding a series of workshops, involving local personnel in both countries, at which the experts discuss irrigation policy issues. The ultimate objective is to produce a publication on irrigation policy issues.

G K W Consult (1985) Rehabilitation and Development of Small-Scale Irrigation Schemes in Communal Lands (Zimbabwe)

The report of the study is in 10 volumes. The study was commissioned by the then Ministry of Lands, Resettlement and Rural Development to examine the rehabilitation of schemes damaged during the war and the further development of irrigation and communal lands. This study and the report are currently the most authoritative source of information on irrigation in the communal lands of Zimbabwe.

Rukuni, M. (1984) Analysis of economic and institutional factors affecting irrigation development in communal lands of Zimbabwe, Ph.D. thesis, University of Zimbabwe.

The study revealed that there is a general lack of information, data and an analytical framework for policy guidelines on smallholder irrigation development in Zimbabwe. Original data characterizing irrigation in Zimbabwe is presented and analyzed.

B. Field Trips

The WMS team was fortunate to be able to travel widely in Zimbabwe and to visit 21 small-scale and small-holder irrigation schemes in addition to large-scale commercial and ARDA estates. A complete itinerary is given in Appendix B. A summary of the small-scale schemes visited is given in Table 1.

Table 1. Small-Scale Irrigation Schemes Visited by the WMS Team.

| Name | Type (ha) | Area | Size of Holding (ha) | Water Source |
|---|---|---|---|---|
| Banga | Derude* | 45 | 0.1 - 0.4 | Gravity from river |
| Charandura | Communal | 3.6 | 0.1 | Gravity from river |
| Devure | Derude | 272 | 0.2 - 2.4 | Gravity from river |
| Duncal | Derude | 12 | 0.1 - 1.0 | Pump/Gravity |
| Exchange | Derude | 158 | 0.1 - 1.0 | Gravity from river |
| Lambo | Derude | 2.5 | 0.1 - 0.4 | Gravity from river |
| Lukosi | Derude | 12 | 0.1 - 0.4 | Sand abstraction |
| Makonese | Derude | 60 | 0.1 - 1.0 | Pumped from river |
| Mhende | Derude | 70.2 | 0.1 - 1.4 | Gravity from river |
| Mushandike | | Under Development | | Gravity from river |
| Mkoba | Communal | 10.2 | 0.1 - 0.4 | Gravity from river |
| Musruugwe | Derude | 56 | 0.1 | Pumped from river |
| Mutambara | Communal | 145 | 0.1 - 1.0 | Gravity from river |
| Mutwma | Derude | 237 | 0.1 - 2.0 | Pumped groundwater |
| Mzinyatini | Command | 32 | 0.1 - 0.4 | Gravity from river |
| Ngondoma | Derude | 22.2 | 0.1 - 1.0 | Gravity from river |

Table 1. (continued)

| | | | | |
|---|---|---|---|---|
| Nyanyadzi | Derude | 414.4 | 0.1 - 1.6 | Pump/Gravity from river |
| Shagari | Derude | 26 | 0.1 - 2.0 | Gravity from river |
| Silalabukwa | Derude | 449 | 0.4 - 1.0 | Gravity from river |
| Tawana | Derude | 150 | 0.1 - 1.0 | Pumped from river |
| Tshovane | ARDA** | 332 | 5 - 10 | Pumped from river |

*Derude = Department of Rural Development
**ARDA = Agricultural and Rural Development Administration

## C. WMSII Experience

### WMSII EXPERIENCE AS A SOURCE OF INFORMATION FOR THE ANALYSIS OF OPPORTUNITIES FOR IMPROVEMENT OF SMALL-SCALE AND SMALL-HOLDER IRRIGATION SCHEMES IN ZIMBABWE

### 1. General Framework

The experience gained under the Water Management Synthesis Project (WMS) has contributed to the development of both an approach to analyze small-scale/small-holder irrigation in Zimbabwe and to develop alternatives for capitalizing on the opportunities which such irrigation offers as a means of achieving the development goals of Zimbabwe. It needs to be stressed that WMS experience can provide neither formulae nor blueprints for the improvement of irrigation in Zimbabwe. In fact, one of the major lessons learned as the result of WMS's experiences is that if either an irrigation development program or an irrigation improvement program is to be successful, it must be based on 1) the characteristics of each site, 2) the characteristics of the general irrigation system, 3) the cultural setting in which irrigation will take place, 4) the technical, financial and human resources which are either available or which can be generated and 5) the development objectives which the program is to achieve. While there are no exact prescriptions, WMS experience has shown that there are certain general principles which are useful in situations such as those related to small-scale/small-holder irrigation in Zimbabwe.

If irrigation programs are to be effective, they need to be viewed in a socio-technical framework. If irrigation programs are viewed as involving only technical issues, it is most likely that such programs will not be effective. While it is necessary to resolve the technical issues associated with the physical nature of the irrigation system if a program is to be effective, other factors must also be considered. One way to begin to deal with the set of interrelated issues which must be addressed is to use the matrix presented below (Figure 1 - "Matrix of Irrigation Management Activities", Norman Uphoff, Ruth Meinzen-Dick and Nancy St. Julian, "Improving Policies and Programs for Farmer Organization and Participation in Irrigation Management," Cornell University, draft of WMSII paper, December, 1985). While the matrix presented below was designed to deal with farmer participation issues, it will serve a broader purpose in this paper. For an irrigation system to be effective, three basic types of activities -- 1) control structure activities, 2) water use activities, and 3) organizational activities -- must be addressed within the context of both a) the hydraulic levels of the irrigation system and b) the management entities which are involved in the irrigation system.

A schematic of these components and the terminology used within WMS is presented in Figure 2 below (taken from a draft of material developed by Dr. Jack Keller of Utah State University for presentation in a forthcoming WMSII Triad Synthesis Report). While it is necessary to deal with each hydraulic level and each management entity, it is also necessary to deal with the interfaces between different hydraulic levels and management entities. The pattern of hydrologic levels,

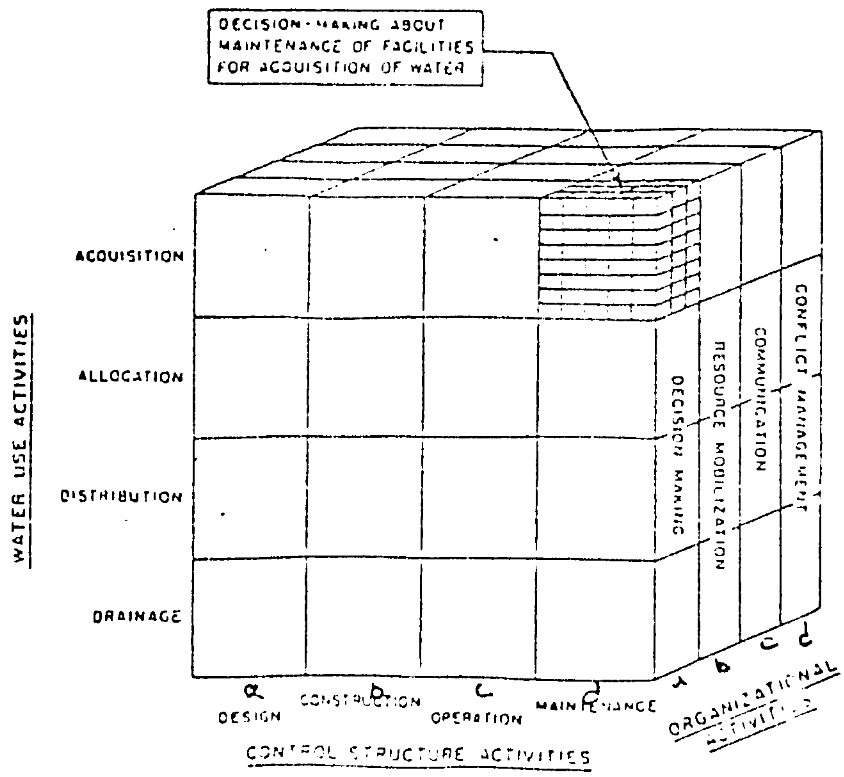



Figure 1. Matrix of Irrigation Management Activities.

organizational entities and interfaces involved will depend on both the general nature of the irrigation system and the particular irrigation scheme and these issues need to be considered if effective irrigation development and improvement programs are to be developed. In some cases, there may need to be changes in the specifications of levels, entities and interfaces if the irrigation program is to be effective.

The basic unit of an irrigation scheme is the field. The aggregation of those fields served by a turnout into a common watercourse is referred to as the Unit Command Area (UCA). WMS experience has shown that in nearly all effective irrigation schemes, the basic organizational entity which must be established is a Water Users' Association (WUA) and the irrigated area managed by this organizational entity needs to be consistent with the area commanded by a hydrologic level designated as a Unit Command Area (UCA).

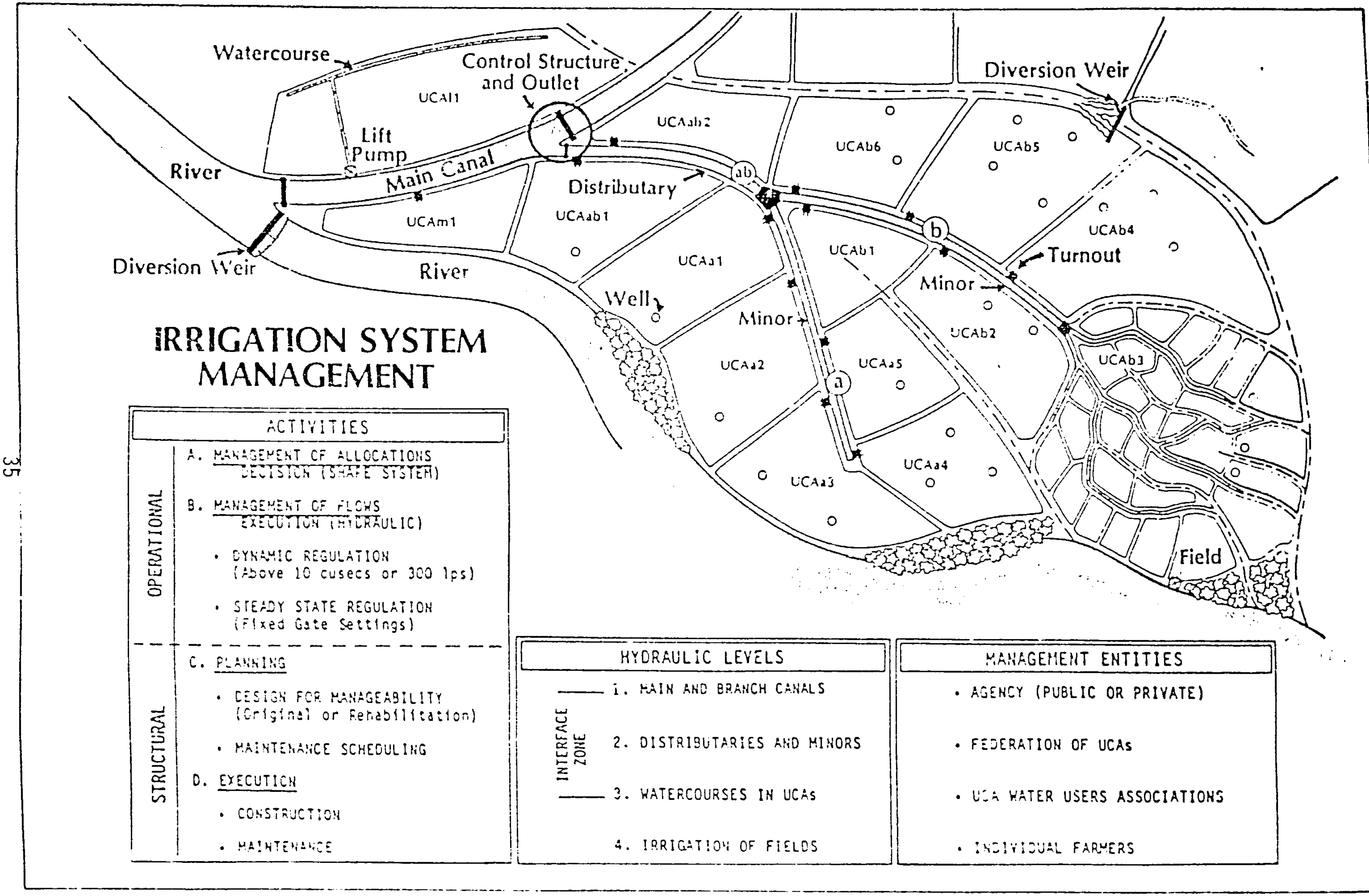



Figure 2. Pictorial sketch and common elements of a relatively large canal irrigation system with outline of irrigation system management activities, entities and hydraulic levels.

However, even in the case of this firm principle, exceptions have been observed. In some cases, where the UCAs are small in terms of the number of farmers, farmers have themselves developed WUAs which serve several closely related UCAs while in other cases where the number of farmers in a UCA were large, subcommittees of the WUA were created and these subcommittees functioned as the operational WUA. It appears that farmers have a good feel for what has to take place in order for an organization to be effective in their environment, and if they have appropriate assistance the freedom to act, they will make appropriate adjustments in the structure of the WUAs. The problems of developing appropriate hydrologic levels, organizational entities and the appropriate interfaces are complex and to be effective, the development must be site specific. While no attempt will be made to repeat the lessons learned by WMS, specific comments based on observations in Zimbabwe that relate to some of the important lessons learned will be discussed below.

## 2. Farmer Organizations and WUAs

The announced policies of the GOZ ("Policy Paper on Small-Scale Irrigation Schemes," MLRRD, Dept. of Rural Development, April, 1983) and the practices observed in the field by the WMS team are consistent with the general principles that WMS has found which need to be recognized in order to bring into being the type of organizations required for the development of effective small-holder irrigation schemes. In addition, the tradition of community cooperation in Zimbabwe provides a general environment which is conducive to the development of effective WUAs. The formal training programs already in existence for Irrigation Management Committees is also clear evidence that the Irrigation Department of the MLARR recognizes the potential usefulness of explicit efforts to build more effective farmer organizations. All of this is encouraging and represents a level of awareness of the importance of socio-economic issues in irrigation development seldom encountered in even fairly mature irrigation societies. What will be presented below is a very brief summary of the material presented by Uphoff et al. (1985) on farmer participation. Not all of these can be applied directly to Zimbabwe, but they are offered as a means of initiating a dialogue which will result in the increased effectiveness of small-holder irrigation in Zimbabwe.

"Farmer participation in irrigation management can vary greatly in kind and degree. The objective -- from farmers' as well as the agency viewpoint -- should be 'optimum' rather than maximum participation because participation entails costs as well as benefits. Possible benefits include increased production, improved water distribution, reductions in conflict, greater local resource mobilization, and system sustainability over time.

Experience documented in the literature shows that farmer cooperation can contribute to increased flows of water reaching downstream areas, greater area cultivated, higher cropping intensity, lower costs of construction, reduction in water issue requirements, expansion of the system capacity and better operation and maintenance" (Uphoff et al., EXECUTIVE SUMMARY, pp. iii, 1985).

Uphoff et al. (1985) list eight elements of strategy which they have identified as contributing to success in different settings and nine generalizations which they characterize as "tenable."

1. Support from top levels of the government and bureaucracy is crucial, although not to push through a preconceived plan.

Rather, a program promoting farmer participation needs to have appreciation and perseverence from above that creates "space" within which bottom-up capacity can be built. The relevant actors will be in various ministries and institutions, so forging a network of supportive leadership, intellectual and administrative, is important for seeing a program through to successful institutionalization.

2. Experimentation phasing and flexibility should characterize the efforts. A "learning process" approach is most appropriate, with the development of a cadre of persons who have knowledge, experience, and commitment relevant to the program's goals.

3. A strategy of building from below, starting with base-level groups as the "building blocks" referred to above, should put the organizations on a firmer foundation than if a conventional top-down approach is followed, including calling large meetings, usually through the local elite or lower officials, to select officers, ratify a present constitution, etc.

4. Where possible, it is advisable to try to work with and through any existing local organizations that have capacity relevant to improving irrigation management.

5. Questions of ownership need to be addressed. Whose irrigation system is it? Whose organization is it? To the extent that water users feel some proprietary interest and responsibility, they will participate more actively and effectively.

6. Intrusion of "politics" into water allocation and distribution will spoil cooperation among farmers. Whether associations will be nonpartisan and their orientation and activities depend very much on whether the government will allow them to remain politically neutral.

7. Getting administrative personnel to work cooperatively and constructively with farmers usually requires some bureaucratic reorientation. This may come, however, not all in advance of a program but as an important and necessary concomitant.

8. The compatibility of objectives between governmental users will affect the viability of organized farmer efforts. If the government wants for farmers and their families what they want for themselves, cooperation becomes "positive-sum" and more readily sustainable.

On matters of program design, the following generalizations appear tenable:

1. Water User Associations should start with a focus on irrigation management rather than be launched as multipurpose organizations. But to the extent that members want to engage in other collective action through their WUAs and feel they can manage the additional functions, they should be able to make such decisions, since the organizations are "theirs" and not the government's.

2. The size and structure of organization should follow hydrologic lines, though these will seldom be simple or symmetrical. Water users should be free to make decisions about the amalgamation and subdivision of groups so as to form "user-friendly" structures of organization.

3. Membership should be based on "field neighbors" rather than residential neighbors if the two sets of persons are different, in keeping with the principle of hydrologically-meaningful organization. WUA membership should be vested in the household rather than in the household head (who is usually male and older), so women and younger persons can play more active roles.

4. Having conscientious, energetic leaders who enjoy the confidence of their peers is the key to success in participatory water management. Sometimes existing local leaders are suitable, but often new talent needs to be mobilized into leadership roles.

5. Having legal authorization and specification for WUAs is important, but such legislation should seek to buttress entities that have their own integrity and reality, rather than turn out organizations that have to win legitimacy and status in the rural community.

6. Technical personnel are so often overloaded with other duties that it is usually a moot point whether or not they have the talent and disposition to organize farmers into water user associations. Some of the most successful programs introducing farmer participation have relied on "catalysts," organizers specially recruited, trained, and deployed to live and work closely with rural people.

7. A strategy of organizational development does well to start from a pilot effort, first learning to be effective, then to be efficient, and finally to expand to other areas. The sequence of efforts will usually proceed from initial organizational efforts on an

intensive scale, to consolidation efforts on a more extensive scale, and then maintenance activities for the long run. Social infrastructure requires certain maintenance investments to remain effective just like physical infrastructure.

8. Nongovernment organizations -- private voluntary organizations and/or knowledge building institutions -- can make significant contributions to a program because of their different styles of operation and different skills and orientation.

9. There is no substitute for leadership from within the agency or agencies concerned. Promoting farmer participation requires a participatory mode of operation within the agency, and building linkages with professionals, administrators, researchers, and others outside. An increasing number of agencies are likely to embark on such efforts based on a growing record of positive experiences with farmer participation in the irrigation sector.

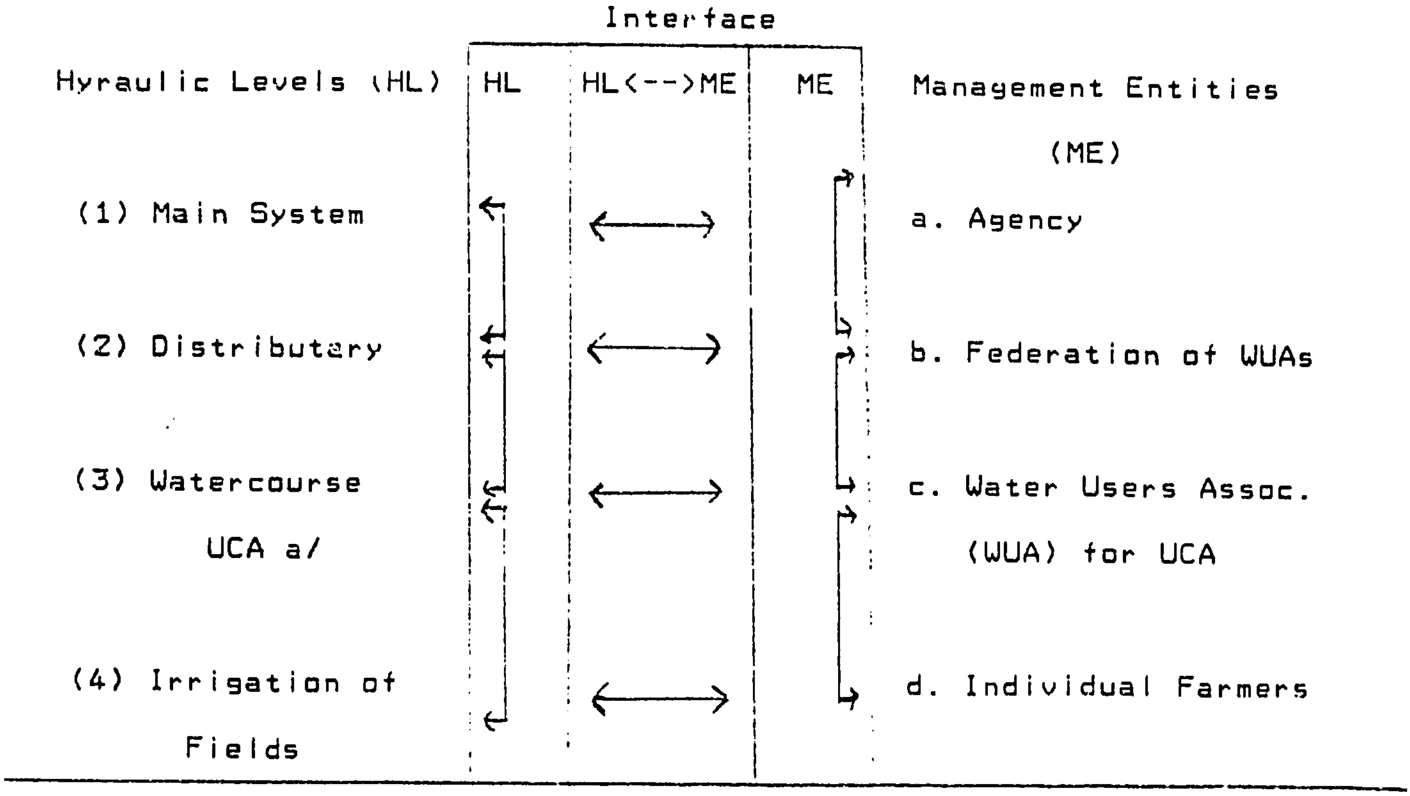
None of the elements of strategy nor the generalizations presented above seem in specific conflict with observations made by the WMSII team while in Zimbabwe. However, it did not appear that these ideas either always followed or were part of an explicit policy. It is recommended that a review of the program for training, selecting, operating and maintaining effective irrigation committees be carried out in cooperation with experts on water user associations and that the ideas presented above be used as a basis for enhancing the existing program. Not all of these ideas may be the best for Zimbabwe, and some may need to be either modified or rejected. However, if this is necessary, the reasons for the changes need to be explicit and understood.

B. Interfaces - Hydraulic Levels and Management Entities

If an irrigation system is to be effective, the interfaces between the hydraulic levels and management entities must function effectively. A highly simplified model of the nature of the relevant interfaces is presented below. This model is based on the assumption that both the hydraulic levels and management entities operate within a hierarchical structure and that management entities correspond to the hydraulic levels. In reality, this correspondence may not occur and either changes in the definition of management entities is required or management entities will have to develop special procedures for managing the portion of the irrigation system for which they are assigned responsibility.

In the case of Zimbabwe, the structure of the interface is not that clear and this may give rise to certain problems. The Ministry of Water Resource and Development (MWRD) is responsible for the hydraulic levels of 1) Main system (which is usually either a reservoir or a pumping station), and 2) Distributary (which often terminates in some type of intermediate storage). If the interfaces are to be effective, it is important that there be two-way communication. Based on the

Hydraulic Level and Management Entity Interface Model




a/ Unit Area Command

teams limited observations, it is not clear that such communication exists in terms of the management functions. Further, it is not clear what the long-term management role will be of the Irrigation Department (ID) of the MLARR. The policy statement of the ID states that it is their objective to turn the operation of the schemes over to the farmers as soon as that is possible. When this state of development occurs, the management role of the ID could be largely advisory. However, such a role could only lead to effective irrigation schemes if the WUAs and their federations were very strong.

Unless there is a specific plan to bring about such WUAs, and at best, this is probably a long-term goal, the ID needs to 1) develop a clear statement of its management role and 2) deal more explicitly with the problems of interface between the MWRD and the WUAs. While the intermediate storage facilities lessen the interface problems between the hydraulic levels of (2) Distributary and (3) Watercourse, the interface between the management entities does not appear to be well designed to deal with such problems.

This is one of the areas which could benefit from 1) further study, and 2) a joint effort to develop a clearer and probably more effective set of interfaces. This issue is closely related to two other issues: 1) the type and effectiveness of WUAs which will be developed, and 2) the ability to integrate small-scale/small-holder irrigation into the planning and development of Zimbabwe's total water resources.

## V. REFERENCES


Blackie, M.J., Hungwe, A. and Rukuni, M. 1984. Irrigation Development and Water Management Strategies in Kenya and Zimbabwe. A report prepared for the Ford Foundation, Eastern and Southern African Office.

Department of Rural Development (DERUDE). 1983. Policy Paper on Irrigation Schemes in Communal Areas.

Dangroup. 1985. Irrigation Development in the Midlands Province. A study carried out for Ministry of Lands Resettlement and Rural Development.

G.K.W. Consult. 1985. Rehabilitation and Development of Small-Scale Irrigation Schemes in Communal Lands. A study carried out for Ministry of Lands, Resettlement and Rural Development.

Kabell, T. 1984. An Assessment of the Surface Water Resources of Zimbabwe and Guidelines for Development Planning. Ministry of Water Resources and Development. Harare, Zimbabwe.

Kay, M. 1985. Irrigation Training Needs in Zimbabwe. Report prepared for the Food and Agriculture Organization of the United Nations.

P.T.A. Agricultural Consultants. 1982. Study of the Agricultural and Rural Development of the Communal Areas of Moshoualand East Province. A study carried out for Ministry of Lands Resettlement and Rural Development.

Rukuni, M. 1984. An analysis of economic and institutional factors affecting irrigation development in communal lands of Zimbabwe. Ph.D. Thesis, University of Zimbabwe.

Thompson, J.H. and Purves, W.D. 1978. A guide to the soils of Zimbabwe. Zimbabwe Agricultural Journal Technical Handbook No. 3.

United States Agency for International Development. 1982. Irrigation in Zimbabwe. Harare. Hawkins Associates, Planning and Development Consultants.

World Bank. 1984. Irrigation - Zimbabwe Subsector Review. Working Paper, Washington, D.C.

# VI. APPENDICES

# APPENDIX A

## Some Aspects of Irrigation Agronomy for Communal Area Irrigation Schemes

### Crops

The main summer crop grown under irrigation is maize. The crop can be marketed as green maize at a favorably high price of Z$0.1 - 0.2 per ear, or can be harvested as grain and sold to the Grain Marketing Board. Some of the grain is retailed for consumption by the farmer.

Where all-year-round irrigation is practiced, the summer maize crop, harvested in December to February, is followed by a crop of sugarbeans which in turn is followed by vegetables. The type of vegetables grown depends on th preferences of the local market.

The table below shows the cropping program.

August October December February May July

Maize

Maize

Cotton

Sugar Beans

Vegetables

Cotton is not commonly grown under irrigation in the communal areas because it has a long growing season such that the farmer can only grow two crops per year. The crop also requires expensive inputs of fertilizers and pesticides and the crop is labor intensive.

Efficient farmers at schemes with a year round supply of water produce 3 crops per year of maize, sugarbeans and vegetables, mainly tomotoes, cabbages and onions.

Fertilizers are applied at most schemes, at levels as advised by the extension worker. Farmers interviewed appreciated the benefit of fertilizer use. The quality of the extension service provided to the farmers on irrigation schemes is generally high.

## Soils

Good irrigation soils should have the following properties:

- deep (greater than 60 cm) to provide adequate rooting depth,

- medium- to heavy-texture for a high waterholding capacity - sandy loams to clayey in texture,

- of reasonable inherent fertility to reduce the need for high fertilizer application,

- of good interal drainage properties to avoid stagnation of water in the soil profile, and

- must not be sodic or saline.

Most irrigation schemes visited had good soils by the criteria listed above showing that soil examination had been carried out prior to the establishment of the scheme. However, some schemes with soils of limited suitability were observed. For example, Lukosi in Matebeleland North Province is sited on what appeared (in the absence of chemical analysis) to be sodic soils. Crops at the scheme showed clear signs of water stress 2-3 days after irrigation and low yields were achieved.

However, at Mkoba irrigation scheme in Midlands Province, the soils are light-textured, and hence of restricted suitability for irrigation, but farmers are able to achieve high yields by following good management practices.

## Irrigation Management

Most of the schemes in communal areas use surface methods of water application. Two schemes using overhead sprinkler method were visited and it was clearly evident, in the one case at Devure Irrigation Scheme, that the system was running at a very low level of efficiency. The equipment was in a poor state of disrepair.

Irrigation frequencies at schemes in communal areas were calculated on the basis of soil properties, and for most schemes visited were in the range 7-10 days. The design irrigation frequencies are not always achieved because of one or more of the following:

a) water shortage for the whole scheme,

b) breakdown of pumping works,

c) over abstraction of water by some irrigators leading to a longer turn around time.

It would appear that the problem of water use efficiency at the schemes need to be closely examined to come up with working solutions.

Mhende irrigation scheme in Midlands Province had an impressive system irrigation scheduling. The days for irrigation for the whole cropping season for each irrigation block were calculated and set out on a calendar before planting.

## Marketing of Produce

Most of the maize produced by communal irrigation schemes is consumed by the farmers. However, some of the maize is sold green, especially where the scheme is situated near major business centers such as a town or mine. The price of green maize is between Z$0.1-0.2 per ear, which is very economic. The remainder of the maize is sold to the Grain Marketing Board (GMB), a quasi-government board which has the obligation of purchasing all gazetted grains at a controlled price, which is uniform at all GMB depots throughout the country. Since the farmer has to bear the cost of transport to the depot, the economics of maize and other grain production under irrigation is heavily dependent on the transport infrastructure available.

Vegetable crops grown on schemes are marketed locally or at major centers. In Manicaland Province, industrial canning factories purchase crops like tomatoes, peas and beans from some of the irrigation schemes in the province. The selection of a vegetable crop by farmers and the profitability of growing the crop under irrigation is heavily dependent on the availability of marketing facilities and the existence of good transport infrastructure.

## APPENDIX B

### ITINERARY - Zimbabwe

| | |
|---|---|
| Monday, January 27 | Leave Fort Collins |
| Tuesday, January 28 | Arrive London - layover |
| Wednesday, January 29 | Leave London |
| Thursday, January 30 | Arrive Harare<br>Meet with Kirk Lawton, MSU, Univ. of Zimbabwe<br>Eric Witt, ADO/USAID<br>Simon Pazvakavambwa, Assistant Director, Irrigation, Ministry of Lands, Agriculture & Rural Resettlement<br>Collect and peruse base data |
| Friday, January 31 | Read collected material<br>Meet with Malcolm Blackie, Dean of Agriculture, University of Zimbabwe<br>Discuss outline of final report |
| Saturday, February 1 | Trip to Lake McIlwaine, Darwendale Dam to look at water resources for irrigation, municipal use |
| Sunday, February 2 | Rest Day |
| Monday, February 3 | Meet with Simon Pazvakavambwa, John Graham and Johannes Makadho, Chief Irrigation Officer, Irrigation Section, Ministry of Lands, Agriculture and Rural Resettlement to plan field work<br>Meet with Alois Hungwe to discuss joining the team<br>Clear with Eric Witt<br>Arrange transportation |
| Tuesday, February 4 | Meet with Alois Hungwe to arrange trip<br>Take care of details prior to departure<br>Pick up vehicle |
| Wednesday, February 5 | Leave for Mutare<br>Meet with Mr. Pat Horsefield, Dept. of Rural Development, Ministry of Lands, Mutare<br>Visit Mutambara Irrigation Scheme |

| | |
|---|---|
| Thursday, February 6 | Visit Devure Irrigation Scheme<br>Meet with Mr. Musonza, Irrigation Supervisor and Mr. Begede, Chairman, Irrigation Management Committee<br>Visit Mutema and Tavona Irrigation Schemes<br>Meet with Mr. L. Sigauke, Irrigation Manager and Mr. S. Gimani, Irrigation Officer, Agritex. |
| Friday, February 7 | Visit Nyanyadzi Irrigation Scheme<br>Meet with Mr. S. Pazvakavambwa, and Mr. Sithole, Irrigation Manager<br>Visit Middle Sabi Irrigation Scheme<br>Meet with Mr. Angus Thomson, Manager, Struan Farms |
| Saturday, February 8 | Visit Chisumbanje Irrigation Scheme<br>Meet with Mr. Gwerengwe, Estate Manager, and Mr. R. Sigauke, Field Manager<br>Visit Tshovane Irrigation Scheme<br>Meet with Mr. Marime, Irrigation Manager |
| Sunday, February 9 | Visit Hippo Valley and Triangle Estates<br>Visit Banga Irrigation Scheme |
| Monday, February 10 | Visit Mushandike Irrigation Scheme<br>Meet with Mr. Ringson Chitsiko, Irrigation Specialist, Agritex, Masvingo<br><br>Work on Executive Summary Report |
| Tuesday, February 11 | Meet with Mr. J. Makadho and Mr. R. Chitsiko, Agritex<br>Visit Makonese Irrigation Scheme<br>Visit Musvuugwe Irrigation Scheme |
| Wednesday, February 12 | Meet with Mr. O. Mutema, Irrigation Manager, Department of Rural Development, Gweru<br>Visit Mkoba Irrigation Scheme<br>Visit Shagari Irrigation Scheme |
| Thursday, February 13 | Meet with Mr. Hungwe, Dept. of Rural Development, Gweru<br>Visit Charandura Irrigation Scheme<br>Visit Mhende Irrigation Scheme |
| Friday, February 14 | Meet with Mr. O. Mutemi, Dept. of Rural Development, Gweru<br>Visit Exchange Irrigation Scheme<br>Visit Ngondoma Irrigation Scheme<br>Return to Harare |

| | |
|---|---|
| Saturday, February 15 | Return rental car<br>Work on report recommendations |
| Sunday, February 16 | Rest Day |
| Monday, February 17 | Meet with Mr. Simon Pazvakavambwa and Mr. John Graham, Ministry of Lands, Agriculture and Rural Development to discuss preliminary findings.<br>Meet with Dr. Malcolm Blackie and Dr. Mandi Rukuni, Faculty of Agriculture, University of Zimbabwe to discuss preliminary findings<br>Work on final report outline |
| Tuesday, February 18 | Meet with Mr. John Graham to discuss trip to Bulawayo and Victoria Falls<br>Meet with Mr. Eric Witt, ADO/USAID to discuss preliminary findings<br>Prepare for Bulawayo/Victoria Falls trip<br>Meet with Mr. Terry Kabell, Design Engineer, Ministry of Water Resources and Development |
| Wednesday, February 19 | Fly to Bulawayo<br>Meet with Mr. Caleb Mbuyazve, Irrigation Manager, Bulawayo<br>Visit Duncal Irrigation Scheme |
| Thursday, February 20 | Visit training course for Irrigation Management Committee members at Iskoveni Training Center with Mr. Mbuyazwe<br>Visit Silalabukwa Irrigation Scheme<br>Visit Mzinyatini Irrigation Scheme<br>Visit Esigodini Agricultural College and talk with members of training course |
| Friday, February 21 | Meet with Mr. Beau Walton, Irrigation Representative Stewarts and Lloyds, and former Regional Irrigation Specialist, Agritex<br>Meet with Mr. Peter Marritz, Regional Engineer, Ministry of Water Resources and Development<br>Fly to Victoria Falls |
| Saturday, February 22 | Visit Lukosi Irrigation Scheme with Mr. Mbuyazwe<br>Visit Lambo Irrigation Scheme<br>Fly to Harare |
| Sunday, February 23 | Work on Principle Conclusions |

| | |
|---|---|
| Monday, February 24 | Meet with Eric Witt, ADO/USAID<br>Meet with Mr. John Maxwell and Mr. Perris Sinnett-Jones Engineers, Hydrology Branch, Ministry of Water Resources and Development<br>Work on Final Report |
| Tuesday, February 25 | Meet with Mr. Andrew Mpala, Deputy Secretary-Operations, Ministry of Water Resources & Development<br>Draft outline of Final Report and assign responsibilities |
| Wednesday, February 26 | Meet with Mr. Eric Witt, ADO/USAID<br>Redraft report<br>Meet with Mr. P. DeVillez, Irrigation Engineer and Mr. G.J. Walpole, General Manager, Stewarts & Lloyds, Harare<br>Meet with Dr. M. Rukuni, Faculty of Agriculture, University of Zimbabwe |
| Thursday, February 27 | Meet with Mr. B.N. Ndimane, Director of Agritex, to discuss findings<br>Debrief with Mr. S. Pazvakavambwa and Mr. J. Graham, Ministry of Lands, Agriculture and Rural Resettlement<br>Debrief with USAID, Mr. Roy Stacy, Mission Director, and Mr. Eric Witt, ADO<br>[Dick McConnen leaves for US] |
| Friday, February 28 | Meet with Alois Hungwe on final report<br>Discuss findings with Dr. Malcolm Blackie and Dr. Mandi Rukuni, Faculty of Agriculture, University of Zimbabwe<br>Discuss possibilities for Joint Field Study |
| Saturday, March 1 | Leave for England |
| Sunday, March 2 | Arrive in London |
| Monday, March 3 | Personal Time |
| Tuesday, March 4 | Personal Time |
| Wednesday, March 5 | Visit Silsoe College, Bedfordshire<br>Discuss African activities with Mr. Melvyn Kay, Mr. Richard Carter, and Mr. Keith Weatherhead<br>Give seminar on irrigation in Colorado and discussion of WMS activities |
| Thursday, March 6 | Return to U.S. |