IRRIGATION PERFORMANCE IN ZIMBABWE

Published by:

IRRIGATION PERFORMANCE IN ZIMBABWE PROJECT
UNIVERSITY OF ZIMBABWE 1994
FACULTY OF AGRICULTURE
P.O. BOX MP 167, MOUNT PLEASANT
HARARE. ZIMBABWE

.SBN 0-86924-108-7

Page Layout & Typesetting:
ALPHABETICA

Origination & Printing:
The Print Shop

Citation:
Rukuni M., M. Svendsen, R.Meinzen-Dick *with* G. Makombe eds. 1994. *Irrigation Performance in Zimbabwe.* Proceedings of two workshops held in Harare and Juliasdale, Zimbabwe, 3 - 6 August, 1993. UZ/AGRITEX/IFPRI Irrigation Performance in Zimbabwe Research Project. Faculty of Agriculture. Univeristy of Zimbabwe.

CONTENTS

INTRODUCTION

Mark Svendsen[a] and Mandivamba Rukuni[b]

BACKGROUND TO THE PROJECT

A collaborative programme of irrigation research to assess smallholder irrigation performance in Zimbabwe was initiated in 1989 involving the University of Zimbabwe (UZ), Agritex[1], and the International Food Policy Research Institute (IFPRI). Mandi Rukuni and Mark Svendsen served as co-directors for the project. Principal researchers on the project were Ruth Meinzen-Dick of IFPRI, Mandi Rukuni of UZ, and Mark Svendsen of IFPRI. Three graduate students also played vital roles on the project. These were Jo Makadho, Godswill Makombe, UZ[2] and Marc Andreini, Cornell University. Makadho, who is also the director of Agritex, provided extremely valuable access to irrigation systems, secondary data, and supporting field personnel, while Makombe managed and implemented the entire questionnaire survey data collection process in the field. The work was supported by grants from the Rockefeller Foundation and the International Development Research Center of Canada[3]. This proceedings reports on the results of that research as presented at a workshop held in Zimbabwe in August 1993.

The project had four specific objectives. These were:

- to examine and compare the performance of different types of irrigation systems in Zimbabwe;
- to develop and test a methodology for assessing small-scale irrigation system performance in Southern Africa;
- to examine system responses to various changes in operational practices and policies; and
- to examine the levels of investment and recurrent cost support justified by current and potential scheme performance.

These specific objectives were underlain by a general interest in the topic of water management, how it is practiced in different schemes and how it can be improved. The research was intended from the beginning to be multidisciplinary, and involved economists, engineers, and sociologists. A primary objective also was to help develop the skills of researchers interested in irrigation-related problems in Southern Africa, and one outcome of the project has been two Ph.D. dissertations; one from the University of Zimbabwe and one from Cornell University in the United States.

The project began with an inception meeting held at UZ in January 1989. At that meeting, individual interests, were explored, discussed and refined objectives for the study, fleshed out research methodologies, identified variables, proposed hypotheses, and laid out plans for the research. Another important function of this

[a] Research Fellow, International Food Policy Research Institute, Washington, D.C.

[b] Professor of Agricultural Economics, University of Zimbabwe.

series of intensive meetings was to build an effective working relationship among research team members. This was followed by a period of data collection which extended over nearly 4 years, coupled with a careful and painstaking process of data entry, checking, cleaning, gap-filling, and extensive analysis. The workshop reported on here brought to a close the phase of the research planned at that early meeting.

INTERNATIONAL CONTEXT

Before moving to presentation and discussion of specific results of the research and their implications, it may be useful to look at some of the trends affecting irrigation in the world outside Zimbabwe, and at some of the themes characterising the change and adaptation currently taking place. Although not all of these are relevant to conditions in Zimbabwe, they nonetheless provide the context in which irrigation investment and management issues are discussed internationally. Following that, this chapter will discuss briefly the African context for these international themes and provide background discussions of irrigation in Zimbabwe, and current irrigation issues in Zimbabwe. It will then offer brief overviews of the methodology employed in the research and of the workshop.

Globally, growth in irrigated areas has declined in recent years, with Asia a case in point. In Asia as a whole and in each sub-region, there have been sharp declines in the rate of growth in irrigated areas during the period 1960 to 1988. In South Asia, the growth rate in irrigated areas dropped from: 2.8 percent, 1975-80, to 1.8 percent, 1980-85, and to 0.1 percent, 1985-88. In East Asia, growth in irrigated areas was over 2 percent annually through the mid-1970s, but was virtually stagnant in the 1980s. In Southeast Asia the growth rate remained strong through the mid-1980s, but declined sharply from 4.1 percent, 1980-85, to 1.5 percent, 1985-88. For Asia as a whole, expansion of irrigated area has fallen from 2.0 percent in the early 1960s to 0.4 percent in the late 1980s (Rosegrant and Svendsen, 1993).

At the same time, investment in new irrigation by international lenders and donors, and many countries, are down. Worldwide World Bank lending for irrigation peaked around 1978 and since that time has declined to less than half its level during the late 1970s (Yudelman, 1993).

In addition, shifts are expected to occur in the composition of investment in the water resources sector. The World Bank estimates that of the amount required by the sector as a whole over the next 10 years, only a minor share will be allocated to irrigation, and much of this will probably be for rehabilitation and improvement work. The bulk of the remainder will be devoted to domestic water supply and sanitation systems. The rationale for this is that almost all of the growth in population expected during this period will come in urban areas where basic infrastructural systems, such as water supply and sanitation, will be under enormous pressure. It assumes, however, that factors other than new irrigation investment will drive the growth in agricultural output needed to feed this growing urban population.

In many parts of the world, fresh water resources are themselves nearly fully allocated to existing uses or to projects currently under development. This is the case in the Tigris/Euphrates basin, in the Jordan River Valley, in Central Java, in Malaysia, in South India, in the Western United States, in the Nile Valley, and in numerous other locations. What then are the implications of these global trends for irrigation managers and planners? We suggest the following:

First, that there will be strong emphasis on improving the performance of existing irrigation systems. Performance improvement programmes will rely on selective low-cost physical improvements coupled with sweeping institutional reforms rather than on the traditional engineering-based approach of comprehensive rehabilitation of civil works.

Second, steps will be taken to reduce the high public cost of operating and maintaining irrigation systems. With the rapid expansion of irrigation facilities occurring since 1950 has come tremendous increases in the costs of operating these facilities. And because governments have retained operational control over the great majority of these schemes, these costs have fallen to the government. Direct cost recovery programmes, in most cases, have fallen far short of supplying the needed funds for this and operating funds for the irrigation sector have become a major component of national budgets. In an era of large debt burdens and constricted public revenues, these budget lines are a natural target for government cost cutters.

Third, because of the limited remaining water resource potential in many locations, there will be reallocations of water from agricultural uses to urban and industrial ones. Herman Bouwer (1993) estimates that in 1900, 90 percent of the water diverted for human purposes was being used for agriculture. By 1980 that share had dropped to 80 percent, and by 1990 to 70 percent. By the year 2000, it is expected to fall further to about 60 percent. With the development of new sources of water drastically curtailed, this means that water currently being used in irrigated agriculture will be shifted to other more highly valued uses.

Fourth, there will be an increased reliance on market mechanisms, private sector actions, and financial incentives to accomplish the aims implied above. This will mean greater use of public utility models for managing irrigation schemes, profit sharing plans for employees of irrigation agencies, handing over of schemes to farmers to operate and maintain, rising prices paid for water, increased private sector development of smaller irrigation works, and possibly irrigated land going out of production when water rights are transferred to other uses.

Fifth, there will be increased emphasis on higher-valued cash crop production on irrigated land. This is a response to the rising cost of water to all users, including farmers.

Sixth, over the longer run we may experience rising global prices for food once again. As Figure 1.1 shows, the long run trend of wheat and rice prices, staple food grains for much of the world, have been steadily downward over most of the past century. This has been of enormous benefit to the world's population, especially the non-agricultural poor. However, the continuation of this downward trend in prices, and the sustained growth in world food production which it implies, will have to depend on sources other than the expansion of gross cropped area and increased yields due to new irrigation development.

The trends mentioned are global in nature and perhaps apply most strongly to situations in Asia and the Americas, North and South. It can be argued that the situation in Sub-Saharan Africa (SSA) is different and that this region is subject to a different set of forces and needs. Several of these are mentioned below. It is important to understand the themes outlined above, however, both because some of them may legitimately apply in SSA, and because they will tend to set the terms of any discussion of priorities for development and change in the water sector which involves the international community.

AFRICAN CONTEXT

Unlike Asia, SSA still faces a serious challenge in dramatically expanding absolute and per capita food production. In addition to sluggish growth of output in the agricultural sector, the region faces the highest regional population growth rate in the world. Population in SSA is expanding at an annual rate of just under 3 percent per year, compared with an average for developing countries of 1.9 percent. By 2025, if present trends continue, SSA will have a population of over 1 billion people, a 150 percent increase above the present population, and by the year 2050 the population could well be over 2 billion (Yudelman, 1993).

Even in Zimbabwe with its relatively well developed production infrastructure, a recent UN publication (UN and IFPRI, 1993) shows the per capita food production index generally declining between 1975 and 1990. Moreover, the ratio of the food price index to the overall consumer price index is about 10 percent higher in 1990 than it was in 1980, indicating that food may have become somewhat less accessible to low-income households, especially non-producer households.

In addition to the overall food security situation, the problem of drought-related famine is very much an issue in SSA. This is a situation which has been brought home forcefully to Southern Africa in recent years by extended drought-induced food shortages. Irrigation development is an obvious response in such situations, though certainly not the only one possible. It must be remembered though, that even comprehensive capital-intensive irrigation development is ineffective in maintaining agricultural output in the face of serious multi-year droughts. The recently-ended six-year drought in California, where public agricultural water allocations were reduced to zero in 1991, amply demonstrated this.

One of the main engines of growth in Asia, irrigation development, has yet to be employed on a large-scale in SSA. While 31.6 percent of arable land in Asia is irrigated, only 3.7 percent of arable land in SSA is provided with controlled water supplies[4]. The difference in productivity of irrigated and unirrigated land in semi-arid environments, or where precipitation is highly variable, is well established, and expanded irrigation has often been advanced as a solution to the chronic problems of stagnant agricultural productivity, declining per capita production and immense year-to-year variability in output which characterizes SSA agriculture.

A number of reasons have been advanced to account for the modest extent of African irrigation development. These include high irrigation development costs, low population densities, highly weathered infertile soils, poor supporting infrastructure, lack of a tradition of irrigated agriculture, and the absence of extensive alluvial floodplains and deltas such as those of the Indus, the Ganges, Yellow, Yangtze, and Mekong rivers in Asia. And while extensive irrigation development is not necessarily a correct developmental path for SSA to follow, the possibility remains to be adequately explored.

Many of the experiments with irrigation development in SSA which have failed have been based on models imported from Asia and elsewhere (Adams 1990). Given the numerous differences outlined above, it is perhaps not surprising that failure has been more common than success. Recent irrigation statistics indicate that small-scale and traditional irrigation systems are more important in SSA than is commonly recognized, serving 47 percent of the total irrigated area and a larger share of the smallholders (FAO, 1987). Yet this tradition is not one which developers have generally attempted to build upon. The underrecognised importance of the traditional irrigation sector,

coupled with the often disappointing performance of modern irrigation projects in SSA, suggest that additional emphasis should be given to exploring development modes and policy options that promote expansion and increased productivity in traditional types of irrigation as alternatives to direct public investment in larger-scale government-managed projects.

IRRIGATION IN ZIMBABWE

Since the turn of the century, irrigation has been regarded as an important part of an overall strategy for agricultural development in Zimbabwe (Roder, 1965; FAO, 1990). However, the history of irrigation development in the country is much older. Substantial areas of stone terraces on hillsides dating from the 15th to the 17th centuries can still be found in the upland Nyanga area. These terraces were watered by means of paved furrows diverting water from streams (FAO, 1990). The first permanent irrigation of the modern period was established in 1859 by three English missionaries at Inyati in Matabeleland (FAO, 1990), while the first sizeable modern development was a 600 hectare scheme diverting water from the Odzani River developed between 1910 and 1920 which is still in operation (ter Vrugt, 1990).

The growth of annual total cropped area under irrigation is shown in Figure 1.2. Figures for early years are estimates, while those from 1980 are based on data from the Central Statistics Office. The downturn in the early 1980s is notable and resulted from drought-related reductions in water supply. A similar downturn is evident in 1991. Growth throughout much of the period is seen to be exponential, but the pace of development appears to have slackened somewhat after 1980.

It is somewhat difficult to get a clear quantitative picture of irrigation development in Zimbabwe with respect to extent, pattern of growth, and breakdown by type. A principal reason for this is the confusion existing between **total cultivated area irrigated** in a given year, which counts multiple-cropped land, and **irrigable area**, which is simply geographic area under irrigation command and unrelated to the number of times the commanded area may be cropped in a given year. The information shown in Figure 1.2 is based on the former.

A recent report prepared for SADC (ACIL Australia, 1992) attempts to rationalize conflicting figures deriving from this confusion and estimates total irrigation command at 138,900 hectares[5] as of 1988/89, broken out as 126,000 hectares (90.7 percent) under large-scale commercial irrigation[6], 6,900 hectares (5.0 percent) under corporate management on the parastatal Agricultural and Rural Development Authority (ARDA) estates, 4,600 hectares (3.3 percent) under Agritex and community managed schemes, and 1,600 hectares (1.1 percent) of irrigated land farmed by small-scale settlers working as outgrowers adjacent to ARDA and commercial estates.

To this total must be added the area cultivated under irrigated *bani*[7] gardens, which is estimated at approximately 20,000 hectares by Bell, Faulkner, Hotchkiss, Lambert, Roberts and Windram (1987), giving a total area under irrigation command for the country of about 159,000 hectares in 1988/89. The total cropped area under irrigation during that year, including *bani* garden area,[8] was probably about 222,000 hectares. This gives an approximate overall irrigated cropping intensity for the country of 1.40 for that year.

Irrigation development in Zimbabwe has proceeded through a combination of private and public investment. Commercial schemes, both

private farms and private and parastatal estates, have generally been developed with private funds, as have *bani* gardens and community managed schemes at the other end of the size distribution. Agritex schemes are developed with public money, as are major water storage structures.

The *prima facie* case for irrigation has been so strong that quite often public schemes in Zimbabwe have been built without an *ex ante* economic analysis (Rukuni, 1984). As Figure 1.3 shows, however, international maize prices have fallen even more dramatically than have rice and wheat prices since 1950, making investment for grain maize production more difficult to justify on economic grounds than in the past.[9] This places a premium on obtaining maximum efficiency from investments in smallholder irrigation and raises questions about utilizing irrigation schemes for maize production, at least during normal times.

In addition to a concern with overall agricultural output, there is, in Zimbabwe, a powerful concern with equity of access to productive agricultural resources, including water. The 90 percent of the total area under irrigation which is in large-scale commercial production is located in regions with high rainfall and bounteous agricultural potential (Rukuni, 1990). The communal areas suffer a double tragedy of being drought-prone and poorly serviced with public infrastructure of dams, roads, electricity, telecommunications and markets. This may recommend additional irrigation development outside the large-scale commercial sector, even when medium-term economic analysis does not support it. This, of course, is an issue that is tied with larger public policy considerations and cannot be addressed in isolation.

In the Zimbabwean case, lessons learned about improved smallholder irrigation system performance apply not so much to upgrading the performance of existing systems, though that is certainly one application of the results, but to new system construction and the policies, institutions, and physical designs which would be used in expanding that portion of the sector. Since smallholder schemes currently make up less than 4 percent of the irrigation sector, the latter application is more significant, in a food policy context, than the first.

CURRENT IRRIGATION ISSUES IN ZIMBABWE

Research findings have to be interpreted in the context of the environment in which the irrigation sector operates. Having looked at irrigation issues prominent on the international agenda, and some of the distinguishing characteristics of SSA in general and Zimbabwe in particular, the chapter now turns to examine major issues facing the irrigation sector in Zimbabwe. These issues provide a locally-specific backdrop against which the findings of the research and the conclusions of the workshop can be viewed.

Water Supply and Distribution Effectiveness

The problem of adequacy of water supply seems chronic on Agritex and community managed schemes. To further complicate the problem, the distribution of water within systems appears inequitable. Tail-enders are often disadvantaged and current management systems appear unable to tackle this problem adequately. The question is, are there enforceable technical solutions to the water inequality problem? It may also be that irrigation schemes, as with communal areas generally, lack a firm institutional and organizational framework for a community-based democratic system of allocating resources and adjudicating disputes. Committees and by-laws then become secondary to other established societal powers and rules. It is not clear this problem differs in nature and magnitude between Agritex and community schemes.

Community Ownership of Schemes

It is a decade now since the policy favouring community management over government operation of schemes was set (DERUDE, 1983). This policy is entirely consistent with widespread evidence of its effectiveness from other regions of the world. However, on the face of it, little progress has been made in this direction in Zimbabwe. The workshop has revealed some of the contentious issues attending the process of moving towards increasing the share of community-managed schemes. It would appear that the more robust the irrigation infrastructure and the more financially viable the scheme operation, the more readily irrigators are willing to take up the responsibilities of owning, managing, and financing the scheme. If this supposition is correct, the changes required in system design, operating rules, financing policies, farmer skills and awareness, Agritex staff development and other areas need to be specified before current Agritex schemes can become community managed.

Scheme Management

At present, Agritex manages its own schemes while playing a major advisory role on community schemes. However farmer Irrigation Management Committees (IMC) seem to have acquired more responsibility for management compared to a decade ago. It also appears that other social groups (royal families, for instance) wield considerable direct or indirect influence on management decisions. The three broad groups, Agritex officers, farmers organizations, and local elites, need to operate in some kind of legal or at least formalized framework that would ensure a clear division of responsibility as well as the capacity to take decisive action.

Once again, the *prima facie* case is for devolving more responsibility to the irrigators. The questions are whether there is sufficient institutional tradition for democratic and equitable management systems at the community level, and what action and further socio-political research is needed to address this important issue.

Many Agritex irrigation staff assert that local belief in witchcraft makes it even more difficult for a transparent democratic process to develop. This is particularly so on decisions relating to allocating land. Other critical management tasks relate to equitable distribution of water, collection of irrigation water charges, and the general enforcing of by-laws.

Bani Cultivation

One of the most exciting parts of this research has been the study of *bani* irrigation. For about fifty years now, conventional wisdom has had it that the cultivation of *banis* is detrimental to the *bani* itself, as well as to streamflow lower down. Current legislation restricting *bani* gardening is based on this conventional wisdom. Recent research, including the present study, casts doubt on this supposition. The most important issue here is the need to review this legislation in light of new evidence and provide guidance for new legislation and further research to fill gaps in understanding to promote the sustainable use of this very rich resource.

Socio-Economic Impact of Smallholder Irrigation

Since the late 1950s (Hunt, 1958), economists and others have questioned the viability of smallholder irrigation in communal areas. Fifty years of previous development had been aimed largely at community-based famine relief, and at settling those displaced from designated white land during the colonial period. After a short lull, government resumed a slow but steady pace of new development. The fact that the Agritex smallholder schemes are largely financed by government has generally been interpreted in the literature to mean that they are not viable.

This issue needs further analysis and interpretation, which should take place at two levels. In terms of financial viability, there is need to establish the extent to which farmers are making a profit and the extent to which these profits are able to cover costs of operation and maintenance. As for the social benefits of such development, there is need for agreement on the items to be considered: food security, nutrition, employment, health, environment, and so on. These questions become more relevant in the face of the increased incidence of drought and the general lack of alternative economic opportunities in communal areas.

RESEARCH METHODOLOGY OVERVIEW

Because the development of a methodology for assessing smallholder irrigation scheme performance in the region was one of the objectives of the project, and because a general understanding of the methodology is useful in interpreting the result obtained, it is useful to take a moment to sketch out the approach used. A more detailed description of the study methodology has been recorded in Chapter 2. An important aspect of the approach employed was the determination to apply equal emphasis to the three different dimensions of the study, hydrology, economics, and institutions and social conditions. All three of these were included in the planning from the outset.

As a result of this multidisciplinary approach, a number of different data collection techniques were available, drawing on the skills of the various team members. These included reconnaissance visits to each scheme, daily observations of hydrologic events, periodic surveys of selected farmers, collection of secondary and scheme-level data on sample schemes, and a postal survey of irrigation managers on all Agritex schemes. Data collected through each of these methods were coded and entered into databases which were then available to all of the project researchers.

A third important trait of the methodology was the way in which sample systems were selected for study. Rather than arbitrarily choosing schemes for study, a careful stratified sample design was worked out to select a representative sample of the types of schemes of interest. In this way, common biases affecting such studies were avoided, including the bias of the paved road, the bias of the pilot scheme, and so forth. More importantly, with a randomly chosen stratified sample, statements can be made and conclusions drawn about system **types** instead of only individual systems. To keep the data collection process manageable however, sampling was limited to provinces where smallholder irrigation is important namely; Mashonaland East, Manicaland, Masvingo, and Midlands.

Because a principal interest in the present study is the effect of management mode on system performance, a slightly different way of breaking out types of irrigation systems was employed than the one reported earlier. Figure 1.4 shows six types of irrigation schemes, along with the average command area and mode of management of each[10]. The four scheme types involving smallholders, namely ARDA settler estates, Agritex schemes, community managed schemes, and *banis* were singled out and lists of all of the schemes of the first three types obtained. These were sampled to yield the set of schemes studied. Ultimately, these included two of the six ARDA schemes with settler components, nine of the seventy completed Agritex schemes, and thee of the eight community-managed schemes. Since there is no register of the irrigated *bani* areas in the country, four irrigated *bani* areas were selected which were relatively near to other schemes in the study and which met other criteria relating to density of irrigated gardens on the *bani*,

water availability, and the absence of streamflow within the *bani*.

THE WORKSHOPS

Two end-of-project workshops were held in Zimbabwe in August 1993[11]. Discussions at both workshops provided researchers with valuable new insights and helped define and illuminate modifications and additional analysis required. The first workshop, lasting one day and held in Harare, was attended by 31 Agritex officers and focussed principally on management issues related to Agritex and communally managed schemes.

The second workshop, at Juliasdale, brought together a more broadly-drawn group of senior officials, researchers, and consultants to discuss the research findings in a wider context over the course of two and one half days.

The purposes of the second workshop were the following:

- To present preliminary research findings for discussion;
- To critically review those findings;
- To use those findings as a springboard to wider discussion of Zimbabwean irrigation issues; and
- To examine the relevance of the findings, and the methodologies developed, for the SADC region.

This workshop was a participatory one where the invited participants were actively involved in providing information and framing conclusions as well as in providing feedback. Of total session time, roughly one-quarter was devoted to presentations, one-half to general discussion, and the remaining quarter to small group discussions. In the first half of the workshop, the focus was primarily on the specific results reported by the researchers and their relevance for smallholder irrigation management and development. During the second half, the emphasis shifted to the broader topic of irrigated agricultural policy in Zimbabwe and the implications for the region. This proceedings reports the results of this larger workshop.

The formal reporting process does not end with this proceedings volume. The principal researchers expect to prepare a formal research report on the study, while individual researchers will prepare articles on a variety of topics growing from the research for subsequent journal publication and presentation. These will give more detail on specific topics.

CONCLUSION

The research findings in this proceedings, of course, fall short of addressing all the issues raised. However, when supplemented with the knowledge of other workshop participants as reports in the final chapter in this volume, they make it possible to indicate desired directions for change and additional research needs. They also comprise an important and necessary step toward creating a critical mass of empirical research on Southern African irrigation which will make it possible to effectively address the broader issues. The database on smallholder irrigation created under this project is probably the largest and most comprehensive in Southern Africa, and the methodology used to collect it has great potential applicability for addressing similar questions in other SADC countries.

REFERENCES

Adams, W. M. 1990. How Beautiful is Small? Scale, Control, and Success in Kenyan Irrigation. *World Development* 18(10): 1309-1323.

ACIL Australia Pty Ltd. 1992. Regional Irrigation Development Strategy Country Report: Zimbabwe. Report prepared for SADCC. Harare.

Bouwer, H. 1993. Urban and Agricultural Competition for Water and Water Re-use, in Allen, R.G. (ed.): *Management of Irrigation and Drainage Systems: Integrated Perspectives.* New York: American Society of Civil Engineering.

Bell, M., R. Faulkner, P. Hotchkiss, R. Lambert, N. Roberts and A. Windram. 1987. *The Use of Dambos in Rural Development, with Reference to Zimbabwe.* Loughborough, UK: Loughborough University (WEDC).

Department of Rural Development (DERUDE). 1983. Policy Paper on Small Scale Irrigation Schemes. Ministry of Lands Resettlement and Rural Development. Harare, Zimbabwe.

FAO. 1987. *Irrigation in Africa South of the Sahara. A Study with Particular Reference to Food Production.* Investment Center and Land and Water Division. Rome: FAO.

FAO. 1990. Irrigation Subsector Review an Development strategy. Harare. Mimeo.

Hunt, A.F. 1958. Manicaland Irrigation Scheme: An Economic Investigation. Department c. Agriculture. Salisbury, Southern Rhodesia.

Roder, W. 1965. *The Sabi Valley Irrigation Projects.* Research Paper No. 99, Department of Geography, University of Chicago.

Rosegrant, Mark and Mark Svendsen. 1993. Asian Food Production in the 1990s: Irrigation Investment and Management Policy. *Food Policy* 18(1): 18-32.

Rukuni, M. 1984. An Analysis of Economic and Institutional Factors Affecting Irrigation Development in Communal Lands of Zimbabwe. Unpublished D.Phil Thesis, Department of Land Management, University of Zimbabwe.

Rukuni, M. 1988. The Evolution of Smallholder Irrigation Policy in Zimbabwe : 1928 to 1986. *Irrigation and Drainage Systems* Vol. 2 :199-210. Kluwer Academic Publishers. Dordrecht, Netherlands.

Rukuni, M. 1990. Key Aspects and Concepts in the Evaluation of Irrigation Investments in Zimbabwe *in* Ruigi, M. G. and M. Rukuni (eds): *Irrigation Policy In Kenya and Zimbabwe.* Published by the Institute for Development Studies, University of Nairobi.

ter Vrugt, J. 1990. Private Sector Irrigation in Zimbabwe, *in* Barghouti, S. and G. LeMoigne (eds): *Irrigation in Sub-Saharan Africa: The Development of Public and Private Systems.* World Bank Technical Paper Number 123. Washington DC: World Bank.

UN Administrative Committee on Coordination - Subcommittee on Nutrition, and IFPRI. 1993. *Second Report on the World Nutrition Situation.* Geneva, Switzerland: WHO.

Yudelman, M. 1993. Demand and Supply of Foodstuffs up to 2050 with Special Reference to Irrigation. IIMI, Colombo. Draft mimeo.