Successful Small-Scale Irrigation in the Sahel

Ellen P. Brown
Robert Nooter
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ABSTRACT

The study reviews the experience with irrigation projects in Africa with particular attention to small-scale irrigation in the Sahel, where small-scale private irrigation systems, based on simple, low-cost technologies, are expanding successfully in a number of countries. It examines the characteristics of the successful projects in order to determine the basis for future successful project design. It then outlines those factors most critical to project success, including full and early farmer participation, low-cost technologies, an adequate financial return that provides a cash flow to farmers at the time that they need it, and sustainability through groundwater surveys and attention to environmental considerations.
ACKNOWLEDGEMENTS

The authors wish to acknowledge the considerable information and financial support provided by Bank staff and the Winrock Foundation in the preparation of this report. The views expressed in this paper are, however, entirely the authors' and do not represent Bank policy or strategy.
In the 1960s and 1970s conventional wisdom said that agricultural production in the Sahel for both domestic consumption and for exports could be increased through irrigation. By the 1980s, however, conventional wisdom was saying that irrigation in the Sahel had failed. Neither was correct. The World Bank published a technical paper, *Irrigation in Sub-Saharan Africa* in 1990, reviewing the experience of public and private irrigation systems in Sub-Saharan Africa, and concluded: (a) small-scale private irrigation was more successful than public projects; and (b) the public sector should be involved in the planning, regulation and management of water resources. In 1991 an OED evaluation of irrigation world-wide concluded that larger irrigation projects performed somewhat better than small projects but that small-scale, farmer-managed irrigation was sometimes a good alternative to large public projects. A subsequent study took this framework and analyzed the situation for the Sahelian countries where food production is an essential national priority both for food security and to generate income.

The resulting paper on "Successful Small-Scale Irrigation in Sahelian Africa" builds on the experience that large-scale irrigation in the Sahel has usually failed while small-scale irrigation has sometimes succeeded. The paper is important in that it identifies, on the basis of an exhaustive examination of past experience in the region, the critical ingredients that make small-scale irrigation succeed or fail. The difference between success or failure of small-scale irrigation is essential to know for the design of future projects. Consequently, the contribution of technical, economic, financial, institutional and sociological factors to success, which the paper outlines in some detail, establishes a checklist for the private and public sector, international donors and NGOs to follow as they determine how to approach the agricultural sector in Sahelian Africa.

The principal conclusion of the paper, that the farmer is not simply a participant but a decision-maker, is always recognized in theory but rarely followed in the practical identification, design, operation and evaluation of irrigation projects. I hope that this paper will change this situation as well as illustrating that the agricultural sector in Sahelian countries can progress with the development of small-scale irrigation.

Michel J. Petit
Director
Agriculture and Rural Development Department
ABBREVIATIONS

ADP ............... Area Development Project
APMEPU ............ Agricultural Projects Monitoring, Evaluation and Planning Unit
CARE ............... Cooperative for American Relief Everywhere (NGO)
Cr .................. Credit
CRA ................ Capital Replacement Account
ERR ................ Economic Rate of Return
FAC ................. Fonds d’Aide et Coopération (French Aid Fund)
FAO ................ Food and Agriculture Organization (UN)
FED ................ Fonds Européens de Development
                   (European Development Fund)
FY ................... fiscal year
ha ................... hectare
kg ................... kilogram
NGO ................ Non-Governmental Organization
OED ................ Operations Evaluation Department (World Bank)
ORD ................ Organisation Regionale de Development
                   (Regional Development Organization)
ORT ................ Organization for Rehabilitation and Training
PCR ................ Project Completion Report
PIC ................ Perimetres Irrigues du Chari
                   (Irrigated Perimeters on the Chari River)
PPAR ............... Project Performance Audit Report
RDF ................ Rural Development Fund
SAED ............... Societe pour l’Amenagement et l’Exploitation des Terres du Delta et de la
                   Vallee du Senegal (Agency for Improvement and Exploitation of the Senegal
                   River Delta and Valley)
SECADEV .......... Societe Catholique pour le Developpement (NGO)
                   (Catholic Development Agency)
SEMRY ............. Societe d’Expansion et de Modernisation de la Riziculture de Yagoua
                   (Expansion and Modernization of Yagoua Rice Growing)
SONADER .......... Societe Nationale pour le Développement Rural
                   (National Agency for Rural Development)
SSA ................ Sub-Saharan Africa
UNDP ............... United Nations Development Program
USAID ............. United States Agency for International Development
VITA ............... Volunteers in Technical Assistance (NGO)
WUA ................ Water Users Association
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EXECUTIVE SUMMARY

This study reviews the experience with irrigation projects in Africa, with particular attention to small-scale irrigation in the Sahel. The review found that while the success rate for irrigation projects (especially large-scale) was low, sustainability of the successful projects was higher than for other agricultural projects in Africa. Also, it found that there were some strikingly successful privately-operated small-scale irrigation areas in Niger, Northern Nigeria, Mali and Mauritania, as well as in Chad, Senegal, and Burkina Faso. In some cases, these developments were entirely spontaneous, and in others, were supported by NGOs or minimal Government assistance. Some areas utilized the infrastructure made available by earlier failed large-scale projects. In some cases, expansion of irrigated areas was facilitated by the awareness of new low-cost construction techniques which reduced the cost of installing tubewells.

In Niger spontaneous irrigation based on farmers' initiatives, using the private sector for provision of inputs, utilizing shallow aquifers and inexpensive low technology, and marketing of surplus production, appears to be quite successful. Irrigation of this kind now covers approximately 60,000 hectares and is expanding. The farmers have used crops with ready markets and inputs that are inexpensive or labor intensive. Public sector large-scale irrigation projects within a "command" framework have also been tried, but have not performed well.

In Nigeria, considerable government and private investment has been made in irrigation during the last two decades with good results. The success of irrigation was due to farmers' active participation but also to subsidized irrigation infrastructure and artificially low input prices subsidized directly through the government's petroleum revenues or indirectly through the overvalued exchange rate. Individually managed, farmer-financed irrigation using manual lift systems has been supplemented by low-cost pumps, which have become readily available through the private sector. Rural roads have allowed farmers to market their surplus production as has access to traders and decentralized food processing plants.

In Mali the performance of irrigation has shown the extremes: failure in the public sector large-scale irrigation and success in the private small-scale sector. Office du Niger, a parastatal corporation, concentrated to such an extent on "public services" that it eventually had one staff member for every 1.5 farmers and for every 11 ha. of irrigation, and only 20% of farmers' fees went for actual inputs. Since many farmers had land outside the Office du Niger irrigation schemes, they put more effort into cultivating their private land than into the project area. Consequently the Office schemes had low returns. In contrast, small scale, private or NGO irrigation has been very successful, especially for high value vegetables.

In Mauritania agriculture along the Senegal River has been changed dramatically by the construction of the Diama and Manantali Dams in the mid 1980s, which have provided more assurance of year-round water control at the same time as they ended traditional recession cultivation based on annual flooding. Expensive public irrigation projects in the 1970s and early 1980s along tributaries to the Senegal, sometimes in remote areas, have been succeeded more recently by less expensive private irrigation along the Senegal River. It is evident that early public investments in irrigation projects, which were not successful at project completion, did demonstrate irrigation's potential and provided a market within which a local construction sector was established, leading to lower investment costs for infrastructure.

Chad has suffered from civil strife for more than a decade so that large scale irrigation efforts have had very uneven support. Small-scale irrigation has been funded in several areas, particularly by NGOs, with much success when it has been based on simple techniques, low costs,
minimal annual inputs and independent decision-making by the farmer, especially with regard to water control, choice of crops, and marketing of produce. Cheap tubewells to tap shallow aquifers, used in conjunction with small pumps that are purchased by individual farmers from the private sector, which also provides maintenance, are beginning to supplement manual water lifting. Almost all successful irrigation occurs on plots owned and managed by individuals with individual water supply control.

**Senegal** exemplifies the changing focus of irrigation from (a) large, publicly-managed irrigation systems with the farmer as laborer, to (b) unsuccessful attempts to make parastatal irrigation agencies more efficient, to (c) government assisted small scale irrigation, to (d) experimenting with non-public sector irrigation. The early phases of this experience suffered from inappropriate construction of irrigation perimeters and from selecting crops that were not economically viable. Project design, operations and reform attempts by both Government and the donors were carried out from the top down, ensuring a low level of farmer enthusiasm. An attempt by Government to stimulate small-scale irrigation failed when the plot size determined by Government was too small to encourage farmer participation.

In **Burkina Faso**, the performance of irrigation has been uneven. Small scale irrigation, which covered 6,200 hectares in 1956 and then declined to 1500 hectares in 1961, had recovered to about 3,000 hectares by the mid 1980’s. Successful projects have been due to a number of factors: (a) a relatively encouraging macro-economic framework has increased the financial returns of cash crops; (b) farmers have used the irrigation infrastructure from "failed" projects to create their own small scale perimeters; (c) periods of drought and economic uncertainty have stimulated farmers to use low cost irrigation for cereals as a hedge against food deficits; and (d) the outmigration of males made irrigation a profitable and necessary channel of agricultural development for women. The use of traditional village systems for organizing irrigation has also proven more successful than "imported" systems.

In **Cameroon**, large-scale irrigation has been successful mainly because of strong expatriate management running irrigation projects using the farmer as laborer rather than decision-maker. Management of water, agronomic decisions and cost recovery were the domain of project management rather than shared with farmers or cooperatives. Farmers have accepted this situation because of high financial returns and because of lack of other opportunities. Small scale irrigation projects, prepared with little or no farmer participation and with non-competitive production systems, have been less successful because farmers turned to non-project activities with higher returns.

The study reviewed the characteristics common to the successful irrigation projects and found that while there were many variations in technology, cropping systems, and institutional arrangements, some common characteristics emerged. These were:

(a) The technology is usually simple and low cost (most frequently small pumps drawing water from shallow aquifers or rivers and streams);

(b) The institutional arrangements are private and individual;

(c) The supporting infrastructure permits access to inputs and to markets for the sale of surplus production;

(d) There is a high financial (cash) return to the farmer at the times that he needs cash;
(e) The farmer is an active and committed participant in project design and implementation.

The study also found that "success" means different things to (i) the development technicians; (ii) the donors; (iii) the beneficiary governments; and (iv) the farmers. Projects are successful when the farmer's definition of success has been recognized and accommodated in the project design.

When the technical design of the irrigation system required an institutional arrangement larger than individual ownership, the most effective arrangements were found to be (in decreasing order of success): (i) extended family groups; (ii) private voluntary groups; (iii) water users' associations; and (iv) cooperatives.

In order to design irrigation projects that take these findings into account, project design should be based on the following concepts:

(a) encourage small-scale, private and individual investment in irrigation;

(b) implement projects with many small components, where NGOs frequently are efficacious implementing intermediaries;

(c) employ methods that ensure early and full farmer participation in project design and operations, devoting as much staffing and funding to studying the farmers' economic and social situation and objectives in utilizing irrigation techniques as to the engineering and financial aspects of project design;

(d) identify and disseminate low cost small pump technology and tubewell construction techniques;

(e) include provision of soil and water surveys beyond the purview of individual farmers but essential for sustainable irrigation;

(f) ensure a macro-economic framework that will reward the farmers' and merchants' desires for low costs and high returns based on real costs;

(g) both financial and economic rates of return must be satisfactory on a sustained basis;

(h) avoid unsustainable subsidies, since their removal could lead to a project's collapse;

(i) ensure the availability of foreign exchange needed to secure supplies of spare parts, inputs and adequate repair facilities;

(j) ensure that there is the essential infrastructure needed for access to imports and markets;

(k) make provision for training in maintenance and irrigation techniques for farmers, preferably through private sector suppliers; and

(l) ensure that environmental considerations are provided for, such as the effect of irrigation on health, drainage and erosion control, which may not be evident to the farmer.
In summary, recent results from small-scale private irrigation in the Sahel have been encouraging. They provide interesting lessons for the design of future projects, which could lead to higher project success rates if taken into account.
INTRODUCTION

This study reviews the experience with irrigation projects in Sahelian Africa, with particular attention to irrigation in Senegal, Mali, Mauritania, Niger, Burkina Faso, Chad, and the northern parts of Nigeria and the Cameroon with the objective of identifying the characteristics that are typical of successful small-scale irrigation projects. The review included spontaneous modern irrigation, traditional irrigation, and World Bank and other projects in the eight Sahelian countries as well as relevant examples in Madagascar and the Gambia.

Chapter 1 reviews the history of irrigation successes and failures in the various countries. Chapter 2 outlines the characteristics of successful projects, with particular reference to the differing definitions of success on the part of donors, governments, planners, and farmers. Chapter 3 contains considerations and recommendations for future successful irrigation project design.

Methodology

The main focus of this study is to identify the qualities that characterize successful small-scale irrigation projects in the Sahel. Donors have, for the most part, turned away from the frequently unsuccessful large-scale irrigation projects as they learned what not to do. Successes can show what one should do and narrow the range of project design possibilities to a more manageable selection. However, such a study cannot ignore what makes some projects fail because excluding the failures can lead to spurious causality, attributing success to factors that turn out to be present in failed projects as well. This study attempts to discover what factors are present in most successful small-scale projects and briefly deals with large scale irrigation, which has a poor record of success in the Sahel. The "success" characteristics are not necessarily fully explanatory factors; we do not know that they cause success, but can be considered as intervention variables, or indicators of a better likelihood of success.

This study has used a wide range of sources. The Operations Evaluation Department carried out a special examination of irrigation projects as part of its 1989 analysis of evaluation results. World Bank Project Performance Audit Reviews (PPAR) and Project Completion Reports (PCR) analyze the successes and failures of Bank projects. Staff Appraisal Reports (SAR) for follow-on projects sometimes discuss the results of earlier projects. These reports, especially in earlier Bank years, are concerned with the economic performance of a project and so their coverage of other kinds of success (technical, social, performance) is erratic. As a result, comparisons of project success based on these sources cannot be systematic. Supervision reports, contained in Bank files, track the development of problems and the attempts the Bank makes to resolve them. From supervision results one can see that some qualities that a successful project has at completion may have been present when it was a problem project, and hence it would be fallacious to include these qualities as indicators of success.

Much of the Bank's involvement in small-scale irrigation has not been in the irrigation and drainage sector but has been carried out in the context of other kinds of projects such as area development, drought relief, or rural development. The authors have identified a number of these activities, aided by Bank lists of irrigation and drainage projects in Africa during FY 47-91 and projects with irrigation components in Africa FY 74-81 but can offer no assurance that all small-

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2 Khushalani, B. Memo on Irrigation Lending and Sector Work, 2 April 1991.
scale irrigation contained in other projects has been discovered. PPARs, PCRs, appraisal and President's Reports for projects outside the irrigation and drainage sector were also reviewed.

The authors also interviewed Bank staff who have been involved in implementing these projects or who are knowledgeable about sustainability and long-term problems because they had dealt with completed projects in later years. Interviews with Bank staff and experts in other organizations dealing with irrigation often revealed aspects of success and failure that were not dealt with in printed reports.

Much small-scale irrigation is traditional, private, or implemented by bilateral aid agencies or NGOs. Such irrigation has only sporadically been analyzed and much of what material exists is not available in Washington. The authors have followed up any leads for ethnographic material, published studies that refer to Sahelian irrigation, and in-house NGO reports. Probably only a small portion of such information has been unearthed.

A number of general conclusions can be drawn from these sources. They relate to the source of water, the technology, the institutions, and the infrastructure involved in the performance and sustainability of irrigation.
CHAPTER 1: IRRIGATION CASE STUDIES

This chapter will summarize the experience with irrigation in Burkina Faso, Cameroon, Chad, Mali, Mauritania, Niger, Nigeria and Senegal as revealed through a review of case studies. These studies provide some indication of the developments taking place in irrigation in Sahelian Africa and the lessons to be learned from these successes and failures.

Burkina Faso

Burkina Faso, like Niger, has a limited amount of surface water but considerable groundwater. Surface water has been exploited through bottomland cultivation, some small dams and a few large dams. Groundwater has been less subject to donor attention but many villages have spontaneously created vegetable perimeters. Small pumps are becoming more popular. The French have had success with shallow pump projects, and in the Rural Development Fund projects (World Bank Credits 317,604,1218) interest in small vegetable perimeters has grown rapidly. Private commercial investment in irrigation has also been growing; outside Ouagadougou and in the Eastern ORD, commercial rice and vegetables are grown by gravity. Sometimes small pumps and dams have been installed to utilize the water more fully.

Small-scale irrigation in Burkina has gone from:

<table>
<thead>
<tr>
<th>Year</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1956</td>
<td>6,200</td>
</tr>
<tr>
<td>1958-61</td>
<td>1,500</td>
</tr>
<tr>
<td>1972-86</td>
<td>3,000</td>
</tr>
</tbody>
</table>

In 1956 a small, gated rice cultivation scheme was built in depressions and transitional flood plains but was abandoned within three years for lack of water control. While bottomland cultivation has been a focus of donor interventions since then, small-scale aquifer and surface water vegetable irrigation has also been burgeoning. A great many villages have shallow dug wells, with or without pumps, for irrigated vegetables but no up to date information was found. Private small-scale vegetable irrigation is done mostly without inputs or machinery; there is no credit available for such purchases in any case. Most cultivation is done to meet local demand.

Several large dams have been built for gravity irrigation of rice and sugar at Karfigela, and gravity and pivot irrigation of rice, wheat and maize at Sourou. The latter has encountered marketing problems and high costs of production. Small dams have not been very successful either. They have either not held up because of poor construction and extremes of flooding (as in the Rural Development Fund projects) or because not enough land has been available for development to justify the dam’s cost (Kamadena and West Volta Agriculture). On the other hand, a number of religious missions have built small dams to provide water for hospitals and other purposes and promoted irrigation in the surrounding area as well. These farmers have exploited the area fully but they are also motivated to remain in a restrained area because of their church associations. No information is available on the economics of this mission irrigation.

Farmers have been interested in bottomland cultivation for many years and, in fact, areas developed for irrigation with dikes, which gave simple, partial control, and dams, which have failed because of poor construction, extreme floods and dryness and/or lack of maintenance (Rural
Development Fund, 1958 perimeters, Comoe), have remained in use for improved rainfed/recession cereal cultivation. Improved bottomlands proved so popular in the first Rural Development Fund that farmers requested more land above and beyond the 115% of appraisal that was accomplished. In the second project, much of the perimeter was not cultivated because of disputes over land tenure, which, although it gives poor statistical results on land utilization and yield, points out the value attached to the improved bottomland. The improved land was popular where the costs were low, such as Rural Development Fund 1 and Niena Dionkele (but not the NDorola perimeter) because in bad rain years farmers got better results than simple rainfed cultivation, though interest in these perimeters may have been colored by the fact that there were low or no fees and payments made through the Food For Work program. In the FAC improved bottomlands (1969-72), considered to be a failure in World Bank reports, farmers were nevertheless getting higher total output on the 65% of land still in production than the estimated output at appraisal for 100% of the project perimeters. Improved bottomlands allow farmers to grow, fairly cheaply, cereal as a hedge against drought or as a cash crop, sometimes even using pumping to ensure enough water. The Rural Development Fund projects also had some success because they used traditional village systems for organizing irrigation. The traditional system was not, however, capable of resolving the land disputes which arose when the value of land was increased by irrigation nor was it able to promote operations and maintenance, which remained poor.

3 Niena and Dionkele perimeters involved cheaper construction (53,000 FCFA/ha or about US$200/ha) but also benefitted from the lessons learned in the construction of the original Ndorola perimeter (470,000 FCFA/ha) which turned out to be located so far from most villages that many farmers were unwilling to make the trek to cultivate their plots once they had planted enough to retain their claim to the land and their Food For Work provisions. The fee for use in all three perimeters was 4,000 FCFA/year. The following table seems to indicate that the convenience of Niena Dionkele and no fees outside the perimeter proved more attractive than NDorola perimeter despite the variable yields outside the perimeter.

<table>
<thead>
<tr>
<th>Year</th>
<th>Outside</th>
<th>Niena Dionkele</th>
<th>NDorola</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983/84</td>
<td>2625</td>
<td>--</td>
<td>1799</td>
</tr>
<tr>
<td>1984/85</td>
<td>1320</td>
<td>--</td>
<td>1964</td>
</tr>
<tr>
<td>1985/86</td>
<td>2025</td>
<td>2210</td>
<td>1698</td>
</tr>
<tr>
<td>1986/87</td>
<td>1875</td>
<td>2140</td>
<td>2290</td>
</tr>
<tr>
<td></td>
<td>n/a ha</td>
<td>85 ha</td>
<td>396 ha</td>
</tr>
<tr>
<td>1982/83</td>
<td>15</td>
<td>--</td>
<td>337</td>
</tr>
<tr>
<td>1983/84</td>
<td>126</td>
<td>--</td>
<td>565</td>
</tr>
<tr>
<td>1984/85</td>
<td>70</td>
<td>--</td>
<td>654</td>
</tr>
<tr>
<td>1985/86</td>
<td>160</td>
<td>126</td>
<td>552</td>
</tr>
<tr>
<td>1986/87</td>
<td>285</td>
<td>122</td>
<td>442</td>
</tr>
</tbody>
</table>
Cash crops grown with irrigation have blossomed. A number of experts interviewed attributed this in large part to the relative freedom from economic control in Burkina. Even rice is grown by farmers as a cash crop where it brings in a secure income or has a high value. Improved bottomland rice farming has been successfully integrated into the traditional cropping system, though it did not replace it as some donors had hoped. In the Kou valley farmers have been growing rice for years with the long-running support first of the Chinese, then the Dutch, who provide support for coops and a secure supply of inputs. However, by Rural Development Fund Project 2 growing rice simply for sale as paddy/milled rice had run into problems for lack of markets (no road construction was included in the project). The Niena Dionkele Project was to deal with problems of the rice sub-sector but it was unsuccessful in this attempt, including the fact that roads projected were not built. At Niena Dionkele farmers sold about 35% to the government at a price guaranteed above market price, thereby guaranteeing their needed cash income, and sold much of the rest in markets in treated forms ("minute rice") which increased its value. At Niena Dionkele 50% of the rice production is grown in the small perimeters, which were built because the original N'Dorola perimeter was much too far from the villages, or outside in the areas which have better moisture due to the perimeter construction. The fact that rice can be made into a lucrative product probably explains the interest women have shown in rice farming. Fifty per cent of the rice growers in the Niena and Dionkele were women cultivating rice semi-intensively on 0.5 ha plots. There is a high level of outmigration among men in this and other areas of Burkina, which leaves the women behind responsible for family maintenance. They are poised to invest additional labor in parboiling the rice they have cultivated and for which they get high returns. Women have also been interested in commercial vegetable farming. At Koudougou women exploit 40% of the land in individualized vegetable plots. Again much of the male population is absent as wage laborers.

There is a great deal of commercial investment in vegetable farming in Burkina. As long ago as 1977 farmers were exporting vegetables to Europe. At Lake Bam an export vegetable cooperative worked well on two 35 ha perimeters but they had such high management costs that farmers who felt they should get more than 50% of the profits split off and set up their own cooperative, run like a commercial business. At Kongoussi cooperatives grow vegetables with government help. Vegetable irrigation was not included in the RDF 1, which was designed for improved bottomlands rice production, but in response to requests from the farmers, 42 ha of pumped perimeter was added; by RDF 2 the vegetable area reached 102% of appraisal whereas bottomlands rice production was only 41% of appraisal estimates (because of land tenure problems, lessening of the drought, and increased cost/ha for construction, farmers were less motivated).

On the border with the Cote d'Ivoire a number of commercial private irrigation farms have been developed employing migrant Burkinabe laborers to grow fruits and vegetables for export to the Cote d'Ivoire. In the Eastern ORD development area and around Ouagadougou private commercial rice, vegetable and fruit farming has been taken up by influential people who get permission to exploit land from the traditional chiefs. They farm the land with urban youths hired as laborers or with rural relatives to whom they confide the farm, and irrigate by gravity or pumps. Likewise poor people in town supplement their income and diet with vegetable gardens. With pumps and rainwater these investors are able to get a second crop of rice. The Eastern ORD is an

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4 The relatively restrained size of commercial rice farming in Burkina is a contrast to the large mechanized rice farms employing wage laborers which have rapidly sprung up in northern Ghana. Some experts attribute this difference to the availability of large loans for agricultural development in Ghana; we have too little information on Ghanaian rice farming to come to any conclusions.
isolated area but most food is sold locally. In Ouagadougou the food is both consumed locally and exported.

Outside Ouagadougou, at Mogtedo, a Dutch gravity irrigation project built two decades ago shows the interesting evolution that irrigation can undergo as a form of cash crop farming. At Mogtedo a gravity canal ran along the high side of the perimeter; in drought years and in the dry season the cultivators at the tail end of the system, who tended to be economically less well-off farmers, could often not irrigate cereal crops. Some poorer "tailers" and others began to irrigate extra-perimeter vegetable plots on the high side of the canal during the dry season, using calabashes to dip water from the canal. When a well-to-do farmer in the perimeter got a pump he, too, began to irrigate vegetables on the high side of the canal. He was rapidly joined by other influential perimeter farmers who purchased pumps. Although they are officially pirating water they have too much power to suffer any consequences. An informal arrangement has grown up among the irrigators which, in fact, makes for a more efficient use of water. In the dry season there is an informal rotation in which pump owners and calabash farmers take water on two days a week. On those days the tailers get nothing for their plots at the end of canal. In the rainy season everyone irrigates by gravity out of the canal on the low side, including the tailers, and there are no pirates.

In summary, the performance of irrigation in Burkina Faso has been uneven. Successful projects have been due to a number of factors: (a) a relatively encouraging macro-economic framework has increased the financial returns of cash crops; (b) farmers have used the irrigation infrastructure from "failed" projects to create their own small scale perimeters; (c) periods of drought and economic uncertainty have stimulated farmers to use low cost irrigation for cereals as a hedge against food deficits; and (d) the outmigration of males has made irrigation a profitable and necessary channel of agricultural development for women. The use of traditional village systems for organizing irrigation has also proven more successful than "imported" systems. In summary, small-scale irrigation, which covered 6,200 ha in 1956 and then declined to 1,500 ha in about 1961, had by the mid 1980s recovered to about 3,000 ha.

Cameroon

SEMRY I (Cr.301-CM) and II (Cr.703-CM), like other agro-industrial perimeters, illustrates that large schemes can work well. Basically, according to the PPARs, SEMRY I and II have the following characteristics:

(a) agro-industrial schemes;
(b) run by efficient management;
(c) fairly low cost infrastructure (lowest investment cost/ha in Africa);
(d) low operating costs (pests and weeds were not a problem);
(e) technically well designed and 100% operational at project completion;
(f) agronomically successful: double cropping of high yield varieties;

No social infrastructure was included in the SEMRY I project. In Mauritania Gorgol Noir the costs/ha went from $22,000/ha to $30,000/ha when social infrastructure was included, and in the Chad Polders (Cr.592-CD) from US$5000 to US$12,500/ha.
motivated farmers; and,

profitable and accessible markets.

How long the markets will remain accessible and profitable threatens the sustainability of the projects, designed originally to provide import substitute rice to the Cameroonian market. SEMRY rice cannot be economically grown and transported to the densely populated coastal areas but it is legally and illegally exported to Nigeria and Chad quite profitably, to the detriment of the local rice production of these two countries.

SEMRY I was the most successful of the projects; each successive follow-up project departed farther from SEMRY I’s successful characteristics and each became less competitive. SEMRY III is not a success, just like the Chari Irrigated Perimeters (PICs), Sategui-Deressia (Cr.489-CD) and the CARE Mayo-Kebbi Village Perimeters across the river in Chad, because none can compete with the low-cost rice of SEMRY I and II.

SEMRY I’s agro-industrial character is due to its designers who were predominantly concerned with technical matters when it was built (1972-76). There was no regional agricultural or economic development plan for the area (PPAR, SEMRY II) and the socio-economic aspects were not examined until 1983 (Arditi, Baris, Barnaud). As a result it was not realized that the local population had become essentially agro-industrial wage earners. Because the local Massa and Mousgoum’s fields had been improved as part of the irrigation network, they had to engage in irrigated agriculture and cultivate to SEMRY’s standards in order to keep access to their land. They did, however, get immediate and substantial benefits from their improved land; income on average was up six times what it would have been without the project and returns/man-day were 60% higher. SEMRY I could afford to do on-farm development throughout the project so that the farmers were able to cultivate the entire area. There was no difficulty in marketing the rice. The technical package worked. The authoritarian management kept the farmers to the agricultural calendar and supervised water distribution. As a fortuitous result of the 1970s drought, farmers saw that transplanted rice greatly improved yields and adopted the technique, already known to them from recession sorghum. Not only did they get high returns but they had low costs since they did not hire labor or need much in the way of pesticides or herbicides. There was no provision for credit in the project. Although farmers had to pay about 44% of their gross income as fees so that SEMRY could sustain operations and maintenance, they were still getting on average 300% more income. Their risks were low because efficient management provided them with a secure supply of water and inputs. No producer organization had been set up; the farmers were not expected to cooperate or manage, just farm. The management closely supervised water management and showed “single-minded dedication...to reach its main target of promoting rice production”.

By SEMRY II the Bank was worried about the sustainability of the export rice market and so put effort into improving rainfall as well as irrigated areas, and included fishing and improved pastures. SEMRY II’s costs were higher and there was a 35% (vs 10% for SEMRY I) cost overrun; as a result on-farm development was carried out on only 50% of the area. The irrigation design was not technically as successful as in SEMRY I but was still satisfactory. Some of the villagers lived far from their irrigated fields (12 km for some), and others farmed such poor areas that they could not even cover their fees. As a result they grew disinterested. In some areas only 2.5-15% Rice yields went from about 1 t/ha, in areas with partial water control as a result of diking from the 1950s, to 4t/ha in 1975.
of the population took up rice farming in the project; instead they turned to fishing, "symptomatic of the keen competition which arises between an immediately profitable low-cost activity calling for low investment in human resources, and a painstaking process of cultivation requiring a comparatively advanced level of technology and considerable financing (PPAR, p 53)"; in SEMRY II fishing provided the same benefits as irrigated rice had in SEMRY I. SEMRY II was, however, able to recruit an interested population to cultivate most of the developed area; Toupouri (often young single men interested in earning money for a dowry) migrated to the area to get access to land and to cash. Though returns to these farmers were not as high as in SEMRY I, some having to pay 50-60-80% of their gross income as fees, they were better off having migrated. Since they did not have land for rainfed crops and stockraising in their new homes, they had to devote themselves to irrigation. In other words SEMRY II essentially recruited agro-industrial wage earners in order to run the project successfully. By the time of the project audit the farmer organization had effectively ceased to exist; SEMRY management ran everything.

SEMRY III, financed by The Fond European de Development (FED), built small pump-irrigated, farmer cooperative-managed perimeters but with little or no farmer participation in project design or definition of project purposes. Farmers were required to pay water user fees and to carry out the maintenance of the irrigation system. Like the adjacent Perimetres Irrigues du CHARI (PICs) on the other side of the river in Chad, they cannot grow rice at a cost low enough to compete with the agro-industrial production of SEMRY I and II. SEMRY III, according to the PPAR for SEMRY II, includes substantial social elements, perhaps justifiable for the benefits it would provide the small, scattered population near NDjamena, but not for the economic value of rice production. In this context the PPAR notes that it is difficult for a project to do viable commercial and rural development at the same time. When required to pay for project operating costs in a context where these costs were difficult to recover, farmers put only limited effort into the project production, preferring to rely on traditional cultivation while taking advantage of the project’s social benefits. Semry I and II, on the other hand, have proven financially and technically successful. Efficient management runs agro-industrial business enterprises, providing secure supplies of water and inputs. They manage water and production closely and do not depend on farmers, who are essentially wage earners, for operation and maintenance. The farmers, without rainfed land, depend on irrigation for their livelihood and so devote their full attention to rice farming. The social justice of SEMRY I, which essentially stripped the farmer/workers of their land, may be questionable but SEMRY II provided a better living both for the local farmers who had become fishermen and for the immigrant agriculturalists who farm the rice.

Meanwhile traditional farmers in the Cameroon-Chad border area who have retained access to their rainfed fields grow some rainfed bottomland rice and lots of transplanted recession sorghum in unimproved areas. Farmers find the yields high enough to justify hiring young people from nearby areas of Chad and Cameroon, where the crops have already been brought in, to harvest the sorghum. Irrigated cereals are therefore uninteresting, except in years of very bad rainfall, and the perimeters of Semry III and the PICs are partially abandoned except in drought years and exploited in part by individual farmers for commercial vegetable growing only.

\[7\] The PPARs for failed irrigation projects in Niger and Nigeria criticize treating the farmers like production workers and the lack of understanding of the traditional farming system, in which rainfed farming offers flexibility and security and irrigation a source of cash income. However, in successful SEMRY I and II, farmers are treated like production workers, which they essentially are. Most no longer have access to rainfed land or participate in a traditional farming system, unless some Toupouri return home for a few weeks to help their relatives with the rainfed harvest.
In summary, large scale irrigation in Cameroon has been successful mainly because of strong expatriate management running irrigation projects using the farmer as laborer rather than decision-maker. Management of water, agronomic decisions, and cost recovery were the domain of project management rather than shared with farmers or cooperatives. Farmers have accepted this situation because of high financial returns and because of lack of other opportunities in agriculture or other sectors. As the donors moved toward small scale irrigation projects prepared with little or no farmer participation and non-competitive production systems, irrigation has been less successful because farmers turned to non-project activities with higher returns.

Chad

In Chad both modern and traditional irrigation is surface and gravity, with both pumps and manual lifting devices. Animal lift irrigation has not yet proven acceptable although animal-powered water lifting is known from pastoralists who use such techniques to draw water from deep wells. Commercial vegetable and fruit growers run successful private pump irrigation farms along rivers or lakes; no information on the average commercial plot size is available though it is doubtful that farms exceed a few hectares since farmers pump only a short distance from the water source through simple, unlined canals and there is considerable water loss. On commercial farms double cropping is common: one vegetable crop in the cool dry season, another in the hot dry season, with fruit trees bordering the plots. Cereals may be grown in the same plots in the rainy season but only rarely with supplementary irrigation. Commercial farmers do not grow cereals for sale other than high value fresh maize for grilling. Fresh vegetable commercial farms are located just outside urban areas. Irrigators who raise produce that keeps may ship considerable distances (onions and garlic from Abeche on one side of the country to N'djamena on the other, or mangoes from Biltine to Abeche, for instance) but they are located near transportation routes. Commercial irrigators tend to be government officials or rich merchants, pensioned army veterans or individuals who are set up with a pump by a rich relative. In other words, most commercial irrigators invest money they have earned from other sources. If credit is involved it is informal since commercial banks do not make agricultural loans and there is no government agricultural credit. According to VITA, which finances small credits on a very limited scale, some women traders also invest because with a moderate amount of money invested in a pump they, like others who can navigate the legal system, can claim land that will become theirs if they "improve" it over a five-year period.

While there is one outlet for a French-manufactured pump in the country, most irrigators, whether commercial or family, get friends or relatives to purchase pumps for cash from Nigeria, Saudi Arabia or France and obtain spare parts and vegetable seeds through the same channels. Merchants and government officials oversee their farms but the work is done by permanent employees. Most of these workers are rural migrants from distant regions who have moved with their families to the urban area in search of work because of fighting and drought. They settle

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8 Before the 1984-5 drought some irrigation was done in polders, wadis, depressions and riverbeds where groundwater lay just below the surface and hand watering from shallow dug pools could be done if necessary. The water table, which had been dropping since the 1950s in Kanem, Lac and Wadai dropped precipitously with the drought and very few farmers are now able to cultivate simply by digging shallow basins into the humid soil.

9 Small farmers get access to land through customary means; this leaves them open to some future appropriation through the application of national legislation but insecure tenure is not yet a problem.
around a commercial farm with workers from the same ethnic group; they prove reliable long-term salaried employees because they have no other opportunities, aside from a little rainfed farming around the village. Women and lucky recipients of pumps from relatives have less capital and so use family labor. They sometimes need to hire labor but it is difficult to find temporary workers. In other words the limit on irrigation for the former is the amount they wish to invest in wages, while for the latter it is labor availability.

Until recently water lifting by pumps has been done directly from rivers and lakes. River and lake levels in most parts of Chad have dropped over the last 15 years, which has made irrigation either very expensive, as in Sategui-Deressia (Cr.489-CD), where only rainfed IRAT 144 gives a reasonable yield in the controlled areas, and village perimeters along the Logone and Chari (Cr.664-CD, FED, USAID and others), or impossible, as at Lake Chad Polders (Cr.592-CD) where, though the risk of pumping was at appraisal thought to become impossible in 1/10 years, pumping first of lake and then of groundwater was necessary from the beginning. In the last six years NGOs have introduced cheap ($160-480) tubewells, tapping shallow aquifers in the Kanem area, with the technology used in conjunction with small pumps imported from Nigeria, which is becoming popular as farmers become aware of it. The water source is more secure than river, lake or well water and the pump overcomes manual water lifting's limits on lift and labor. The pumps, which farmers bring in legally and illegally from Nigeria, are cheaper than the large pumps most irrigation projects use. The farmers make arrangements with local merchants who travel to Nigeria to bring back pumps and spare parts. From the farmer's point of view the small pumps have a number of advantages: they can be paid for and operated (at his own convenience) by an individual, so he does not have to join a farmer group, coordinate his irrigation, or pay irrigation fees; the pumps are portable and so can be used in a number of different fields and easily taken in for repair; breakdowns do not destroy everyone's crops and it may be possible to borrow a neighbor's pump temporarily or irrigate part of the field manually. Those who had been doing manual water lifting are able to cultivate a larger surface area. The impact of this new technology is a rapid and substantial increase in cash income averaging 130%, with a simultaneous decrease in the number of man-days of labor of 64%.

In the Sahel of Chad, small farmers who engage successfully in irrigation put their main effort in the cool, dry season into high value vegetables. Successful farmers who use manual water lifting may only cultivate a cash crop in the cool,dry season; those who use pumps grow at least two, if not three, vegetable crops per year in order to cover their investment, because water lifting is so much less difficult and because the larger amounts of water available with a pump reduce stress on plants and increase yield above what is normal in the hot dry season. In the northern area, where the weather gets cool enough, some grow wheat as a high value cash cereal crop. Because the rainfed harvest and time for sowing wheat are close together, not many choose to take the risk of growing wheat; farmers prefer crops that can tolerate slippage in planting and harvesting dates.

In individual plots and small scale schemes throughout Chad, irrigated cereal is grown mostly for food security. Farmers who live along rivers, fossil river beds or clay pan areas make bunds to grow recession sorghum or rainfed rice. In wadis farmers may plant cereals which demand more water than simple rainfed crops, and do a supplemental irrigation if the rains are insufficient. This type of cereal irrigation demands only an investment of labor, not capital. Though rice is grown on a large scale as a cash crop at Sategui-Deressia, monocultured rice has not proven economical in Chad, even when double-cropped, in part because it must compete with cheaper rice

10 Wheat usually sells at 5-6 times the price of maize and 3-4 times the price of coarse grains.
imported from the nearby SEMRY projects in Cameroon (Cr.302-CM, Cr.1512-CM, and Cr.763-CM). At the Sategui-Deressia project farmers found the returns on irrigated rice too low to induce them to grow enough to support the infrastructure and management; the collection rate for fees in 1984, for instance, was only 7%. They grow some rice for the project because the government is obliged to buy it at a fixed price, hence the farmer is guaranteed some cash income. They eat more than half the rice and sell the rest on the private market, depending on the price and their need for money. Inputs to raise yields and timely preparation of land in the perimeters would require more investment than the farmers are willing to risk. Most are ineligible for credit for inputs and animal traction. Since the return on rice grown in the improved areas outside the perimeters (or in the decayed areas inside the perimeters) is greater than rice grown under project conditions, farmers put the least effort into perimeter rice, especially since the water supply there is more secure than in the rainfed and improved rainfed areas. The improved areas have been popular from the project’s beginning. Since only 30% of the fields for which canals were constructed received land preparation for rice cultivation because of cost overruns, there are more farmers using the remaining unprepared land, plus the areas within the perimeters which have decayed for lack of maintenance or water, for improved rainfed rice and coarse grains, than are growing irrigated rice in the prepared areas.

As a result of the civil war in Chad, project management ceased in many perimeters from 1979-84. Even so, in the PICs, irrigated perimeters on the Chari, 51% of the surface area, where permeability and soil fertility were less of a problem, remained under cultivation at a (lower) level of intensity that farmers could sustain on their own with inputs they themselves imported from Cameroon and Nigeria. Although the double cropping rotation of cotton/sorghum and wheat/fallow initially proposed by the projects proved agronomically and socially impossible, individual farmers developed their own rotations of cereals and cash crops on parts of these perimeters and now they do sustained irrigation of two or three crops a year. In the “abandoned” Lake Chad Polder project in 1980 the World Bank observed that farmers were actively cultivating the land improved by the project even though much of the infrastructure had been destroyed. Such evidence, plus the heavy utilization of the improved areas outside Sategui-Deressia, indicate strong local demand for irrigation at a simple technical level, low cost, with minimal inputs, and individual independence.

Farmers in the modern pump perimeters in Mayo-Kebi and Chari-Baguirmi grew rice with the thought that double-cropping and high yields would cover the costs even though the farm family ate much of the harvest. In FED, USAID and NGO perimeters this proved uneconomical because the infrastructure and pumps needed to assure enough water for drought years, when the cereals were needed for food security, were too expensive to operate in normal years.

We found no information on commercial farmers’ use of inputs. Gasoline and diesel fuel for pumps have always been available in local markets even during the height of the civil war. Small farmers use few inputs, in part because fertilizer, pesticides and improved seeds are hard to

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11 In the first year of the project 660 of 2000 ha in the perimeter were cultivated and 1,200 ha of improved land outside the perimeter; in the next year 1,250 ha in the perimeter and 2,900 in the improved area outside. The author found no figures on present use but farmers interviewed periodically over recent years express more interest in the improved area outside the perimeter than in cultivating inside. In the early years of the project farmers got an average of 1.3t/ha, in traditional rice areas, 2.0t/ha in the improved area and 2.5t/ha in the perimeter. Within the perimeter yields from individual plots varied from almost zero to 3.5t/ha. for all of which water charges in principle had to be paid. Given the risks, farmers were very reluctant to pay irrigation fees and to take out credits for inputs and animal traction.
get, in part because they want to keep their costs down. Quality does not affect market value except for the very limited expatriate market, and so improved seed is not necessary and farmers usually produce their own or buy from local specialists. Yield is also of secondary importance; farmers need to make a minimum amount to pay for taxes, clothes, etc. If they can assure that income by investing their time and labor in cultivating enough surface area through water application or improved agricultural techniques, then they do not need to risk investing money in high yield seeds. The limit on irrigation for small farmers is the availability of labor. NGO projects throughout the country have found hired labor is almost never used so that the limit for manual irrigators is how much water can be lifted; for pump farmers the limit becomes how much land can be prepared and weeded.

For small, poor farmers who have access to land, irrigation is a way to invest labor only and yet produce a cash crop. Many of these high labor-low capital farmers hope to use the money they make to get out of irrigation and into some less physically demanding money-making activity such as commerce. Their commitment to irrigation is not sustained; however in cases where small pumps have been introduced, their income has risen sufficiently and their labor reduced commensurately so that they become committed to irrigation. Commercial investors in irrigation do not envisage getting out of irrigation in the same way, because they either hire labor or use labor-reducing irrigation techniques such as pumps, and therefore their commitment is less tenuous.

Small producers who practice sustained irrigation also have access to markets, either at nearby cities or through transport of long-lasting food to distant places; even though others may be isolated from major cities they have access to sizeable local or regional markets. Thus irrigation in the Lac, Kanem and along the Batha River flourishes even though transportation to and from these zones is difficult and expensive. Farmers who cannot travel make traditional or informal marketing arrangements with friends or traders; they make less profit than if they had a marketing cooperative, but then it is the traders who take the risk if the crop is not sold. Marketing cooperatives have failed except for those that receive long-term and sustained support from NGOs like SECADeV, a Catholic organization that has worked for many decades in the country and can assure continuous funding. Because most farmers invest little or nothing in fertilizers, seeds, etc, manual irrigators lose only their labor if the market is glutted; pump farmers lose more but balance that risk against improved chances of making a sale if they have some uncommon though perishable item to sell. Private irrigation farmers are therefore interested in trying small quantities of new items to see how well they are accepted. New and improved varieties of seeds are, however, hard to find even in the capital; on the other hand projects that distribute seeds on credit have had a dismal repayment record, as have input credits.

Almost all successful irrigation occurs on plots owned and managed by individuals and the supply of water is controlled by the individual. In a few pump projects along the Logone and Chari rivers where NGOs like CARE and SECADeV give long-term support, farmers cooperate in irrigating individual plots from communal canals and pay operation and maintenance fees for the large pumps. In the PICs (Irrigated Perimeters on the Chari) and similar projects, beneficiaries were not

12 The exception is recession sorghum in some areas like the Salamat, where transhumant pastoralists work in exchange for some of the harvest which they take home with them and the area around Bongor and Kim near the Cameroon border, where young people earn money by harvesting the recession sorghum which matures later on the other side of the frontier.

13 See Kent, Lawrence, 1988, "Farmers' Marketing Cooperatives and the Commercialization of Cheddra Produce", CARE/Chad.
involved in perimeter design or decisions on cooperatives. After farmers had been given fields they were formed into cooperatives based on irrigation blocks; in other words farmers had no choice about cooperating or with whom they would cooperate. While fee collection for pump maintenance was above 86%, maintenance was very poor. After project or NGO support was withdrawn coop membership dwindled. A few cooperatives with excellent leadership have continued with a reduced number of voluntary members. In other perimeters a few farmers, usually from the same ethnic group, have continued to maintain and cultivate their own plots in the perimeter. They jointly finance the operation of the pump. Many produce three crops per year. For them water delivery has become essentially delivery on demand because so few use it. In years of bad rainfall other farmers reenter the perimeter, rehabilitate the adjacent canals and pay part of the pump operating costs. Management then becomes an informal mixture of communal operation and maintenance of the pump and main canals but individual exploitation of plots. While there is no statistical data available, field observation indicates that many of the farmers who sustain cultivation in the perimeters are immigrants from other parts of the country, like those who work on merchants' farms, while those who move in and out of irrigation depending on the rainfed situation are local farmers who have rights to rainfed land, background as fishermen, etc. No cooperative marketing seems to have arisen among farmers who remain in a perimeter although farmers may occasionally agree to rent a pickup truck to get produce to market. All marketing of vegetables is private.

In summary, Chad has suffered from civil strife for more than a decade so that large scale irrigation efforts have had very uneven support. As river and lake levels have dropped, irrigation based on expensive pumping has proven physically infeasible. Small-scale irrigation has been funded in several areas, particularly by NGOs, with much success when it has been based on simple techniques, low costs, minimal annual inputs and independent decision-making by the farmer, especially with regard to water control, choice of crops, and marketing of produce. Cheap tubewells to tap shallow aquifers, used in conjunction with small pumps that are purchased by individual farmers from the private sector, which also provides maintenance, are beginning to supplement manual water lifting. Irrigation has been particularly successful for high value crops but also for irrigated cereals when the irrigation requires only an investment of labor, not capital. Almost all successful irrigation occurs on plots owned and managed by individuals with individual water supply control.

Mali

Mali uses mostly surface water for irrigation. According to the UNDP Water Master Plan there is little ground water in Mali. Except for a few areas around Gao and Timbuktu, for example, much of it is too deep to exploit economically. 99% of the irrigated surface is found in perimeters of one hundred or more hectares; 62% of irrigation is controlled submersion and 30% is total control gravity. Most irrigation is done in the Niger River valley, where The Office du Niger began operations in 1932. Until the 1960s Mali exported rice. After Independence the macro-economic situation changed. Until 1980 the government supported collectivized agriculture. Irrigation fell to the point where, in 1990, only 130,000 ha were irrigated and 50,000 ha had been abandoned. The Office du Niger had gone from 53,000 ha in 1960 to 43,000 ha in 1998.

In the 1970s the state and NGOs started building small perimeters for rice, wheat and vegetables. After 1980 private investment in irrigation increased substantially, mostly in vegetables and fruits, and some high value cereals. Except for the NGO and Church perimeters there are few communally managed irrigation systems. Irrigation is done independently or on the fringes of public irrigation perimeters (which provide the water source) using pumps, small dams or hand lift. While the rice cultivated in the public irrigation projects has been attractive in its way (see paras. 44-47),
private or independent and small scale initiative has been invested in cash crop production \(^{14}\). Although about 70% of Mali's irrigated surface area is used for rice and only 6% is under vegetables and fruits, that small area grows produce equal in value to one third of the rice crop\(^{16}\).

Church groups and NGOs have supported small perimeters, giving technical assistance, large pumps and doing the pump maintenance. The farmers individually exploit their plots but cooperate in operating the pump. In some unrehabilitated rice perimeters village groups have agreed to irrigate, each person taking a 1/10-1/20 ha parcel which they individually exploit by double cropping vegetables. Outside Bamako farmers have rehabilitated a collapsed irrigation project to use for small-scale vegetable growing; in another perimeter where modern center pivot irrigation failed because of clay soils, farmers have subdivided the plots into small traditional basins, which now make efficient use of the sprinkler water for growing vegetables but which makes it impossible to use the mechanized or animal traction for which the perimeter was intended. Despite its remoteness, the area around Gao and Timbuktu, where there is a good local market for high value rice and wheat as well as vegetables and fruits, has expanded with small-scale pumping from the river with small diesel pumps. Around Gao alone there are thirty or more village schemes of 20-30 ha with medium-size pumps and individual plots. In this area there is groundwater exploitable by tubewells and pumps but when large conveyance systems are added they become less economical. The irrigators in the area are familiar with larger gravity conveyance systems and pumps, not individual tubewells and small pumps. Voluntary groups of village farmers cooperate in construction but exploit their plots independently. Individual investors have also taken up pump farming. There is no repair or maintenance infrastructure unless the irrigators have NGO or church support. No private domestic companies have emerged to build irrigation systems in the zone. Most of the financing, unless the NGO or church has given money for the pump, is done with informal credit or money from non-agricultural sources. The financial return to many of these farmers is, in theory, marginal because of the high cost of labor, whereas if the cost of labor is halved then the return is very favorable. In fact the farmer is investing his own labor and so he expends no money on labor and the return is very attractive.

Peri-urban irrigation has increased rapidly everywhere in Mali, as on the strip of river between Timbuktu and Gao. Peri-urban irrigation has also grown without any formal financing and much of it without any technical support. Many of the urban irrigators are commercial investors--civil servants, merchants, educated youths, retired people--who acquire state land and set up 3-10 ha farms, using gravity or pumps, some fertilizer and perhaps improved seeds. Like similar commercial farmers in Mauritania and Burkina Faso, they often achieve poor results because they lack agricultural experience. Other urban irrigators are subsistence farmers and artisans who, to supplement their income using family labor, do hand lift or small pump irrigation from the river or shallow wells. Most peri-urban farmers use neither machinery (other than pumps) nor animal traction and so the main constraint on production is labor.

\(^{14}\) The World Bank study # 9386-MLI "MALI: Irrigation Strategy", 1990, Washington, D.C. comes to the preliminary conclusion on the results of small-scale pumping, controlled submersion, and rehabilitated and unrehabilitated large-scale irrigation of rice that small-scale pumping gives good financial returns and that controlled submersion is competitive when conditions are optimal (page 19).

\(^{16}\) In 1986 the government freed the rice market but set a guaranteed price at which it would buy rice. Most of the rice is sold on the parallel market because it usually fetches a better price and because the government is inefficient in its rice purchases.
This small-scale cash crop irrigation has grown remarkably in the last ten years. Rice remains, however, the main irrigated crop. In the last few decades irrigated rice projects have rarely been successful from the donors' point of view for many reasons, including the costs per hectare for secure water control, low yields (much of the production is eaten on farm), and parastatals' poor management, maintenance and financial situation. From the farmers' point of view, however, some of these projects have been very attractive—and others very unattractive.

Irrigation managed by the Office du Niger was very unattractive, although farmers had little alternative. By 1983, farmers had become de facto sharecroppers, receiving a certain amount of rice each year out of their own production, and were subject to extortion through centralized marketing and threshing operations. The same conditions which made SEMRY I a well-run business existed in the Office du Niger: authoritarian ("military"-like) control, cultivation to standard or loss of land rights, full management control of operations, and financial independence since the Office generated its own revenue from farmer fees. Unlike SEMRY, however, the Office du Niger put all its effort into the slow central bureaucracy. For each staff member there were only 1 1/2 farmers.

16 Mopti Rice III cost approx. $7,000/ha for 95% probability of flooding versus Mopti Rice I which cost $504/ha for 90% chance of flooding (based on records kept from 1940-1983). Mopti I was cultivable only 6/10 years, the other 4 only 1/4-1/2 of the land was flooded.

17 A review of the irrigation sub-sector in Mali (9386-MLI, page 19) gives the following information which indicates the advantages of small-scale pumped rice cultivation.

**Financial Benefits of Various Technologies**

<table>
<thead>
<tr>
<th>Kind of Perimeter</th>
<th>Average Yield ha (kg)</th>
<th>Gross Margin ha (FCFA)</th>
<th>Gross Margin per man day (FCFA)</th>
<th>Gross Margin kg of paddy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small pump perimeters (Timbuktu)</td>
<td>4000</td>
<td>220740</td>
<td>654</td>
<td>62.6</td>
</tr>
<tr>
<td>Small pump perimeters (Gao)</td>
<td>4800</td>
<td>184777</td>
<td>547</td>
<td>90.0</td>
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<tr>
<td>Controlled submersion (Timbuktu)</td>
<td>1200</td>
<td>60320</td>
<td>548</td>
<td>50.3</td>
</tr>
<tr>
<td>Office du Niger-intensive rehabilitation (Retail)</td>
<td>4500</td>
<td>214418</td>
<td>827</td>
<td>47.6</td>
</tr>
<tr>
<td>Office du Niger - semi-intensive rehabilitation - (Arpon)</td>
<td>3500</td>
<td>150734</td>
<td>972</td>
<td>43.1</td>
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<tr>
<td>Office du Niger - unrehabilitated</td>
<td>2200</td>
<td>73550</td>
<td>579</td>
<td>33.4</td>
</tr>
</tbody>
</table>

Source: Rajasekaran - 1990
and a mere 11 ha of irrigation. Although farmers' fees gave the Office financial independence, 80% of the farmers' fee debts were for fines and charges and only 20% for actual inputs. Because many had land outside the Office they put more effort into cultivating outside the perimeter. In these circumstances the returns to farmers' irrigation investments were very low.

In contrast, farmers judged Mopti Rice I and II to be a success, though by donor criteria only Mopti I was successful (mainly because the price of rice increased by 300% during the project period). In Mopti I farmers got, under controlled flooding, an average of 920 kg/ha in a bad year and 1,260 in a good, versus 617 kg/ha from traditional rice. The attractiveness of irrigation was enhanced by the fact that the projects were implemented during droughts so that traditional rice yields were even lower. Hence farmers were eager to get irrigated land; in the Sarantomo Syn polder farmers were demanding land even though there had been virtually no harvest for two years. The good performance achieved in the Sofara polder can be explained by the fact that there are few other opportunities for rice cultivation outside the polder in the Sofara area. By contrast, lack of farmers' response in the Dia and Tenekou polders can be explained by the importance of rice cultivation outside the polders and the marginal water control improvement offered by irrigation works. On polders where rainfed crops are important (Soufouroulaye), slow progress of weeding on project fields can be explained by the competition between dry and irrigated lands. Farmers give priority to hand weeding of dry lands where weeds, as they see it, are more serious competitors for the soil's residual moisture 18, whereas the rice in the perimeter was protected by irrigation (farmers in Sategui-Deressia in Chad have the same priorities). Farmers rapidly accepted sativa rice in the place of the traditional seed but not line seeding and other activities requiring equipment. Few farmers used animal traction but most of those who did bought animals direct from herders rather than going through the project. Farmers also irrigated small vegetable plots for home consumption and cash. Mopti I and II showed that controlled flooding could not guarantee high yields and was not economically successful given the cost/ha and the lack of water control. But it also showed that it could give farmers better yields than traditional cultivation, especially in droughts, gave them low cost water/ha and did not require drastic changes in existing agricultural techniques, and raised their standard of living, for which the farmers considered it a success.

Another cereal irrigation project, Action Ble Dire 19, was also a disaster from the donor's point of view yet farmers were still eager to participate for as long as irrigation could be sustained. The problems this project encountered and the farmers' problems it resolved are illustrative of some of the reasons small pump irrigation has succeeded and failed in the Sahel. In this project the donor introduced small scale-diesel pump technology without an umbrella of support services, in an isolated area between Mopti and Timbuktu. Farmers traditionally cultivated rainy season rice and sorghum on alluvial land, followed by wheat and vegetables in the cool dry season, watered by hand lift. An initial project perimeter in this area irrigated rice with French diesel pumps. Action Ble Dire planned to introduce inexpensive irrigation infrastructure, small, easily transportable diesel pumps, along with sufficient spare parts and contract mechanics to ensure repairs while local youths were trained as mechanics. Fuel and spare parts would be brought in by river at high water. It was proposed that four farmers would jointly own one pump but because of farmers opposition this was altered to individual ownership. Many of the components of successful irrigation projects

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18 PPAR, 1981, Mali Mopti Rice Project, #3523, World Bank, Washington, D.C.

were included: cheap technology, high value crops with an accessible market, private individual ownership, farmer participation in project design.

But other characteristics of success did not exist. The project encountered delays and problems with local project management. In order to stick to schedule farmers and mechanics were not trained and were forced to plant late (which for wheat in the Sahel guarantees a disastrous harvest) so that yields were low and returns to their investment bad. In this isolated area, with the river level dropping because of drought, the project was unable to provide the inputs and fuel promised, interrupting irrigation and harming the crops. Eventually farmers learned it was safer to buy poor quality fuel on the private market. Farmers refused to pay their fees because of the project's lack of timeliness and of low harvests. The pumps selected were from India, so that spare part supply would have been difficult even before the company went out of business. Lastly, with the drought, the shallow pond surface water used for irrigation dried up. Thus the criteria of secure water from shallow aquifers, a supporting infrastructure for the provision of inputs, a high financial return, and the farmer’s right to help reorient the project during implementation were not met and the project was not sustained. The project, in order to stick to schedule and to find the cheapest technology, abandoned attempts to create a local service infrastructure. Nevertheless farmers irrigated wheat with pumps as long as they could because the drought made hand lifting impossible; without pumps they would have had no crop at all. Moreover 86% of the farmers had also gone into irrigating valuable cash crops such as onions, spices and tobacco. This is typical of irrigation throughout the Sahel: farmers irrigate cereals, even though the returns may be negative, because they get more grain than without irrigation, and they irrigate valuable crops because they get money.

In summary, the performance of irrigation in Mali has shown the extremes: failure in the public sector large-scale irrigation and success in the private small-scale sector. Office du Niger, a parastatal corporation, concentrated to such an extent on “public services” that it eventually had one staff member for every 1.5 farmers and for every 11 ha. of irrigation. Although farmers’ fees gave the Office financial autonomy, only 20% of their fees went for actual inputs. Since many farmers had land outside the Office du Niger irrigation schemes, they put more effort into cultivating their private land. Consequently the Office schemes had low returns. In contrast, small scale, private or NGO irrigation has been very successful, especially for high value vegetables. Action Ble Dire illustrates how irrigation can be successful from the farmers’ viewpoint but a disappointment for the donors. The project included factors such as cheap technology, private individual ownership, farmer participation in project design and high value crops with an accessible market which have promoted success in other cases. However, the project also imposed on the farmers poor public sector management of the overall scheme, delays in input arrival through non-private channels, and inappropriate agronomic conditions and procurement of pumps from a company with no after purchase maintenance service. These factors discouraged farmers, who took matters into their own hands, irrigating cereals, even though the returns were "negative" economically, in order to get an adequate food supply in drought conditions, and irrigating high value cash crops to obtain money. The result was not "optimal" from the donors point of view but seems to have been so for the farmers as long as the pumps functioned.

Mauritania

With the 1972-73 drought, rainfed agriculture, which had met about 60% of Mauritania’s food needs, dropped to filling only 15% and never rebounded significantly. Except in the upper portions of the Senegal River Valley rainfed/recession agriculture alone has not, since then, provided enough for farmers to survive. The Diama and Manantali dam reservoirs in 1988 decreased the area suitable for recession agriculture along the Senegal River, causing even more
farmers to turn to irrigation in order to produce enough for subsistence. Local farmers still put their first hope into rainfed farming with few inputs but plant irrigated rice for insurance against bad rainfall 20.

Initial investment in irrigation was done with donor funds for the most part, but in the latter half of the 1980s privately financed irrigation has increased dramatically. In 1964, when irrigation began in Mauritania, there were only 1,800 ha. By 1990 private irrigators grew most of the rice produced in Mauritania. According to a 1991 World Bank study (9409-MAU):

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Irrigated (hectares)</th>
<th>Private Small-Scale (hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>4,000</td>
<td>200</td>
</tr>
<tr>
<td>1984</td>
<td>5,000</td>
<td>1,000</td>
</tr>
<tr>
<td>1987</td>
<td>15,000</td>
<td>8,500</td>
</tr>
<tr>
<td>1989</td>
<td>n/a</td>
<td>12-15,000</td>
</tr>
</tbody>
</table>

Several reasons for this surge in private investment are discernable: (a) changes in land laws in 1984 gave land rights to people who "improve" it by irrigation or other investments and can do the paperwork to claim it; (b) as a result of the drought and a deteriorating economic situation in Mauritania people with money were looking for new avenues of investment; (c) government investment in public perimeters at the beginning of the decade demonstrated that irrigation was financially attractive; (d) the prospect and then the opening of Diama and Manantali dams gave irrigators more water security and flexibility in planting dates; (e) the government raised and protected the producer price of rice, making it a more attractive crop; (f) local farmers have been impelled into irrigation because if they do not improve the land themselves others will lay claim to it; (g) fewer and fewer local farmers living along the river can depend on rainfed or recession farming. Outside as well as local investors were attracted by the prospects. What was, in effect, a land rush began in the second half of the decade. People are still maneuvering to get a piece of land along the river, where cheap irrigation can be done in small private perimeters. Once this land along the banks is gone, getting water inland will require larger investments in canals and infrastructure and necessitate larger perimeters to be profitable.

Initially small-scale public perimeter irrigation in Mauritania, begun as drought relief for traditional farmers and herders in 1973, had enthusiastic farmer support; people contributed to construction, operation and maintenance. The cost/ha. was low. Subsequent projects (Cr.888-MAU and Cr.1571-MAU) enlarged the perimeters to 20 ha or more and installed single pumpsets in order to be more efficient. These perimeters run in size between 20-130 ha. The large diesel pumps installed meant that at least four farmers had to work with one pump. Although codependent for

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20 In Sategui-Deressia in Chad farmers do the same. Because the perimeter makes the supply of water more secure than rainfall, farmers invest their labor (at no cost) primarily in risky by possibly high return rainfed cereals before they work in the high cost (water fees, inputs, land preparation) perimeters, whose yield is more secure but whose incremental production is increased only moderately by inputs and timely planting. The farmer is more willing to risk his no cost labor than his money.
irrigation water in these later perimeters, individual farmers could still choose what crops to grow and market them privately. Similar FED (1972-5) and FAC (1975-7) Village Irrigated Perimeters had self-governing village coops which signed contracts with SONADER for inputs and marketing and received subsidized pumps. Despite the farmers’ enthusiasm, willingness to contribute to construction and right to make independent decisions, debt collection and maintenance were a problem and coops seemed to think maintenance was the responsibility of the irrigation parastatal, SONADER. Village perimeter farmers double-cropped on an average rice plot of 0.3 ha in the rainy season and vegetables on 0.1 ha in the dry season as a complement to recession agriculture. Although farmer contributions kept the costs of construction and maintenance low, production still could not compete with Senegalese rice.

In contrast to the initial success of village perimeters, Gorgol (Cr.1068-MAU) was an economic failure at completion (ERR of 2.7%) and fraught with financial and technical problems. Nevertheless, it has performed fairly well in the long run. Because of cost overruns only about 3/4 of the secondary canals were constructed and only 17% of the tertiary canals, drainage and land leveling was done, which contributed heavily to the initial poor economic performance. However, all roads and feeder roads were constructed. Gorgol has been characterized as “a resettlement project with an irrigation component”. Settlers had to prepare their own land in exchange for Food For Work. Inhabitants of the area flooded by the Foum el Gleita dam were given irrigated fields but concentrated most of their effort on fishing in the newly created reservoir and on cultivating their remaining rainfed and recession fields. The settled nomadic cattle herders concentrated more on irrigation, enthusiastically doing on-farm works rather than building housing at the beginning of the project. All farming operations were under the control of the beneficiaries. The settlers now do double and sometimes triple cropping in their irrigated plots. Water control has evolved, in the absence of effective management, to supply on user demand; farmers take water according to their needs and do no night irrigation. They provide their own seed, use few inputs and sell 60-70% of their crop on the private market. Though cooperatives were set up, the ethnic mixture has made them hard to organize; the cost recovery rate is only about 76%. Although farmers produce several crops per year they are unwilling to use many inputs because they feel the risk of investing and then losing the crop does not outweigh the modest increase in yield gained from using inputs.

A World Bank study (9409-MAU) found that 40% of the privately irrigated surface area in Mauritania is worked by cooperatives. Cooperatives, involving traditional local farmers and sedentary pastoralists, started in 1963 but increased in number only after NGOs became involved in 1984. By voluntarily forming a pre-cooperative on their own, villagers qualified for a perimeter for which SONADER would provide technical advice, a pump and inputs. While many cooperatives are only legal fictions set up under the impetus of traditional leaders in a village or individual outside investors in order to get the advantages open to members, some are real cooperatives. In true village cooperative perimeters, although they are irrigated cooperatively—for example 7 motorpumps for a surface of 130 ha—each participant has his own surface proportional to the contribution he made to establish the coop. Rice is usually marketed collectively, vegetables collectively or privately. Farmers collect their money and then pay the fees; recovery is not a problem even though the farmers could withhold their fees if they wished. The cooperatives obtained their pumps and inputs from SONADER, on credit from an NGO, or by private financing. Now most inputs are bought directly from private suppliers, without credit. The SONADER cooperatives were organized into one of two Unions that help their members acquire credit for tractors, rent threshers, and so forth. The Unions function well, as do some of the cooperatives, depending in large part on the quality of the leadership. Some do well because they are only nominal cooperatives, formed at the instigation of a big man who wanted access to SONADER, which are run on a business-like basis. Others work because a small group of farmers volunteered to cooperate to get SONADER equipment, etc. In some areas the cooperatives received excellent
support, which helped them succeed. However many of the cultivators were not originally farmers and sometimes their production is quite poor. Infrastructure maintenance in the cooperative perimeters is a problem.

On the remaining 60% of privately irrigated land, organization involves:

(a) an extended family head who manages the communal cultivation and division of profits among the family under his control; the pump is usually financed by contributions from the entire family. In a few cases when the family head has moved into vegetable farming, all members of the family consider this a private enterprise on his part and do not provide labor;

(b) the heads of restricted nuclear/polygynous families (who are often young, educated men), who get credit for a pump or finance it themselves, and finance inputs themselves. They put more emphasis on vegetables than rice, which requires a larger surface area and more labor; and

(c) non-farmers, mostly civil servants, business men and others who have funds to finance irrigation themselves. They are commercial investors in pump irrigation, hiring workers and raising crops for profit.

Only about 1/4 of the individual investors are financed by credit. Irrigation design and construction is simple and cheap. The price/ha is also kept low because often no provision is made for drainage, and therefore soil quality will likely become a problem in the future. Prices are low because several private construction firms and technical offices have opened up; in contrast, at the beginning of the 1980s the lack of indigenous construction firms and local design and study capability was a major reason for the high cost/ha of the Gorgol (1068-Mau) perimeter ($30,000/ha versus approximately $2,800/ha for private irrigation infrastructure today. The pumps installed in cooperative perimeters were capable of irrigating 20-25 ha. No information was found on the size of the pumps that private investors have recently installed. Perimeters built by non-farmers run from 20-180 ha. in size and average about 50 ha. Pumps and inputs have become increasingly available through private suppliers. The early commercial farmers acquired as many inputs as possible through SONADER but, as that channel dried up, chose to use fewer inputs because they still get a large harvest from their extensive perimeters. Smaller farmers are reported to realize that fertilizer is worthwhile and so buy what they can afford and find available on the private market. Small farmers’ land preparation is mostly by hand. On large farms most land preparation is by tractor because finding and paying labor is not easy. Tractor owners rent out their equipment to earn extra money but there are not enough tractors to meet demand. Some large farmers have found that hired labor and mechanized farming is not as profitable as sharecropping and will give sharecrop fields to nomadic settlers or local farmers. In the last few years individual cultivators have split into two sorts: 1) those who irrigate rice for home consumption and use money from other sources to support this ability to grow food—a result of declining rainfed and recession agriculture; 2) those smallholders and big commercial farmers who irrigate to earn money—a result of increasing opportunities in irrigation. Investors diversify their crops away from rice when possible to increase profits but the soils are often not suitable for other crops.

The Dutch working in the 1980s with SONADER promoted vegetable cultivation for women’s groups in the off-season in the Rosso-Traorza area. Women’s response was enthusiastic and many tried to irrigate larger areas but ran into conflict with the cooperatives, mainly male-run, which worried about wear and tear on the cooperative pumps. But seeing the high returns on vegetables, cooperatives decided to get into vegetable/corn farming and were followed by private
farmers. Local farmers and poorer immigrants grow rice on their small plots for subsistence, sell the residue, and depend mainly on vegetables, grown on only a part of the perimeter, for cash. Private farmers with larger perimeters grow both for cash. Double cropping of rice has always been possible in certain areas but it requires intensive work, organization, and preferably mechanization. Vegetable farming in the off season is much easier and more profitable.

In summary, agriculture in Mauritania along the Senegal River has been changed dramatically by the construction of the Diama and Manantali Dams in the mid 1980s, which provided more assurance of year-round water control at the same time as they ended traditional recession cultivation based on annual flooding. Expensive public irrigation projects in the 1970s and early 1980s along tributaries to the Senegal, sometimes in remote areas, have been succeeded more recently by less expensive private irrigation along the Senegal River. It is evident that early public investments in irrigation projects which were not successful at project completion did demonstrate irrigation’s potential and provided a market by which a local construction sector was established, leading to lower investment costs for infrastructure. It is unclear whether irrigation will continue to expand as all of the land near the Senegal River is brought into production and investors are forced to move inland where capital costs will be higher, as they were before the dams were constructed. Private irrigation investors have also neglected drainage, which threatens the long-term sustainability of their investments.

Niger

Niger has a centuries old tradition of dry-season surface irrigation in wadis and bottomlands and recession cereals. The water lifting technology until recently was simple: ground humidity, and hand-lifting with calabashes or other manual systems; the shadouf was not known in many areas. Some irrigation was done in bottomlands and river beds. Elsewhere traditional extensive canal systems had been built by sultans with farmers' forced labor. Once constructed, the sultans maintained their own gardens for vegetables and cereals with slave labor; farmers could request individual plots, which became their own to exploit for high value crops such as wheat, cotton and vegetables. Irrigation was a lower class activity. With the advent of a colonial vegetable market private, income-oriented dry-season farming grew, until the government introduced cooperatives in the 1960s. Even though irrigation was an income earner, as late as 1975 at wadi Mirria farmers had not adopted modern water lifting because the value of the crops produced was not enough to pay all of the costs of a pump that had been installed in the wadi. With the drought of 1984 irrigated farming expanded dramatically in many parts of Niger; the government promoted irrigated cereal and vegetables to replace rainfed crops and put thousands of wells at farmers' disposal. Most grew vegetables for cash, not cereal. After 1986 merchants started stocking cheap, small petrol pumps in most major towns, along with parts, PCV pipe etc.

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21 Even though they use ground humidity the farmers carefully scrape the earth into basins to bring the water nearer the surface, so there is some sort of water management. As the water level drops some farmers will dig shallow depressions to collect water for irrigating. On the other hand in Niger and in Chad farmers who have been farming with surface humidity will often give it up as too hard when the water table drops. Even though other farmers in nearby areas have traditionally been irrigating with calabashes or shadoufs from shallow dug wells, so the technology is known to them, they rarely go into labor-intensive irrigation after using ground humidity; why not is not known.

22 The preceding also describes traditional, and to a large extent, modern irrigation in the Kanem, a neighboring area of Chad.
Large numbers of wells, washbores and bailer-tubewells were installed. Most water is pumped from shallow aquifers of less than 5 meters, although for rapid recharge one must sometimes go deeper.

According to the FAO/World Bank Cooperative Program Report, in 1990 70,000 out of a potential 270,000 ha was irrigated in Niger: 12,000 in full-control modern projects, the rest in mostly off-season bottomlands, recession and micro-parcels with water-lifting. Along the Niger and Komadougou micro-parcels with little individual 2-5 horsepower pumps form what have become extensive perimeters, but without any overall system of drainage or management. Large areas outside towns and along the rivers are heavily irrigated in little perimeters of about 1,250 square meters. Suitable land in the Dallols and Goulbi de Maradi where groundwater is easily reached is now sold and goes for 500,000 FCFA/ha vs. dune fields in the same area worth 100,000.

Except in public perimeters, irrigation by family or commercial farmers is done through the private sector and without credit or technical assistance, neither of which is readily available. Investors are individuals, not government cooperatives or groups that voluntarily get together. Some merchants and civil servants invest in pumping underground or river water, because they have money, and run farms anywhere from 3-20 or more ha. with hired labor but irrigation remains mostly a lower class activity of poorer farmers. NGOs have also become involved in small-scale irrigation, mostly in well digging and operation and maintenance of pumps. Despite the lack of credit farmers somehow manage to afford pumps or do manual water lifting. Fresh vegetable farming is done near the cities which provide ready markets, but traditional vegetables that keep well and can be transported are grown in more distant areas. Input supply through the government is unreliable but fertilizer is available from past projects and from Nigeria and can be bought in the market. Merchants stock pumps and will take special orders. Mechanics who service motorbikes, etc. also service pumps. No information about the quality of service, maintenance by farmers or the life-span of pumps could be found. Such irrigation is mostly for high value cash crops and not cereals. Commercial farmers outside Niamey irrigate fodder and sell milk. Farmers are now producing 3 or more cash crops a year with irrigation. Since widespread pump irrigation is only about 5 years old its sustainability cannot be judged; however pump irrigation where it has been used for a considerable time, in places like Mirria, appears to have had no damaging consequences.

This private investment of small amounts of capital in cash crops is a great contrast with modern government and donor financed grain irrigation projects. Surface irrigation construction, as opposed also to traditional forced labor, proved very expensive: $15,000/ha at Namariongou (Cr.851-NIR) and $13,000-20,000/ha in Irrigation Rehabilitation (Cr.1618-NIR), with a projected cost of $30,000/ha at Gabou-Bonfeba. Fees in the perimeters do not cover capital investments. Although farmers on World Bank projects were double cropping, using improved seed, fertilizer, etc. and getting 3-4 t/ha, the value of the cereal they were producing was insufficient to justify the high capital cost. A project at Sona and Djiratoua found that supplemental irrigation of rainfed cereals cost five times less than irrigating rice in the dry season but the pumps received too little use to justify them, while dry-season irrigation alone did not earn enough to pay for pumps; hence small-scale double-cropping of cereals/vegetables was necessary to make the project economically viable. Farmers earn 1,000 CFA/man-day with supplemental irrigation of cereals, versus 500 CFA for rainfed. They have not, however, switched over entirely to supplemental cereal irrigation;
instead they keep their regular rainfed surface area and use their dry-season vegetable/wheat area for supplemental cereals. If the rains are bad they increase the area in irrigated cereals.

Most farmers rushing into irrigation are not, however, doing supplemental cereal irrigation. They irrigate several times a week during daylight hours, using cheap water lifted from shallow aquifers or river water over short distances, usually less than 100m., to water cash crops in micro-perimeters. Even pumping lake water into small perimeters turned out not to be economical in Maradi (608-NIR). The project found pumping 30-40 m. deep groundwater, in order to get fast enough recharge, was economical if the farmers did all well development on their own, with an ERR of 11-15%. The ERR was negative, however, if the farmers just paid the costs of technical assistance and extension even though the well was developed at project expense. In other words it was economical when it remained private, which is essentially what has happened even in projects such as Dosso (Cr.967-NIR). In this project farmers rejected the cooperatives and improved rainfed part (98%) of the project but welcomed the 2% that dealt with improved bottomland. They readily paid in cash and kind for bottomland development and asked for more areas to be improved because income increased dramatically. In the bottomlands they applied the agronomic techniques they had learned but often did not apply in rainfed fields. Most were too poor to use any purchased inputs. The successful portion of this project thus resembles the successful spread of private irrigated agriculture: rapid and impressive impact on revenues, simple improvements in water lifting and delivery, low investments in inputs, no credit (the project conditions being so strict most did not qualify). Management was individual and informal, and not done through the cooperatives. Farmers marketed through commercial channels except for rice and cotton that they sold to the government at a subsidized price.

In summary, Niger has a centuries old tradition of irrigation, both by individual farmers and by sultans using forced labor. In the modern era, irrigation based on the farmers' initiative, using the private sector for provision of inputs, utilizing shallow aquifers and inexpensive low technology,

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23 This double cereal/vegetable cropping on a limited surface area in conjunction with traditional rainfed crops has also occurred in Chad, either in small private perimeters or in NGO or donor perimeters where the double-cropping of cereals for which the perimeters were developed has been dropped. "Abandoned" perimeters are double cereal/vegetable cropped on a continual basis by individuals who maintain the pumps and part of the network. When rains are bad they increase the area. These farmers have developed the cash and food security aspects of irrigation in their own way. Other farmers have abandoned the cash side of irrigation but return when they need food security. In bad times empty parts of the perimeter are occupied and rehabilitated by new or returning farmers who grow irrigated cereals until adequate rains return. The perimeters provide them with what has decayed to the equivalent of slightly improved land which will retain moisture, a nearby source of water and a water-lifting device. Portions of other schemes and "outside perimeters" in other countries also fulfill this function.

24 In Niger and Nigeria a number of farmers borrow land during the dry season to grow cash crops. Some of them migrate from rainfed areas without alluvial land and borrow from a farmer who does not plan to exploit it in the dry season but who knows he will benefit from the irrigator's fertilizer residues. Mentions of this phenomenon did not explain the arrangements worked out between loaner and borrower. In other countries such as Mali, Chad and Madagascar farmers who irrigate borrowed land are usually disinterested and unmotivated to produce high yields because the borrowed land is worked under a sharecropping agreement. A number of studies have mentioned this arrangement in Niger but not why the farmers are motivated. This would bear looking at in a study of the relationship between land tenure and irrigation.
and marketing of surplus production, appears to be quite successful and expanding. The farmers have used crops with ready markets and have not had access to substantial external financial resources so that inputs have been inexpensive or labor intensive. The tradition of the sultans has been continued by the public sector for large-scale irrigation projects within a "command" framework. Lacking the coercive nature of the sultans, the public sector projects have not performed well in Niger.

Nigeria

Nigeria has invested heavily in large-scale irrigation and built a number of dams, including thirty in the three states of Bauchi, Kano and Sokoto where small-scale irrigation has also expanded rapidly. The dams disrupted the flow of water into the fadamas, perennially or seasonally flooded areas in which farmers had cultivated one rainy season crop and perhaps a few dry season vegetables and the luxury crops of wheat and rice at least since the 16th century. Fadamas also provided fish and pasture for the local people and transhumant pastoralists \(^{26}\) before the dams were built. However the water stored behind the dams has caused year-round shallow ground water levels not to fluctuate and provides water control. Farmers, having lost the traditional use of the fadamas, have turned to small-scale irrigation and small-scale irrigated farming in the fadamas is growing. According to Underhill \(^{26}\) fadama irrigation in Nigeria has gone from 120,000 ha in 1958 to 800,000 ha in 1978. Within the ADP areas there has been a 19% increase in cultivated surface area of former fadamas since project inception.

Traditional irrigation was individually managed, farmer-financed, using shallow lift by shadouf or calabash in the dry season. In the early 1970s a few farmers, with help from relatives or extension agents, got small pumps through private traders to do direct lift irrigation. Simultaneous Area Development Projects were intended to improve rainfed agriculture and build livestock reservoirs but technicians in the project knew the Indian experience with tubewells and small pumps and introduced them as appropriate technology for the fadamas. This technology reduced the cost of constructing shallow tubewells by about two-thirds, with a commensurate increased return on tubewell investment. By the end of the first ADP in 1980, irrigation was the most popular part of the project. While 60-80% of the farmers were using only the rainfed techniques that they could adapt to traditional rainfed farming (fertilizer, seed dressing, and maize, which is shorter cycle than millet), they were asking for more fadama development. In 1982-3 Kano ADP alone sold 2000 pumps for cash to individuals or small farmer groups (vs. selling only 10 out of a projected 20,000 animal-drawn carts in all three zones). As in Niger, farmers began migrating from inland and renting individual fadama plots for cash crop farming. They often grow two crops in a dry season.

Farmers prefer the traditional shadouf or small 2-5cm petrol engines. Eighty percent of the irrigation systems are direct lift, only 17% washbore and small pumps, even through there is a

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\(^{26}\) Traditional fadama cultivation inside city walls also provided food security. Barth, who traveled in northern Nigeria in the early 1850s, mentions in his journal how the city walls of Kano enclosed much open space and irrigated gardens. If attacked the farmers could grow cereals, otherwise they were well poised to sell their vegetables in the market. Fadama cultivation still provides food security; if farmers see the rains are bad they plant cereals in the fadamas where residual moisture will help it mature after the rains have gone. In essence, subsistence cultivation, other than rice, is not the main purpose of fadama farming except in bad times.

\(^{26}\) Underhill, 1984, p 7 & p 10.
50% subsidy on washbores. Pumps are very popular (especially before the Naira was devalued). Farmers like them because they can irrigate at their own convenience, fuel prices are low, and pumps are readily available in big towns from local merchants, as are spare parts and even second hand engines. Merchants now supply Niger and Chad with pumps. Nigeria already had a good national road network and the railway passes through the project zones. ADPs added all-weather feeder roads, which had an important impact on opening up new areas, eased access to inputs and created a major increase in market traffic. They did not specifically build fadama roads but every farmer was, in principle, no more than 10 kms from a feeder road. Prices of many agricultural commodities are protected so that the return to the farmer is high (an average 30%). An average of 9.4% of a farm’s surface area is irrigated but provides 22.9% of net farm income. Marketing through private channels is efficient, with farmers-cum-traders, bulking traders, and urban retailers. Farmers get 70% of the consumer’s price. Traders come all the way from Port Harcourt to the north to make purchases. Food processing plants have been set up so that an industrial market is developing as well as local and national markets. In Kano State 40% of the population lives in big settlements of 5,000 or more, and so large urban markets are nearby. Farmers in different areas have found special production niches adapted to the soil, labor and water availability, and market demand. The private sector has been able to handle all these developments; however, inputs are provided by the government or the projects. The subsidies for inputs are so large that farmers in other countries such as Chad buy their fertilizer in Nigeria. Farmers like fertilizer so well that they will pay 2-7 times its value to get it illicitly from traders, and a private market in inputs has developed. It is not clear to what extent farmers employ fertilizer in the fadamas. Credit is not readily available (in the ADP projects it was available only to farmers who adopted the entire rainfed package) and so farmers have been using informal sources of credit such as relatives, money lenders, traders. Labor is a limitation, as it is in other countries, but since about 1984 a market has been developing for hired labor. Now an average of 15% of a farm’s labor is provided by paid workers.

The organization of fadama irrigation is primarily individual, with small pumps and direct pumping from a nearby open water source or borehole. In Kano, Bauchi and Sokoto there are coops, which for the most part arrange and finance wells, but not marketing. In Anambra State, Water Users Associations have only 50-60% recovery rates in successful schemes. There are also WUAs in the Kano River large scale irrigation, which has a 200% cropping intensity and 6-70% collection rate; the farmers own their own land and make their own farming decisions. There is also night storage irrigation. Performing less well is the large Bakolori scheme where much land cannot be irrigated because of breakdowns (only 1/3 of the sprinkler area can be used, for example), the authority owns the land and night irrigation is required.

In summary, Nigeria also has a long tradition of irrigation and considerable government and private investment has been made in this sector in the last two decades. The success of irrigation was due to farmers’ active participation but also to subsidized irrigation infrastructure and artificially low input prices subsidized directly through the government’s petroleum revenue or indirectly through the overvalued exchange rate. The subsidized inputs have been smuggled to other countries in the region where they have also contributed to the growth of irrigation. Individually managed, farmer-financed irrigation using manual lift systems has been supplemented by low-cost pumps, which have become readily available through the private sector. Rural roads have allowed farmers to market their surplus production as has access to traders and decentralized food processing plants. The success of irrigation as a commercial enterprise has also led to

27 V. Branscheid explains the popularity of petrol pumps for groundwater exploitation by low initial costs, low weight, existing repair facilities and spare parts availability and fuel availability.
increasing use of hired labor, which now makes up on average 15% of farm labor in areas where irrigation has become common. Irrigation will now have to prove its worth in an era of market prices for inputs and hardware.

**Senegal**

In Senegal, SAED (Societe pour l'Amenagement et l'Exploitation des Terres du Delta et de la Vallee du Fleuve Senegal) has changed its focus over the years from (i) implementing and managing large government irrigation schemes to (ii) parastatal farming to (iii) small village irrigation to (iv) getting out of production entirely. Donor concern with irrigation in the Senegal River valley has been primarily the management difficulties of SAED underlined in one supervision report after another. Management was initially granted control of planning, constructing and managing the infrastructure and of all phases of production: water control, supply of inputs, cultivation techniques, collection and sale of outputs. A 1984 report summarizing the condition of SAED notes that the only efficiently operating and money-making part of SAED was the rice mill. Many technical difficulties also contributed to bad performance; much of the land developed was not irrigable and tomatoes, intended to make the costs sustainable, could not be cultivated because of salinization. But the World Bank Debi-Lampsar Project (Cr.775-SE), though unsuccessful, performed better than other SAED interventions. At about the same time the World Bank Drought Relief project, instituted to help the country recover from the 1972-3 famine, showed that small-scale irrigation worked better than large-scale irrigation, and so donors turned their attention to small perimeters. The Small Rural Operations (Cr.991-SEN) and Debi-Lampsar were intended to be smaller and simpler than operations that had gone before.

The problem with SAED, the Senegal River Polders Project (350-SE), Debi-Lampsar and other rice projects is that rice irrigation on the Senegal River is not economical. From the Dagana Perimeter donors learned that total control of water was necessary, but also expensive. Producers' cash income from rice was insufficient to pay recurrent costs and replacement of assets. At approximately $10,000/ha development costs and $200/ha annual recurrent costs SAED needed more revenue. SAED tried to get it by making its perimeters more like the small perimeters that had been giving higher yields. From 1978-83 SAED turned over to the farmer control of his parcel and farming decisions. SAED also constructed more small village irrigated perimeters. Construction, however, continued to be a problem. In order to justify two dams on the Senegal River (Diama and Manantali) SAED had to bring 5000 ha/year under development. At Debi-Lampsar in 1978, its best year for constructing new perimeters, it installed only 2960/4800 ha, not all of which was farmed, and on average it constructed canals on only about 1250 ha/year, of which it developed only 50% for irrigation. Only 75% of the developed area was actually farmed and only 5% double cropped. Debi-Lampsar was supposed to be cash crop irrigation of rice and tomatoes for industrial use. In fact, in 1981, farmers ate 33% of the project's rice, sold 67% and had a repayment rate above 90%. In other large perimeters they ate about 50% of the rice. The failure of rainfed farming in the region was forcing the inhabitants to depend on irrigated rice for food self-sufficiency. As a result they were not contributing as much to national rice self-sufficiency as the donors and government had hoped.

Nor were the returns from large-scale irrigation enough to interest the farmer in raising his yield. Income for farmers in Debi-Lampsar was about three times the situation without the project, but with this sum farmers had to hire labor and were eating about a third as well. 50% of the plots were so small that farmers were not getting enough cash to cover their costs and so they subsidized their rice growing with money from other sources (vegetables, hiring out as laborers and other sources), and there was a high degree of indebtedness to SAED. There is a long history of credit delinquency with SAED, even with cooperatives. In 1978 63% of farmers had cash
vegetable gardens, 3% had livestock and 6% income from other sources. Yet project tomatoes failed; production was low and what matured was left to rot in the fields, in part because SAED was too disorganized to collect them, but also "because of the total disinterest of the farmers in "SAED tomatoes": from the first harvest they had to choose between SAED's tomatoes which they had to sell to the processing factory for 17 FCFA/kg and their own (private) fields of tomatoes sold in the market (and paid for immediately) at 60-100 CFA/kg. Broken canals which could not deliver water to the fields had been turned into livestock watering troughs and four fish ponds.

Traditional irrigation had involved individual and family recession cultivation and a few dry season vegetables. With the development of Dagana, Debi-Lampsar, and the rehabilitation of Savoigne perimeter farmers were clamoring for land in the perimeters. By 1981 upstream irrigation had increased so much that the number of pumps was reducing the flow of water into the Delta. Village perimeters were spreading from Matam to Bakel on both sides of the river. Demand grew dramatically in 1983, which experienced only 20% of normal rainfall. Farmers asked for land in small and large perimeters. The repayment rate in Debi-Lampsar went from 76% in 1981-2 to 100%. A new rule also contributed to this increase: a farmer had to have repaid or he received no service. The experience of small perimeters in the Drought Relief Project had been that farmers got higher yield/ha, cultivated a higher percentage of the developed area, double cropped a larger area and therefore produced more per ha than the large schemes. However, as more small perimeter projects were brought on line it appeared that maintenance was no better than in larger perimeters. The lower development costs/ha were traded for higher maintenance costs and a shorter life span. The World Bank Staff hoped that farmer participation would improve project operations but in the end design, planning and implementation was still top-down, though the farmers contributed their labor. In some perimeters substantial pressure was exerted on farmers to come up with initial contributions and labor and so participation did not truly represent farmers' attitudes. Because SAED was the only large-scale supplier of inputs, the farmers and coops in any size perimeter were still dependent on SAED's erratic delivery and were therefore reluctant to use inputs. Small village perimeters had a far worse repayment rate than large SAED schemes (5% vs. Debi-Lampsar's approximately 90%) because the plots were smaller, hence production was smaller and a larger portion was used for home consumption. At Matam perimeter, for example, where plots were small, farmers sold only 8% of their rice production. By 1983 the World Bank considered that rice alone was not profitable; Valley and Delta perimeters were producing rice at 150-180 FCFA/kg, (if amortized the cost was 250-300 FCFA/kg) whereas imported rice was selling in Dakar for 85-87 CFA/kg.

Irrigation in the Small Rural Operations Project (Cr.991-SE) was even more farmer-oriented than in the village irrigation schemes; the project was intended to respond directly to farmers desires and have direct farmer input in defining the project. Cooperatives were to set rules, pay initial contributions and organize labor contributions, and collect annual fees. In fact, however, most of the planning was still top-down. Irrigation perimeters for vegetables were successful whereas bananas ran into technical problems; but implementation in the N'Galenka Valley (1984)

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28 Project manager to World Bank.

29 Land in the perimeters was of interest, in good part because farmers paid only 13% of all perimeter related costs. On a perimeter plot a farmer could therefore produce a cheap, guaranteed subsistence crop. In 1984 the state was paying 57% of perimeter costs; SAED 30%; and the farmer 13%. The state was paying 18% of production costs; SAED 41%; and the farmer 40%; in principle only since the farmers' repayment rate was so poor. 45% of SAED's budget was spent on the management, 55% on farmers and production.
foretold the failure that followed in those perimeters. The perimeters were intended for irrigated rice, which had already been shown to be uneconomical. Farmers in Small Rural Projects were to pay 5% up front as a sign of their interest. When the money was not paid in N’Galenka, the project was simply delayed until enough money had been raised. A number of farmers boycotted and paid only under stress.

Another feature of the Small Rural Operations was that beneficiaries were to establish Capital Replacement Accounts (CRA) to purchase the equipment loaned to them and save for replacements. Farmers had difficulty understanding the purpose of the accounts but once a perimeter used the CRA to replace a pump they rapidly accepted the idea. In places where farmers did not fund the CRA, farmers turned to informal credit mechanisms to raise money when needed.

The Small Rural Operations Project depended on coops to help with construction, organization and management. SAED and the Bank had turned to coops in the hope they would induce farmers to do more maintenance and to raise their yields. The Bank and farmers hoped that cooperatives would be more efficient than SAED. In the Senegal River Valley as a whole, some cooperatives have worked; the perimeter-wide "Comites Paritaires" offered farmers a voice to maintain a dialogue with SAED. But the coops set up in Drought Relief perimeters withered. Small perimeter coops did not maintain their infrastructure better and had a poor payment history. At Lampsar the leader was highly respected and, it was reported, there were no problems with water distribution, perhaps because, as is reported elsewhere, water control was so poor that it was essentially on user demand. The collection rate for this coop was poorer that at Debi, where water delivery to most parcels was much more secure, though the coop was less effective. Alongside these two perimeters a number of individuals and informal groups were pirating water and irrigating their own fields. This indicates that irrigation interested the farmers but that they liked it cheap or free and with user control.

By 1990 irrigation on the Senegal River had developed to a point where both large and small perimeters ended up with essentially individual user control of water, little maintenance, poor supply of inputs through SAED, and informal financing to purchase material on the private market. Debi-Lampsar’s water control system was so sophisticated that farmers bypassed it for uncontrolled self-service. SAED’s primary concern was with building new perimeters and maintaining its own bureaucratic organization, not with getting reliable cheap water to the farmers. Social equity was similar in large and small perimeters. It would appear from Bank reports that in 1979 only 14% of the lowest social stratum in Debi-Lampsar had plots whereas 50% of the plots were held by absentee landlords, important village officials, etc. The situation in large perimeters was similar to the social situation in villages elsewhere. No mention has been found of the situation at present.

In summary, Senegal exemplifies the changing focus of irrigation from (a) large, publicly-managed irrigation systems with the farmer as laborer, to (b) unsuccessful attempts to make parastatal irrigation agencies more efficient, to (c) government assisted small scale irrigation, to finally (d) experimenting with non-public sector irrigation. The early phases of this experience suffered from inappropriate construction of irrigation perimeters and from selecting crops that were not economically viable. The height of "command" inefficiency may have been in the late 1970s

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30 A parallel can be drawn with Water Users Associations at Lake Alaotra in Madagascar where farmers who had experienced disastrous destruction of their perimeters in the past understood the point of paying fees for future repairs whereas other WUAs resisted.
when farmers refused to sell tomatoes to the Government parastatal at artificially low prices which, in any case, the parastatal was too unorganized to collect and take to the processing plant; farmers preferred to sell what they could on the open market at much higher prices. Project design, operations and reform attempts by both Government and the donors were carried out from the top down, ensuring a low level of farmer enthusiasm. An attempt by Government to stimulate small-scale irrigation failed when the plot size determined by Government was too small to encourage farmer participation. Irrigation has also suffered because Government has wanted to promote cultivation of expensive "long" rice while macro-economic policies and consumer preferences have encouraged the importation of cheap, "broken" rice at lower prices. Recent successful irrigation in Senegal has been characterized by individual control of water and informal financing of inputs and has shifted from rice to vegetable cultivation.
CHAPTER 2: CHARACTERISTICS OF SUCCESSFUL PROJECTS

This chapter explores the characteristics of successful irrigation projects in the Sahel in relation to the different expectations project participants, donors, governments, institutions and farmers have of irrigation. Participants do not always agree on how they want irrigation to perform, the type of technology they want, the institutions that will carry out irrigation efficiently or the financial incentives for investing in irrigation. Chapter 2 also discusses how to weigh these different views.

Success Rates for Irrigation Projects

A review of World Bank agricultural projects in Africa that had been completed and reviewed by OED as of 1989 found that of the eleven irrigation projects included in the review only four were considered as successful at project completion (36%). This compares with a success rate of 51% for all agricultural projects completed during this period. However, all four of the "successful" projects continued to be successful five to ten years after project completion compared to an overall sustainability record of about 59% for all Bank agricultural projects in Africa. The irrigation projects under review were predominantly large scale in nature, since no separate data were available on the smaller scale irrigation activities that were financed as components of larger projects.

World Bank area development projects with irrigation components appear to have a success rate of 44% but agricultural crops projects with irrigation components only 24%; these are not direct measures of the irrigation component's success but of the entire project. The FAO determined in a 1989 study that irrigation projects surpassed other types such as agriculture, fisheries, rural development and livestock. According to this study almost 50% of African irrigation projects achieved a re-estimated rate of return equal to or higher than appraisal and also achieved yields higher than appraisal estimates. Clearly, the exact degree of irrigation success and failure is hard to pin down and quantify and a direct comparison of large and small-scale irrigation is even more difficult.

Success at the time of project completion or an OED audit may not be sustained. The Gambia Agricultural Development Project (Cr.333-GM) was a success at completion in 1977 but ten years later only 10 out of 182 ha was still cultivated—and that not irrigated. A number of projects successful at completion have needed rehabilitation. On the other hand, Gorgol Noir in Mauritania (Cr.1068 MAU), a failure of major proportions at completion (estimated ERR of 7%, ERR at completion of 3%, and a cost of US$30,000/ha), is now considered a "success". Semry I (Cr.302CM) was a disaster at the beginning of implementation but management turned it around. Others look economically successful because some of the costs are "sunk", as in Rahad (Cr.364 and 364-1-SU) in Sudan. Much private small-scale irrigation in Nigeria has been developed because of the dams built for economically and socially unsuccessful irrigation projects such as Bakolori. In many "failed" irrigation projects farmers are still using the project infrastructure years later at a level they can independently sustain.

According to Plusquellec, McPhail and Polti, the record of irrigation is less satisfactory at full development, five years after project completion, when the Bank carries out impact evaluations, than at appraisal or project completion. Nevertheless, irrigation is frequently sustained over the

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longer term, although at a lower level than originally planned. They find that the social impact is substantial, food security is improved, and poverty alleviation occurs. Irrigation projects do poorly in part because of overly optimistic assumptions at project appraisal and in part because of bad construction and poor physical performance. But irrigation is frequently sustained, which shows that it is rendering an important service.

What Constitutes Small-Scale Irrigation?

Development experts and irrigation specialists use large-scale and small-scale irrigation interchangeably with formal and informal irrigation. By "formal" irrigation Carter, Carr and Kay (1983) meant "the development and management of irrigated agriculture in a structurally formal way usually by a government body...Formal irrigation projects...are large scale (up to 1,000,000 ha. each); they are often established with very little prior involvement from farmers or landholders; and they are usually managed by a structured government organization." They contrast this with informal irrigation which involves "schemes which are under local responsibility, controlled and operated by the local people in response to their felt needs." Informal irrigation is usually found in smaller projects because the structure of water control and conveyance mechanisms in this context are smaller and require less complex management. "It is clear that small-scale irrigation in this context is distinguished by small farmer management and control rather than by small scale." But small perimeters can be as centrally planned and managed as larger ones, a point made by Underhill (1984). This paper uses the equivalents of formal with large scale and small scale with informal as working definitions but explores in depth in Chapter 3 the precise characteristics of size and management that make "small-scale" irrigation more successful.

Definitions of Success

Irrigation, agriculture and development experts interviewed for this paper had various ideas of what constituted a successful project. The beneficiaries of the project, the host government and the executing agencies also have their own, often conflicting, views of success. The beneficiaries may feel that projects are successful because they receive "free" goods and services from inefficient parastatals or because they become financially self-sufficient. Host governments may define a project as successful because it pays for a higher level of public employment or because it helps farmers achieve a sustainable high level of revenue. The executing agency may feel a project has been successful because, at one extreme, donor funds have been disbursed, or, at another extreme, food security has been improved even if agricultural production is subsidized. With large-scale projects it is primarily the donors' and government's ideas of success that determine whether investment will continue in follow-on projects. Since the trend is to make the beneficiaries themselves responsible for much of the management, maintenance and investment decisions involved in irrigation, the beneficiaries' definitions of success becomes critical in determining whether investment and maintenance will occur. For small-scale/private irrigation to occur the projects will have to offer a chance for "success" to all parties involved.

General Characteristics of Successful Projects

Successful schemes generally employed simple technologies, a secure supply of water and individual control of water. It appears that these three aspects are inseparable in successful projects. For example, gravity distribution of river water can be simple and cheap if unlined canals are used and the civil works are kept to a minimum. The supply of water managed in this way may

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32 Carter, 1989
not, however, be secure since the river level may sink, the simple civil works fail, and so forth, and consequently the supply may not be available year-round. The farmers are, moreover, often codependent and must cooperate with others for water distribution; taking water on demand may damage the irrigation network or damage neighbors' crops. Groundwater supply is more secure and perennial than river flow but the irrigation system used may require individuals to cooperate in water distribution or in sharing a big pump, the operation and maintenance of which may not be simple.

**What Constitutes Technological Success?**

To the engineer a technological success not only delivers sufficient water at the right time but also makes the most efficient use of the water resources available. The engineer's tendency is to design a scheme that takes maximum advantage of potential water availability and that delivers it in a way that uses most of the water. Government and donors also wish to maximize the benefits that the natural resources of water and soil provide for development and so they seek to use water to its full technical potential. The agronomist has the somewhat different technical objective of maximizing yields. He can do this through the types of crops cultivated, the varieties selected, the agricultural calendar followed, the inputs applied, the cultivation techniques used, and by meeting crop water needs most efficiently. He may try to develop a package, the optimum combination which gives the highest yield. Already there is room for disagreement over "success" since the engineer may feel that the agronomist is letting water go to waste or is requiring it at the cost of inefficiencies in the water system.

The farmer, on the other hand, often has a different idea of what "sufficient water at the right time" means. "At the right time" means at the convenient time for him, not for the water source, the system or its managers, or for the crop selected and its water needs. As Moris and Thom note, project designers see the potential benefits but they rarely achieve them because they expect extraordinarily high efficiencies from the farmer, maximizing and using all the irrigable area, night irrigation, sharing water channels, etc., instead of providing flexibility to the farmer. Despite the high costs of large-scale irrigation, they add, planners do not consider paying for the features that would give the farmer easy, flexible production. Moreover, the farmer and the agronomist may have different ideas about "in sufficient quantity" because they may have different ways of judging crop water needs and tolerances and because the farmer applies water as a function of the time he has available, not just of crop water needs. The engineer may consider that the system as a whole delivers sufficient water but an individual farmer may be unhappy because he is at the tail end, because his land is improperly leveled, or because he does not get enough water at the time convenient for him.

"At the right time and in sufficient quantities" has the most meaning for the farmer at the time he most needs water control, in times of drought or flood, which require the engineer to

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33 Moris and Thom, 1990, p.74.

34 For example, in the wadis of the Lake area in Chad, farmers judge a sufficient quantity to be when he can see water has flooded the irrigation basin up to a certain point on the side, but a project agronomist judged this to be excessive and to deprive the plants of oxygen. Plants in the wadis may not receive enough water because the farmer is busy irrigating another part of the field or because he has been called away for a funeral or some other social obligation. Then the farmer overwaters when he returns.
design extreme tolerances, which is expensive. The farmer may also want a technology that does not interfere with important non-irrigation aspects of his life. For example, in Nigeria and Madagascar, farmers cut through irrigation canals to make paths for their livestock. The government may also consider a scheme a success because it can produce food not only in average years but under extreme conditions, providing food security, while the donors and beneficiaries, although glad for food security, may find the cost of irrigating in normal years so high, because of the elaborate infrastructure, that the project is not a "success".

The engineer, agronomist, government and donors tend to deal with the averages. Modern farmers can also work to some extent with averages, but the subsistence farmers and low income people for whom irrigation development projects are often intended are already living on the margin and worry about the extreme conditions that may push them over the edge rather than the averages. The farmers' ideas of a "successful" technology are, therefore, often at odds with the engineers' and others' definition of "success".

Technical Characteristics of Successful Projects

The most frequently successful sources of water supply are aquifers, rivers, and streams. Improved swamp irrigation has also interested farmers. Areas outside perimeters, which have been slightly improved, usually for additional subsistence farming by farmers in rice perimeters, or which retain moisture because of the perimeter, and degraded expensive irrigation works have also been highly popular for cereal cultivation. Production in these areas is more secure than in traditional rainfed/recession conditions. However, water from these sources has proven so unreliable, even with expensive high technology full water control, that cereal cultivation has not been economically viable. Since farmers exploit these areas after only minor improvements or in degraded high technology, complex improvements and a high probability of flooding are not necessary for exploitation, if only the works can be done with minimal capital investment.

Sources of Water Supply

(a) Aquifers. The shallow depth aquifers that are scattered over more than 100 thousand hectares of Niger, and that also exist in smaller areas of Northern Nigeria, Mali, and other Sahelian countries, provide the most interesting possibilities for successful small-scale, private irrigation systems since the costs of water lifting are low, wells and pumps can be managed by individual farmers and the technology is simple. The aquifers must be rechargeable (as they are in Niger), and the water drawdown rate must be consistent with the rate of recharge. Further work to identify additional aquifer areas is an obvious high priority for future irrigation development in Africa. An obvious limitation to expansion of irrigation on this basis is the limited area where such aquifers exist, and the possibility of overtaxing the recharging capacity of these areas.

(b) Rivers, streams and lakes. Gravity discharge when possible, or pumping from rivers, streams and lakes offers the next most feasible technology, as this is also simple and can

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36 Mopti III, which was designed to give 95% probability of flooding, cost $7,000/ha vs. Mopti I, which had a 90% chance and cost $504/ha. Moreover farmers may give up irrigation if it is not capable of dealing with extremes. Farmers in CARE perimeters at Bongor and Kim, Chad, are only interested in drought-secure cereal production in bad years and in growing cash crops in other years, but the infrastructure required to provide for drought years makes growing cash crops, no matter how valuable, too expensive to maintain the perimeters. So farmers farm but the perimeters and pumps deteriorate due to lack of maintenance.
frequently be managed on an individual basis. Although larger scale pumps, which serve more extensive command areas accommodating groups of farmers, may be able to enlarge the irrigated acreage by carrying water farther from the water source, they also require greater initial investment and more complicated institutional arrangements and therefore more often fail.

(c) Surface water runoff. The use of seasonal rains and streams to irrigate crops through channelling of runoffs can expand the use of these waters. However, applicability is limited to areas where the terrain and soil permeability are suitable. Moreover, the institutional arrangements usually involve a sizable number of farmers who must cooperate in a well-organized joint effort for construction and periodic repairs. Runoff is also an insecure source of water since it depends on rainfall. Small dams can make the water supply somewhat more reliable but they increase the cost whereas the insecurity of the water source is mainly offset in the farmers' eyes by the very minimal costs of operation. This indicates that site-specific investigation will be required.

(d) Swamps and marshes. These offer interesting possibilities where proper conditions exist, although drainage is difficult and the agricultural technology must be adapted to the specific swamp conditions.

(e) Dams. These are the most commonly considered source of irrigation in Africa (with water distributed either through gravity feed or through sprinklers and/or drip irrigation), and are the major technology used in past Bank projects. The pros and cons of their application are well known and will therefore not be described in detail here. Generally, however, dams require large scale investment to put in place and complicated, extensive organizational arrangements to operate. Results have been mixed at best, as elaborated in the 1989 OED report on evaluation results, and costs of installation are often high. The positive aspect of dams that has emerged in this study is that small-scale irrigation can take advantage of dams' regulated flow and recharged ground water.

(f) Deep wells. These can be drilled in areas where shallow aquifers do not exist, but the high cost of drilling and pumping limits its usefulness to a source of drinking water in most parts of Africa.

Water Extraction

While the most successful kinds of irrigation use low level technology, simplicity, while important, is a concomitant of what is really primary—low cost technology. Cost can, however, be balanced to some extent by secure production as long as the costs remain relatively low. If tubewells are cheap enough, the secure water supply can offset the fact that hand dug wells or direct pumping from a river or lake is cheaper. The insecure yield of partially controlled flooding may be compensated for by the small investment needed to control the runoff. Even though a small pump may require a large lump sum for purchase and its maintenance may be problematical, the financial returns may be so high that some farmers may treat the pumps as "throw-aways," to be replaced when they can not be repaired\(^3\). Nevertheless, boosting spare parts supply and good

\(^3\) For example, in one sub-prefecture of the lake area in Chad, which later was the site for an ORT/USAID small irrigation project which emphasized pump repair and maintenance, three farmers had acquired petrol pumps between 1983-86. The first had bought two Honda pumps in Nigeria, one to be cannibalized for spare parts for the others. When the pumps no longer functioned he brought a third in Nigeria. The second farmer had a Lombarde pump acquired through contacts in France; when it broke down he replaced it with a Nigerian-bought Honda, which he thought worked better. The remaining farmer had a Yamaha he bought in Saudi Arabia; when it died he replaced it with a Honda from Saudi Arabia. Thus within three years the farmers had each gone through at least one pump.
repair services is crucial to successful irrigation through small pumps, lessening the economic loss farmers suffer when pumps break down.

Another important characteristic of successful irrigation is that farmers have water more or less on demand, because they have their own source or because they have night storage. Farmers judge irrigation a success in large schemes where all the land prepared is not farmed because there is more water supplied than there is demand. This inefficiency provides a challenge for engineers and agronomists—how to provide the farmer the maximum control of water without wasting it.

Scale of Irrigation

The most successful scale for irrigated farming has been individual plots with individual water supply. Where larger conveyances have been used, the most successful have been fairly large gravity canals but not large pumping stations, with little intervening between the farmer and the main water supply. The more individual control the farmer is able to have within a large scheme the more successful it is. Dams have also helped in irrigation. Small dams like those built in the Nigerian ADPs, or traditional Chadian polders, which require some initial capital and labor investment but not much subsequent attention, seem to work. Large dams such as Bakolori in Nigeria and Manantali on the Senegal River have had very disruptive effects, but in the end farmers have made the best of it with individual irrigation dependent on the dams’ retained water.

An important difference in scale between large and small pumps comes when the pump breaks down. With a large pump out of commission a number of fields are deprived of water, a number of farmers suffer economic loss, and a number of farmers must cooperate to arrange and to pay for repairs. With a small pump only one or two farmers are affected; they may be able to borrow a pump from a neighbor, because they are easily transportable, or to water a part of the plot by hand. Because the pump can easily be transported for repair it is not necessary to send for a mechanic and then wait for him to arrive, hence down time is reduced. Finally, if no one can repair the pump it can be "thrown away" without a large number of farmers losing the capacity to irrigate. We do not use the term "throw away" facetiously, for the economic loss to the farmer who cannot find spare parts or a competent repairman is substantial; but the anthropologist has noted a difference in attitude between farmers in large pump perimeters and in small pump perimeters. When a pump is beyond repair in a large perimeter, farmers seek to continue irrigating at a lower level of performance, using what is left of the infrastructure. When a small pump breaks down the farmer's attitude is often that he will continue irrigating by hand/shadouf, while making every effort to acquire a replacement pump as soon as possible.

What Constitutes Economic Success?

Donors consider economic success of an investment is achieved when the investment generates a rate of return on the investment equal to or higher than alternative uses of capital. This is at present generally considered to be about a 10% return. The return should be sustainable over the life of the investment or indefinitely, since the allowance for depreciation should generate enough financial returns to replace the original investment when it has completed its useful life. Costs and prices used to calculate the economic rate of return are based on the use of a "real" (equilibrium) exchange rate to convert local costs into convertible currencies, regardless of what actual exchange rate may be in effect.

The financial return to the project may be quite different from the economic return since the producer may be not paying fully for his capital goods and inputs, and may receive for his
product prices that are distorted by subsidies or by over-or under-valued exchange rates. The financial rate of return must be adequate to maintain the farmer's incentive to produce or else he will seek alternative employment opportunities even if the economic rate of return may appear to be satisfactory.

There are a number of implications for project design arising from these concepts:

(a) Both economic and financial rates of return must be satisfactory on a sustained basis for a capital investment to be successful.

(b) Subsidies may produce temporarily desirable financial incentives to producers, but may eventually lead to project failure since it is unlikely that governments will be able to sustain them over the medium to long term.

(c) Exchange rate changes that affect the cost to producers of traded inputs and the prices of outputs can make successful projects collapse and vice versa.

(d) The cost of the capital investment per unit of output has an inverse relationship to the rate of return (i.e. the lower the cost the higher the return) and therefore technologies that reduce capital costs improve project viability.

(e) Double cropping holds the prospect of more than doubling the rate of return since the capital costs are spread over two production cycles instead of one each year.

Subsistence farmers consider the economic success of a project to be achieved when it meets two basic needs: a) food security; and b) the minimum amount of cash they need in order to meet recurrent demands for taxes, clothing, everyday necessities and perhaps school fees. Farmers may engage in irrigation for cash, food or both, but this study found that farmers more often engaged in sustained irrigation when farmers irrigated for cash rather than for home consumption. When they grew cereal on a sustained basis they did so because they treated it as a cash crop.

Large and small irrigation projects studied succeeded in farmers' eyes when they provided them with enough cash at the time they needed it. They failed when the cash was not available when needed, even when high returns could be realized at a later date. Irrigation projects failed if they required the farmer to pay fees/water charges/credit at a time when farmers had difficulty coming up with the money. Farmers judged irrigation an economic success when it had high profits and a convenient cash flow. The farmers were not always interested in maximizing profits; they often needed cash when prices were low so that maximizing profits was not possible. Cash may not have been available for two reasons: 1) the crops grown did not mature at the time the money was needed, eg. wheat or rice are not ready when school fees, and taxes in many countries, are paid; and 2) the purchasing organization was not organized or financially able to purchase the crop. To deal with these problems, farmers in many projects select their own crops rather than those suggested by the project and sell the produce privately. Most irrigation projects have ended up with different cropping patterns from the ones originally selected at appraisal, because the rotation turned out not to be viable with respect to the farmers' financial needs. A 1989 FAO study on agricultural investment found, for example, that of the 6 irrigation projects investigated, all ended up with very different cropping combinations. In addition, saving large sums of money is often difficult in the social situation in which farmers live. Cash flow is a sort of forced savings since one cannot spend or help out relatives with what one does not have. The problem of savings is not one
that credit alone \(^{37}\) can resolve because, in the marginal cash position of most subsistence farmers, incurring large debts for inputs, land preparation, farm labor and so forth could be too risky even though the profits might be large.

Economists talk of the "opportunity costs of capital"; a farmer's "capital" that he has to invest could be considered to consist not only of money but also of his time, labor and his other resources, including land and water. If he can get what he wants by investing this "capital" at a cheaper opportunity cost in something other than irrigation then he will. \textit{The key to successful project design, therefore, is to understand the farmer's goals}. Concomitantly, the key to irrigation success is to engage in irrigation only when it meets the farmer's aims more easily, or with a lower opportunity cost to him, than other alternatives.

Farmers who engage in irrigation are of three sorts, according to our observations. In the smallest group are farmers who have access to money or pumps from relatives or other sources. Some of them irrigate in order to produce subsistence crops for home consumption (with sales of any surplus) if they have difficulty in obtaining cereals from other sources. They pay for operation, maintenance and replacement with money from the non-agricultural source. Other farmers who have access to money or pumps from relatives or other sources produce cash crops (and perhaps a few subsistence crops for food security). Operation, maintenance and replacement are paid for by irrigation profits and money from non-agricultural sources, depending on the cash flow of the moment.

For the largest group, money is the rarest commodity, but taxes, clothing and other expected social obligations mean they must have at least a certain amount. Taxes are the undeniable minimum most farmers must produce for. Because such a farmer has more labor (his own and his family's) available than money, he often prefers to invest more labor than cash for the same return. The downfall of many irrigation projects has been that farmers prefer to put more labor into extensive production outside irrigation perimeters than money into inputs for raising yields within the perimeter, because labor is more available than money. Irrigation projects have found, too, that many choose to work harder doing manual preparation of the soil than to invest in animal traction, even when animal traction credits and subsidies are available. Likewise a farmer will use his own or family labor but be reluctant to hire labor because hired labor takes money whereas his own is "free". By "free" we mean that he controls his own labor and can decide to invest it even at a theoretical loss if he wants to. This willingness to take a loss accounts for the fact that at Sategui-Deressia in Chad farmers retain irrigated perimeter plots for which they pay water fees and in which, with minimal expenditures for inputs, they put enough labor to produce the rice sold at a guaranteed price which will cover their taxes. Then they invest more labor and no inputs other than their own seed in rainfed (with a yield of 1.3t paddy/ha in southern Chad) and improved rice farming from which they get yields (2.0t/ha) close to perimeter yields (2.5t/ha) rather than investing more money in inputs to raise yields within the perimeter. Likewise Malagasy

\(^{37}\) The anthropologist has remarked that in many parts of Chad when she interviews farmers as part of the project design process they all hope that credit will be part of the project. Further discussion reveals that they do not conceive of credit as a means of buying inputs or paying for labor before the harvest but as getting cheap or free cash loans to keep afloat until they sell their crops so they do not have to sell livestock or standing crops. When they hear what credit is available for, many say, essentially, "forget it". For farmers envisaging a future project, credit is related to cash flow, whereas for donors and governments credit is more often related to the problems of "lumpiness", of finding large sums to invest in project activities. Once a project is underway farmers tend to become more aware of the problems of "lumpiness".
farmers with rice plots too small to feed the family will feed the family from rainfed hill crops and invest just enough labor and money in irrigation fees to raise the rice necessary for their cash needs, but not invest in inputs to raise their yields, which even with good results would be insufficient to feed the family, much less pay back the inputs. Senegalese perimeters encountered similar problems 38. In their circumstances, the return from irrigation is simply not high enough to offset the risks of having to invest in cash inputs.

Capital Cost Considerations

Small pumps are expensive compared to farmers' incomes but attractive when they use a cheap source of water. Direct pumping from a river or shallow, hand-dug well, in conjunction with cheap boreholes, have proven successful. Farmers who use direct pumping turn to boreholes when the water level drops or the recharge rate is not rapid enough. With cheap boreholes farmers irrigate areas without direct access to open water, or where open wells are expensive or impossible to build. But faced with expensive tubewells farmers may quail. Where tubewells are expensive the use of small pumps is limited. It is important to develop cheap tubewell technology.

Water conveyance to a number of farmers has proven less successful than individual plots with their own water sources. Although shared conveyance can achieve economies of scale in construction costs it has the disadvantage of needing more maintenance, and maintenance has proven the weakest point in all kinds of irrigation in the Sahel. We will not revisit the arguments for and against expensive infrastructure, which have been well covered in the OED 1989 report.

The most important economic characteristics of successful irrigation appear to be that the technology used was:

(a) cheap, with low levels of capital investment, inexpensive maintenance, low replacement costs, inexpensive inputs;

(b) profitable, with the technology and crops offering high financial returns to the farmer; and,

(c) produced a timely cash flow.

If small pump technology and tubewells are so successful, why are they not more widespread? The answer is that these technologies are unknown in many parts of the Sahel. But they have spread quickly once discovered, as Nigeria, Niger and Chad attest. Once the sources of pumps are known they are widely used on open water. When it is possible to drill cheap tubewells the use of pumps spreads even beyond open water. In Nigeria pumps were not used until the early 1970s, when a few farmers with outside contacts began to acquire them. Then, in the mid-1970s expatriate technicians with experience in Asian irrigation concluded that the technology was appropriate for Nigeria and introduced it more widely. Once known, the technology spread not only in Nigeria but in Niger. In Chad a limited number of farmers, who had seen pumps used in Nigeria, were using them on open water sources. When they got a cheap washbore technique for drilling boreholes, the number of users jumped. In Mauritania private farmers learned about pump technology from observing the government irrigation agency.

The same lack of knowledge inhibits the spread of different irrigation plot configurations and improved agronomic techniques. "The main reason why these techniques are not more widely applied at present is the lack of knowledge among farmers." Extension services need to publicize and demonstrate technologies at the farm level, not just on demonstration farms that few farmers ever see.

Macro-Economic Setting

The most sustainable systems are those that rely on private markets for needed inputs, marketing and credit, since this avoids the frequent breakdowns in public sector operations that have been characteristic of the past. However, in considering a project design that relies on private suppliers for pumps, fertilizer, seeds and other inputs, the first consideration is whether the macro-economic conditions in the county make this a feasible option. It is essential to examine the effect of exchange rates on the cost of inputs and on crop output values. The exchange rate may either penalize current production or overvalue it with a risk that a later exchange rate adjustment may undercut what appeared to be a profitable technology package.

Fortunately many African countries are undertaking structural adjustment programs that have tended to "get prices right", have freed up restrictions on inputs and on exports, and have made goods more available in the private market. Where this is not the case, the project designer should be aware that a special channel of project-financed inputs will create an unsustainable situation that will not survive after project completion unless the macro-economic conditions have been improved by that time. Alternatives in such a case are to design simple projects using as few inputs as possible or simply to postpone the project till overall macro-economic conditions are more favorable.

Credit Systems

Public sector credit systems have a poor record of sustainability, in part because inflation frequently makes it difficult to maintain positive real interest rates and consequently the credit institutions' working capital is eroded, but also because farmers feel only a very limited obligation to repay a public institution. Lending to groups of farmers has been somewhat more successful, since peer pressure can be brought to bear by the group for repayment.

In cases where formal credit systems are not available or where farmers are reluctant to accept loans, the number of farmers who are able to acquire pumps and tubewells has been limited to those with rich relatives, livestock or other sources of income and to richer farmers. Middle level subsistence farmers, the anthropologist has found, can afford to maintain and replace pumps with the income the pump generates; the problem has been the difficulty in making the initial investment. Non-credit ways of overcoming this problem, such as tontines (or funds to which all members make regular contributions and each member receives the entire sum in turn), should be examined. If credit is made available, farmers who have had to pay back the full periodic payment from the beginning that they will have to bear in the future, when the project has ended, appear more likely to sustain irrigation.

Another important economic aspect of irrigation, and of cash cropping in general, is that the family members who engage in communal subsistence farming cannot necessarily be counted on for their labor when a crop is grown primarily for cash, even though the family may eat some of

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it. Frequently, when cultivation turns to cash cropping, extended family members, married sons or sons old enough to marry, and wives will withdraw their labor and expend it on their own behalf. This is another reason individual plots have a good record; the irrigation farmer sets the area to be cultivated according to his actual labor supply, not a theoretical one.

Women in Irrigation

In a large number of irrigation projects, especially ones constructed in swamplands, where women are often the primary irrigators, women have ended up in a marginal position in irrigated agriculture. There appear to be two important reasons for this, one of which is land tenure. Women frequently do not possess direct rights to land but get access to cultivable land through their husbands or male relatives. As a result they are not automatically given access to project plots included in WUAs or cooperatives, or considered as direct project participants. The other is that designers and management often assume that, because a family is already consuming what a woman produces, the woman will voluntarily transfer her labor to any irrigation destined to improve the family's standard of living and that women will willingly work in the plots the project allocates to their husbands. This assumption fails on two counts. First, women's cultivation might better be viewed as producing women's discretionary income than as growing food for the family. Her harvest is hers to expend as she wants. A woman frequently chooses to expend a good part of the harvest on feeding the family, because that may be one of her responsibilities, but she has others as well—clothes, school fees, spices for cooking, etc. She may also choose to go into commerce or to contribute to a relative's bridewealth. Since she has direct rights and control over the crop she has grown she can decide what portion she wishes to expend for different purposes, including feeding the family. Transforming the area she has cultivated into an irrigated perimeter in which her husband has control over the crop deprives her of her discretionary income and grants it to her husband. Secondly, we have seen that irrigation is usually done for cash. As a result women no longer are producing food to feed the family but simply laboring to produce cash for their husbands, which they are frequently unwilling to do. Thus marginalized, women often withdraw almost entirely from irrigation.

Performance Characteristics of Successful Projects

Most successful project performance depended on certain circumstances:

(a) two crops a year (minimum) grown without interfering with subsistence agriculture 40;

40 Another factor in performance, as far as the donors and government are concerned, is whether the farmer produces enough to fulfill the government's and donors' goals, which usually includes a saleable surplus. This can sometimes be achieved by multiple cropping but sometimes necessitates a large surface area. Yet on the Senegal River, irrigated parcels are often barely sufficient to feed the family, much less produce a surplus. In Madagascar many farmers' plots are far too small to feed the family; in this case the farmer sells his rice for cash and feeds his family from hillside crops. When a Malagasy farmer in this situation produces a saleable crop he makes no effort to increase its yield because the profit he would make from his tiny parcel after paying for inputs would be minimal. The Malagasy farmers who produce rice commercially rather than simply to meet the family's minimal needs for cash are those with large plots, for example at Lac Alaotra, where 4 ha parcels were initially distributed. Moreover, large surface areas often require land preparation, a cause for many projects' failure.
(b) access to a market where the output could reliably be sold; and,

(c) adequate maintenance and spare parts.

Two crops per year: Successful systems have produced at least two crops per year. In this way the farmer can earn enough beyond the subsistence level to pay for operation, maintenance, amortization and perhaps capital costs. Farmers balanced income from increasing yield beyond the point needed to generate this income against the opportunity costs of time, labor and resources and against the risks of losing a larger investment should the crop fail. The level of performance is limited by the time, labor and money the farmer and his family can invest in irrigated agriculture and the opportunity costs of this investment.

Two crops and access to a steady market also ease the cash flow problem for farmers and give them the money to pay for inputs and repairs when needed. The market does not have to be national or international, just large enough to absorb the produce on a regular basis.

Access to markets: Since irrigation is usually done for cash, markets for the sale of produce at a reasonable price have been important to irrigation success (and failure). Where such free markets exist farmers take advantage of them rather than selling to the government marketing organization at a lower price or at a theoretically higher price that is not paid as promised. Likewise the material for irrigation must be available, along with the spare parts and whatever inputs are used. To what extent does successful irrigation therefore depend on integrated services being provided by a project? Roads to output markets and the knowledge about and availability of technology are both crucial. Inputs and spare parts are also important. The private sector can, and has, provided the markets, the irrigation hardware and inputs but it cannot readily provide roads or spread information about technology and agronomy. These are the services that need to be integrated into projects.

Maintenance: Maintenance is a necessity if irrigation is to be sustained. In a system using machines, the machines must be repaired rapidly or crops and income will be lost. When a machine has reached the end of its lifetime the farmer must be able to replace it. Thus fuel, spare parts, and necessary inputs must be readily available. Many projects have provided infrastructure and pumps but neglected maintenance. Maintenance appears, from this study, to be a problem in all systems, even where irrigation has been successful. Upkeep has often been poor even when private individuals are irrigating. Moreover, cheap technology, while it has proven the most attractive to investors and subsistence farmers, also requires more maintenance, which has been the weakest point in irrigation. The occasions on which farmers have received intensive training in maintaining mechanical equipment are few and the evidence on whether such training works is not yet in. Members of small voluntary groups also often decry the fact that each member expects the others to do the maintenance.

Donors and governments depend on cooperatives and water user associations to do maintenance themselves or to call on the private sector for maintenance. The private sector has not, however, been quick to develop excellent maintenance; helping the private sector to develop this capability should also be integrated into an irrigation project. But only a well functioning cooperative, which can organize its members or collect its fees, can actually carry out or pay for maintenance. Therefore private maintenance must go hand in hand with efficient management. When a system was well-maintained and produced two crops a year that could be sold at a reliable price, farmers were not only interested in maintaining a certain level of performance but were able to do so.
Some of these characteristics seem self-evident (markets providing for inputs and sale of outputs, for example), yet they often seem to be overlooked when irrigation is considered for rural development or drought-proofing of remote areas. If completed projects are any indicator, irrigation projects destined for areas without ready access to markets are unlikely to succeed and yet many have been funded.

An instructive comparison can be drawn between the unsuccessful South Chad Irrigation Scheme in Nigeria and the successful ORT Farmer Training Project across the lake in Chad. Both are located in the same geological area where road construction is very difficult and both areas are remote and isolated. The Nigerian scheme was intended to produce crops for which there was only a miniscule local market, which were to be sent to other parts of Nigeria but this never materialized because of lack of roads. In contrast, the ORT Project promoted products that could be sold in the local and regional markets; despite the recent construction of a major road through the Chadian project area that gives access beyond the immediate region, farmers have shown little interest in marketing their output elsewhere because the demand in local markets is still strong.

Another comparison between the two projects is also instructive. The Nigerian project depended on gravity irrigation from Lake Chad and eventually had to rely on expensive large pumps as the surface water level dropped drastically; the ORT Project has depended on small petrol pumps and shallow groundwater and, as a result, has been able to bring back into cultivation areas that had been abandoned as Lake Chad fell.

What Constitutes Institutional Success?

The engineer’s idea of a successful organization is one that: a) manages the network so that the water flows, is stored and is delivered at a speed and level which does not damage the works; b) which prevents or punishes water piracy, livestock watering and other damaging acts; and c) maintains the water distribution network and its operating parts, headworks, etc. The government’s and donors’ ideas of a good organization is one that maintains the network at a level that sustains production, produces the yield they expect, and pays any fees and charges. The system managers and, to some extent, the government civil servants want an organization that guarantees them jobs, whether or not they operate efficiently and effectively. Avoiding government-run schemes and parastatals may not necessarily avoid this problem because this is sometimes also true of water users’ associations, cooperatives and other farmer organizations, though the interest of the national or parastatal employees may be in salaries whereas the latter may want power, influence and position. In either case considerable political jockeying may occur in order to maintain the organization even though it is not fulfilling the purposes set by the engineer, government, donors or farmers.

The farmer’s idea of a good irrigation organization is one that allows him to achieve what he wants through irrigation, which minimizes the difficulties of doing so, and which does not require any more of him than this. Though he will always seek to minimize his difficulties (by not paying back credit, or not cleaning canals), he will put up with increasing difficulties and inconveniences in time, money, labor, resources and participation in the organization as long as he sees irrigation as the most efficient way to achieve his aims. He wants water at a time that is convenient to him and in quantities sufficient to produce the yield he wants. He wants a system with cropping patterns and maintenance, water delivery and location that do not require more time, money or labor than he has to invest, not only in irrigation but in other on- and off-farm activities.
Leisure and the time to pursue social goals are also important to farmers. He wants a yield sufficient to his needs and to be able to use his harvest in a way that allows him to meet his needs. He does not want an organization that pushes him to produce more, invest more, sell more or that forces him to produce something he does not want or to sell it at an inconvenient time or a low price. He also wants an organization that lowers the risk of investing in irrigation.

Farmers have been most likely to sustain their investment in irrigation if it performed reliably to produce cash, and a steady cash flow was often more important than the total earnings brought in. When farmers engaged in irrigation because it performed well in providing food or cash in extreme years, then they were less likely to sustain their activities at a high level in average years because alternative, less demanding activities could provide sufficient, though not necessarily the maximum, food or cash.

Institutional Arrangements

The organization necessary to manage irrigation is related to the technology used and its cost. If the technology is expensive farmers may have to invest jointly in order to afford it. The technology may require an organization that provides for cooperation in water distribution and maintenance of the network, collects fees and makes inputs available. This sort of organization adds to the project risks. Poor management and institutional failure are major reasons that large scale irrigation has often failed. Seventy per cent of irrigation projects in the FAO's 1989 study had poor management; this weakness is supported by Nooter and Walter's informal survey in which Bank staff attributed irrigation failure to management/institutional failure five times more often, and to technical/design failure four times more often, than to any other reason except lack of government support (two times more often). If sustained irrigation depends on farmer operation, maintenance and amortization, then the type of organization in which farmers are willing to participate, if any, should be investigated before project design and the technology should be selected as a function of this. One reason small and cheap technology has been the most successful is because it requires minimal organization.

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41 Dia, Mamedou, 1990, "Cultural Dimensions of Institutional Development and Management in Sub-Saharan Africa (SSA)", World Bank. This paper points out the importance of projects providing for:

- leisure as a reward;
- a search for compromise rather than a spirit of litigation;
- ritual to cement commitment to activities.

Dia also urges reinforcing collective bonds, rather than selfish private returns, as an incentive. Reinforcing traditional collective bonds can enable farmers to cooperate in activities such as irrigation credit and maintenance but, since irrigation is essentially done for private returns, collective bonds will have limitations.

42 70% also had poor engineering (FAO, 1989, 19-20).

The most successful kinds of organization, in decreasing order of success, are:

(a) private individuals;
(b) private voluntary groups;
(c) water users associations;
(d) pre-cooperatives and cooperatives.

Small-scale irrigation management has ranged from individuals to cooperatives and water users’ associations that are expected to perform many of the same tasks as a public institution. In this case the cooperative/WUA meets many of the same difficulties public institutions face; it is not surprising that cooperative/WUA management arrangements do not always work in these situations. What counts is the leadership; in this way large cooperatives resemble large-scale public irrigation systems—they seem to succeed or fail based on the quality of management.

Private individuals. Most successful irrigation in Africa has been done by private individuals. To begin with, an individual engages in irrigation because he is motivated to do so; a farmer working in a perimeter with many other farmers may be irrigating because his land has been appropriated and unless he irrigates he will lose it. An individual can also decide on how much capital he is willing to risk in irrigation infrastructure, operations and maintenance, whereas in a perimeter his costs are not totally under his control. An individual can plan his crop rotation, surface area and planting dates according to labor availability and his need for revenue and food, not according to a perimeter schedule and management demand. An individual has the flexibility to continuously adapt his irrigation to changing situations and demands. An individual who informally finances his own irrigation investment has willingly taken on his debt and obligations, and he does not have to enter into cooperative or economic relationships with people he cannot necessarily count on. In other words an individual sizes up the risks and benefits and then commits himself. He will do what he can to minimize the risk and increase the benefits—i.e. irrigate successfully.

A fascinating letter from the former head of SEMRY to the managing director of the Senegalese irrigation parastatal SAED, contained in the Senegal project files, underlines the importance of good management for success. He compares the situation of the SAED, which he had evaluated, to the condition of SEMRY I. Early in the project’s life, SEMRY was a disaster because no priority was given to production and its marketing but all effort was being put into the project’s slow central bureaucracy. Hence the project could not be self-supporting, the farmers had no confidence in services, the suppliers were not paid and so refused to provide inputs, the personnel was disorganized, unpaid and unwilling to work. SEMRY was getting an average of only 830 kg/ha on 5,000 ha in 1971. When appointed to head SEMRY the writer turned management and implementation around and SEMRY became a success; he spent time getting money from the outside to pay suppliers so that inputs would be assured and he delegated authority so that services were provided. By 1974 the amount of rice SEMRY marketed stabilized at 4,300 kg/ha. By 1976 the economic situation had improved to the point SEMRY could self-finance new structures and by 1978 was repaying IDA credits. Farmers net average revenue was up 12 times. But even so, farmers thought SEMRY was not paying them enough and they wanted to be allowed to sell their output in Chad (which eventually they did). Competent, authoritarian management concerned with running an efficient business and with the bottom line, along with a work force motivated because it had no other way to earn a living, made an unsuccessful public project into a successful one.
Informal voluntary groups. Small voluntary groups of farmers who consider that they have interests in common and can trust one another to work together can overcome problems of finance or water sources that require cooperation. When farmers themselves choose the people with whom they will cooperate they have already tried to reduce the risk of failure in their selection of certain colleagues. Informal, self-selected groups are more often successful than other kinds of groups such as cooperatives.

Water Users Associations (WUA). Donors and governments have turned to water users associations more recently than cooperatives; they are more focused on one task - water delivery - than cooperatives and may, therefore, work better. The impact of water user associations is not yet as clear as for cooperatives in the Sahel.

Water user associations have been built on:
(a) Existing irrigation groups;
(b) Other existing groups - matrix groups;
(c) Newly-created groups (in rehabilitated perimeters, especially the functions of the parastatal may be handed over to a WUA).

Existing irrigation or matrix groups have the advantage of being experienced and legitimized. To use existing groups, however, designers need to know what groups exist, their functions and functionaries, their strengths to be used, and their weaknesses to be avoided. Sociologists need to discover this during pre-appraisal and work with the engineer, because the latter cannot create a physical irrigation system de novo and expect it to mesh automatically with the existing social system.

Cooperatives, pre-cooperatives and Water User Associations. Cooperatives and pre-cooperatives have been successful only occasionally in the Sahel, which suggests that cooperatives should be the last resort for organizing irrigation instead of the automatic solution. The main factor in a cooperative’s success is dynamic leadership—whether from a local leader, an NGO, or project personnel. Use of NGOs, with explicit performance objectives, to support cooperatives should be encouraged when cooperatives are established. Likewise management training should be included since happening upon a dynamic leader is not guaranteed. Depending on the traditional or political structure has not always worked because these leaders do not necessarily have the qualities cooperative leadership demands. However, working with existing social groups to form the basis of a cooperative or water users' association can often be helpful because the existing group contains a matrix of important social connections that will be important for any irrigation group. Cooperatives are also more effective when limited in size. Individuals may be more motivated to

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46 Some WUAs are really informal voluntary groups. Many WUAs, however, have been set up to unite farmers in pre-existing perimeters. In this situation farmers are obliged to participate (unless they wish to lose their fields). Such WUAs differ, however, from cooperatives because they are focused on a single activity—water use—instead of multiple activities and demands that often make coops less effective than WUAs.
share ownership and responsibility with a smaller group of well-known people 46. Moreover "the
size of local organizations is socially and ecologically determined by factors such as
communications, transportation, economies of scale and interaction patterns that are not subject to
administrative fiat. This results in a certain uniformity of organization size" in effective groups 47.

Rather than designing a cooperative or water user association to take care of an
infrastructure already designed by the engineers, the engineers, sociologists, and institutional
specialists should cooperate to create an efficient management-cum-water delivery system. The
infrastructure designed should allow for workable base units of farmers that can carry out:

(a) management leadership;
(b) technical functions/tasks;
(c) communications and information diffusion;
(d) fee collection;
(e) water control/distribution; and,
(f) maintenance.

Beneficiary Participation

The Operations Evaluation Department has found that in rural development projects
beneficiary participation was interpreted in one of four different ways 48:

(a) farmer contribution to resources or labor;
(b) recovery of project costs from farmers;
(c) farmer organizations and cooperatives; and,
(d) farmer involvement in identification of project priorities.

Interpretations (a-c) are the most commonly found. (a) and (b) are attractive to donors and
government because they reduce their capital or recurrent costs. Small scale irrigation appeals to
donors and governments because its less sophisticated construction means that farmers can

46 Ike, B., 1987, "Man's Limited Sympathy as a Consequence of His Evolution in Small Kin
Groups," in Reynolds, Falger, and Vine, eds., The Sociobiology of Ethnocentrism. University of
Georgia Press, Athens, pp.216-234.

47 Romanoff, 1991, "The Bottom Line or How Farmer-Promoters Reduced the Cost of
Organizing Producers in an Integrated Rural Development Project," Culture and Agriculture', no. 4.
According to Romanoff's experiences, this size in producer cooperatives was on average 30, with a
median of 22-23 members and 2/3 of all the groups he surveyed ranged from 10-30. If there is a
strong basis for membership, such as irrigation, or demands on members are light then the groups
can be larger. Ike discusses the psychology and sociology of groups which are most efficient when
they number from 5-11-30, at an outside 100. If project designers decide they must use WUAs or
cooperatives as management tools in irrigation perimeters, they should first consult experts in
WUAs and cooperatives before designing the institutions and infrastructure, which can be made to
coincide with the institutions.

48 OED report # 6883.
contribute their labor and some materials to construction, thereby reducing costs. Smaller schemes also require less sophisticated management so that farmers can manage the schemes by themselves. Farmers' willingness to contribute to construction or to pay some of the costs is seen as a token of their commitment to irrigation; they will not, supposedly, contribute unless they see that they will benefit from doing so. However, such up-front beneficiary participation has frequently been deceiving; farmers contribute their time and material but do not maintain the irrigation works adequately or maximize the irrigation potential. In some cases unwilling farmers have been pressured by authorities to participate because the project is of benefit to the area (in Madagascar, for example); in some cases participation is seen as just another form of corvee labor demanded by the authorities, to which farmers are accustomed (e.g. Chad). A considerable amount of coercion is sometimes involved in getting farmers to donate money, materials or labor (e.g. Mali) where local officials oblige them to provide materials or money with threats and harassment. Pressured beneficiaries are not participating because they are committed to irrigation, and so the commitment is not sustained.

Food For Work is also used officially or unofficially to get farmers to participate. When Food For Work is given for labor that is counted as beneficiary contributions, as it was in Chad (Cr.664-CD and various NGO projects) and Niena Dionkele (Cr.1013), farmers may work for the food without a real commitment to irrigation. On the other hand farmers may be committed even though they receive Food For Work, as CARE farmers in the Kanem of Chad attest. The attraction for many farmers is the food and not the long-term benefits of irrigation, which is therefore not sustained. Food For Work performs well for one-shot activities such as construction, but it cannot be used to indicate beneficiary interest beyond the food distributed.

It is hoped that farmer organizations, like payment of project costs, will make farmers feel more responsible for operations and maintenance. However, organizations imposed by the donors or governments have almost always failed; the infrequent successes with farmer organizations are found where farmers already had an organization, received considerable training and extension, and the groups remained small. Rarely did they evolve into groups capable of autonomously operating an income generating project and thus ensuring its sustainability.

Cost recovery has been difficult, in some cases because it was not explained well at the beginning and farmers were included in the project only after the investments had already been made. Cost recovery has failed in other projects because it is hard to penalize farmers for non-payment or because politicians told farmers services were "free". Where services are delivered promptly and regularly cost recovery has been easier.

Farmer involvement in identification of project priorities and the design of the project has been rare. Direct participation has been avoided because it is difficult: (a) to include farmers in centrally planned projects; (b) to assure that government and donor priorities remain foremost; and (c) to stick to tight construction schedules. Technicians often do not understand the importance and usefulness of farmers' goals and knowledge or have the sensitivity or training to deal with farmers and government agents are fearful that they will become redundant if the farmers decide

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49 In an analysis of SAED's problems on the Senegal River, the Bank commented that involving farmers in perimeter management or giving them training in running the sophisticated water distribution network would not make the farmer more responsible since the root cause of farmer disinterest was that returns on his investment were too low and that, no matter whether the farmer participated or not, SAED could not deliver its services which were also necessary.
the agents' "services" are unnecessary. These problems have made farmer participation in planning difficult even when projects are committed to such participation. However, when farmers were included from the beginning, as in Anony and Ankaiafo, Madagascar, Burkina Faso Rural Development III, and Chad Lake Farmer Training Project, the projects succeeded. One of the primary reasons why private irrigation has been more successful than public irrigation is that the private investor is essentially designing his own irrigation project to suit his own needs. In public projects local civil servants and foreign technicians interpret, often wrongly, "what is good for the farmer".

The conclusion to draw is that farmer contributions of labor, materials or money in the early phases of a project are not reliable indicators of farmer commitment to irrigation over the medium to long term whereas farmer participation in project design and implementation may be more productive.

The Changing Role of the Farmer in Irrigation Decision-Making

The farmer's role in decision-making in irrigation is changing more quickly than the design of the sector's investments and of operations. Several decades ago, the farmer was considered a laborer without any management responsibilities in irrigation projects whose design assured the farmer a certain wage level and some aspects of his social welfare. More recently, the farmer was seen as a combination laborer/decision maker. In certain aspects of project design he was still a laborer meant to adjust his behavior to "economic pricing" and command decisions from governmental institutions. On the other hand, he was supposed to make his own decisions with regard to saving funds for cost recovery and maintenance and contributing his labor for activities in his own self-interest. However, his role in decisions on the investment and its operation was minimal, mainly translated through the voices of government officials and expatriate technicians who were usually agronomists, economists or "community development" experts. According to our findings, irrigation has worked when the farmer is either a laborer, with no rights and no responsibilities, or a decision-maker, with both. In a cooperative or water users' association donors and governments expect a farmer to bear willingly the costs of operation and maintenance and to work hard to raise yields and keep the infrastructure in good condition because he will benefit from the increased yields and income. In fact we have seen that the yields and income may be more of secondary interest, more illusory than real, or insufficient to interest him. Because the farmer has been given the right to decide whether or not to participate in or contribute to maintenance, fees and credit, it is not surprising that he often chooses not to participate or contribute when he does not consider it to be in his interest. Therefore it is not surprising that cooperatives or water users' associations do not work as well as project designers had hoped.

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61 The Government of Madagascar has formally committed itself to farmer participation and handing over responsibility to water users associations. The Ministry of Agriculture has been receiving technical assistance to carry out the transfer of financing, operations and maintenance to the farmers in World Bank rehabilitated perimeters and elsewhere. The plans for this transfer are well conceived, well outlined and sociologically sound. Despite central government and donor support these factors have resulted in the financial responsibility being transferred--that is to say the farmers now pay the recurrent costs--but control over most other aspects has been transferred only nominally and, as a result, farmers have not always been cooperative.
When, as is the case in many irrigation projects, he has been a laborer and a partial decision maker, providing labor for an activity he could decide was not, in fact, in his interest, the projects have a tendency to fail or be unsustained. The reason the farmer as laborer/decision-maker has not performed in large and medium schemes in the way donors and government hoped was because a) he labors in a scheme not designed to do what he wants and that does not fulfill his own interests but b) he has the right to decide whether and how to participate.

Today, the farmer is being asked to be the principal decision-maker, both because of the concern for cost recovery and because it is the main way of ensuring development success at the farm level. The farmer’s views will, therefore, have to be more carefully considered in the design of the capital investment and of its operations. Consequently, as much attention will have to be paid to the real concerns of the farmer as to technical features or the exchange rate. This attention to the farmer must be professional, statistically valid, carefully surveyed over a sufficient period of time to be accurate, and continually monitored during project execution in order to reflect changing conditions. This change in emphasis in project design will require the traditional experts, both local and international, to reorient their thinking and their training. It will not be enough simply to hire a token sociologist or anthropologist as a part of the project design team, but it will be necessary to integrate the farmer’s point of view in all technical, economic and financial aspects of the project.

Investment Decisions

The farmer may very well not want what the irrigation engineer does (to make the most efficient use of water potential) or the agronomist (to maximize yields), or the national government (national food security, import substitution, exports), or the donors (economically viable and sustainable development projects), or the irrigation management (to keep their jobs). But if the farmer is to become a major investor of "capital" (time, labor, resources and money) in an irrigation project, then his wishes must be taken into consideration. In fact, if the government and donors wish to turn over operations, maintenance and management to the farmer, he becomes the ultimate arbiter of success, since it will be his definition of success that will prevail once he is in charge. It then becomes the task of the other participants in the irrigation design to develop a project whose main purpose is to allow the farmer to achieve his idea of success while at the same time making it as successful as possible from the other participants’ points of view. If any of them feel that his idea of success is too compromised by tailoring the design to the farmers’ idea of success and that the investment will be wasted, then the project should not be done. But the farmer, as the ultimate arbiter, should have a primary say in project purpose and design. This study has found that farmers are rarely consulted in a systematic and professional way during project design and preparation. Design and preparation usually includes technical, financial, economic and institutional parameters which, coincidentally, are the kinds of expertise most development experts have. When farmers are consulted it is usually through chance, ad hoc, and usually short.

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\[52\] Anthropologists or sociologists hired for project teams are often either geographical specialists who know the area but not irrigation and so are unaware of the precise information technicians need to make decisions, or they know irrigation but not the geographical area and so they do not understand the local farmers’ interests and social, economic and agronomic constraints. Both options give disappointing results. Technicians and geographically specialized sociologists need to work more closely together so that the sociologists understand clearly what kinds of information will be useful to the technicians.
discussions by these technicians, or sometimes a sociologist or anthropologist. Farmers in this situation have a tendency to tell the experts what the farmers think the experts want to hear.

Farmers and government/donors think that irrigation can contribute to food security but their ideas about how to do this often diverge. The governments and donors see irrigated cereals as producing grain even in bad years, as creating a national reserve, and perhaps as import substitution. Farmers see irrigation as offering a guarantee that they can turn to cereal crops in bad years but often prefer growing high value cash crops to growing low value cereals in normal years. Except where cereal prices are protected, as in Mauritania or Nigeria, or where value can be added, as in Burkina Faso, farmers may give up irrigated cereal farming in good years. Moreover, even in bad years they may keep up cash crop farming because they can use the income to buy cereal on the market when their own crop might fail or be insufficient to feed the family.

Irrigation Success and Failure

The private sector works because it rewards success and does not protect people from failure. Turning over the responsibility for irrigation to private investors means that the donors and government lose control over equity. Private investors—commercial or smallholder—who have undertaken private irrigation have done so because they see that their willingness to take a risk will bring them high returns. The smallholder tries to temper his risk by retaining risk-reducing elements in his irrigation: some cereal crops, low investments in inputs, minimal recourse to hired labor and attentiveness to rainfed over irrigated crops until it is obvious what the outcome of the rainy season will be. Public projects can be designed to retain these risk-reducing elements. Even so, those smallholders and commercial farmers who have gone into irrigation tend to be those who are more willing and able to take risks. If a project tries to reach the poorest farmers, some of them will be unwilling to take the risks and will not benefit from irrigation, i.e. it is difficult to guarantee equity in a project that promotes private investment in irrigation. Projects sometimes attempt to retain equity by a credit component but repayment rates are often dismal. Also, since the poorest are the least likely to risk taking on debt they are less likely to take advantage of credit. Some projects undertake construction in isolated areas because the farmers in these areas are disadvantaged; this study finds, however, that these projects are less likely to succeed.

We found no studies on private success and failure rates but it is unlikely that everyone who invests succeeds. If donors decide on a private sector irrigation project it must be willing to accept that some of the farmers will fail and that attempts to protect them from failure undermine the very purpose of the project, which is to create economically successful and sustainable irrigation. However, the farmers themselves, in deciding to invest or not invest, are deciding whether they can tolerate failure. Attempts to promote equity may have the opposite effect. Projects that try to cushion failure and to maintain equity by reaching more farmers through credit and subsidies in fact may only tempt onto dangerous ground farmers who would otherwise decide the risk was not worth taking and who, for this reason, often give up irrigation after the project ends.

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63 This is not an overstatement of affairs. An engineer-agronomist told the anthropologist that he "worked in close collaboration with the farmers every time he went out in the field." By this he meant, it turned out, that he was accompanied by the manager of the perimeter and the head of the county government. In another instance, at the introductory meeting of experts who were going to work together on an irrigation project, she was introduced for the first time to the irrigation engineer who said, as we shook hands, "What are you doing here, we don't need you. I know everything we need to know about the farmers."
CHAPTER 3: CONSIDERATIONS FOR FUTURE PROJECT DESIGN

This chapter makes recommendations on how to translate past experience with irrigation projects and farmers' definitions of success into project design. It will deal with the technologies, institutional approaches, methodology, and staffing and funding changes that will allow planners to design successful projects.

Overall Findings

The case studies described in Chapter 1 provide some indication of the developments taking place in small scale irrigation in Africa. From this review of Sahelian irrigation several common characteristics appear and interesting lessons emerge. This is so even though there is an extreme diversity of techniques, cropping systems and institutional arrangements employed in the various schemes. Each irrigation scheme is clearly embedded in its own physical and social context. What crops can be irrigated are determined by the particular hydrogeography, seasons, altitude and soil type, as well as by the degree to which rainfed agriculture and other activities provide economic support, the size of the family/number of workers, and the lines of social and political cleavage and union in each society. This indicates that in-depth site specific investigations will be required in each case, and generalities will have limited application. Nevertheless some guiding principles can serve to avoid the errors of the past and to improve the prospects for project success.

Certain kinds of irrigation have proven more successful than others, in part because they are able to avoid or cope with problems that arise. Small plots can avoid patches of bad soil, for example, and take advantage of microclimates; individual management reduces the chances that social tensions will disrupt the farmers who irrigate in the same area, and so forth. Generally, the characteristics of successful irrigation are characteristics that minimize risk for the farmer.

Project Design Issues

The characteristics most frequently found in the successful projects included in this review are outlined in Chapter 2. It may not always be possible to design a project with these characteristics--some areas may be unsuitable for growing two cash crops a year, a reliable source of water that can be cheaply extracted may not exist, and so forth. This does not mean that irrigation cannot be done in these areas, but the chances for success will be reduced. Designing a project with these "success" characteristics may not use the maximum potential water resources; the optimum planting dates for the irrigated crop may not be observed because they interfere with subsistence agriculture; the farmer may not sell his produce in more distant markets even though prices there are higher. In other words irrigation may not be as successful as the designers, technicians, donors and government may wish. Nevertheless the track record of projects with these "success" characteristics has been good.

Simply designing a scheme with the characteristics associated with successful projects, however, and imposing it on an area where it is technically appropriate, will not guarantee success. To begin with, irrigation will have to help farmers resolve difficulties they themselves consider as problems and do so in ways they consider efficacious if they are to be motivated. Richard Carter reminds us of "the sheer complexity of irrigation development. Whatever the scale, many agronomic, engineering, social, legal, financial, organizational and environmental problems have to
be solved simultaneously. Failure can result from inadequacy in any one of these "These warnings, and the farmers' point of view, will have to be taken even more seriously where irrigation infrastructure has already been built or where the technical characteristics discussed below are not appropriate for the physical setting. In these cases one is locked into certain solutions; at this point, if it is not possible to readjust an existing scheme to offer farmers the maximum individual physical and economic control with minimal joint management oversight and maintenance within the farmers' limited economic and technical capability, then large-scale irrigation done in the way this study has found tends to be successful—run as a well-managed business with an eye on the bottom line and a disciplined work force of laborers, not decision-makers—should perhaps be considered.

Chapter 2 also points up the need to consider project viability holistically, taking into account not only the technical possibilities for irrigation but the prospect for a sustainable supply of equipment, spare parts, and inputs, reasonable prices for inputs and outputs, access to markets and to competent maintenance, rainfed agricultural alternatives and an appropriate macro-economic framework. The ideal combination of circumstances would combine a low cost technical solution with the possibility of individually owned and/or managed irrigation, private supplies of inputs and private marketing channels, and reasonable cost relationships that produce an attractive return to farmers.

Target Groups

What private individuals provide good targets for irrigation development? Among individual subsistence farmers those who have enough cash income and food security may invest in irrigation; those closer to the margin may be unwilling to take the risk. At the same time, subsistence farmers who are finding rainfed agriculture more unreliable, resettled or deprived people without other means of subsistence than the irrigated farming now offered, and subsistence farmers with no other source of cash will probably be well motivated. Commercial investors in irrigation—merchants, traders, government workers, war pensioners and ex civil servants—have the means to invest but often lack the technical knowledge that farmers have and so need support in this. A number of failed projects also show that women should be targeted on an equal basis with men.

The Public Sector Role

The approach outlined above puts the major emphasis on individual ownership and maximum utilization of the private sector to meet farmers' needs. Nevertheless, there are some functions that must of necessity be met by the public sector in most parts of Sahelian Africa, although these should be kept to the minimum. While these requirements will vary in each case, typical functions that must frequently be addressed by the public sector include the following:

(a) Knowledge and access to new technologies, both for improved farming systems and low-cost water extraction techniques;

(b) Soil and water surveys beyond the purview of individual farmers, to assure that drawdown of groundwater does not exceed sustainable levels;

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(c) Environmental considerations that may not be apparent in the short-run, such as the long-term effects of the use of chemical fertilizers and pesticides, the impact of irrigation on various health vectors, and drainage and erosion control; and,

(d) The provision and maintenance of essential infrastructure in the project area, especially transportation and communications facilities.

The Bank's Contribution to Small-Scale Irrigation

The Bank can contribute to successful irrigation project design by:

(a) taking sustainability issues more into account during project design;

(b) designing a project that requires minimal risks by farmers; and,

(c) encouraging beneficiary participation in defining project strategy and problem-solving.

Sustainability. A crucial contribution to sustainability is for the Bank to continue a policy dialogue to improve the macro-economic framework that would encourage, inter alia, private sector investment in small-scale irrigation and in supplying hardware, inputs and repair services necessary for sustained irrigation. Project designers can also conceive of projects not only in terms of implementation but of sustainability. Projects should be designed so that farmers bear from the beginning the costs they will have to bear at full development, when project financing is no longer available.

A project should not involve just irrigation but the whole system of hardware, inputs and training in maintenance and repair. It may make projects more sustainable to train local mechanics in repair, merchants in ordering, stocking and managing irrigation equipment and inputs, and local or regional well teams to become companies capable of installing low cost wells. Farmers themselves need training in maintenance and improved irrigation layout, water efficiency and agronomic techniques. However, experience has shown farmers cannot be expected to accept a technology "package"; each technique introduced should be able to stand on its own and make a contribution to increased production, since farmers adopt and adapt what suits them best. In addition the design should consider whether markets and transportation are reliable enough for farmers to get fairly high returns and have fairly low costs.

Minimizing risk. Basic to minimizing the farmer's risk in irrigation is providing enough water at the right time. Small pump irrigation and cheap water extraction help do this. But small-scale private irrigation projects will have to provide not only water but a secure situation that reduces investors' other risks such as pricing, marketing, transportation, maintenance and spare parts.

Beneficiary participation in project strategy and design. A number of experts, including Bank personnel, have outlined over the past ten years steps to take to ensure that the farmer is included in the design process 56. Various Project Performance Audit Reviews and Project

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Completion Reports also urge that the farmer be included. It is beyond the scope of this study to establish why the Bank has been slow to follow these suggestions. For the future, farmers' interests and perceptions should be the starting point in designing projects. This will require meetings and discussions to be carried out in a truly collaborative manner rather than as a basis for informing the farmers of decisions already taken. Project design should give particular attention to farmer concerns regarding the risks involved in the new technology, and may require pilot activities to demonstrate the results that can be achieved. It should also give particular attention to farmer desires regarding institutional arrangements for project management where collective action is required. The steps set out by the authors mentioned in the previous footnote provide many guidelines for this that could be followed with great benefit.

Including the farmer should start with project identification and design. Sophisticated social and farming system studies of the same depth as are done for soil and hydrogeology should be carried out during the identification and preparation stage over as long a period as is necessary for collecting adequate information to design the project. The commitment of so much effort early in the project cycle may require supplementary funding for project preparation.

A thorough sociological study before appraisal is the first step in tapping farmers' ideas of successful irrigation and determining if they are motivated to participate. Project design is often a matter of helping the farmer identify his problems and then helping him to discover possible solutions. A project using his solutions, designed into a project that deals with his problems is more effective than solutions imposed from the outside. During project design the farmers should have an equal voice with the technicians.

1986, Propositions pour la mise au point d'une methodologies de consultation des exploitants sur les travaux de rehabilitation envisages et la creation d'associations d'usagers sur quatre petits perimètres irrigues dans la region de Vakinankastra.


In the past, farmers' views were incorporated and successful irrigation developed: (1) by rejection-farmers did not cooperate with the project as designed but developed their own system of crop rotation, water distribution, etc. using the same infrastructure; (2) by default-PPARs chide early projects for not having included farmer cooperatives, credit or inputs; (3) by learning-donors saw and duplicated what had worked well in previous projects; (4) by design-Small Rural Operations and perimeter rehabilitation in Madagascar.
The direct participation of the farmer early in the project cycle has been rare because it is so difficult. If the farmers have been thoroughly consulted during pre-appraisal, the sociologist can, to some extent, act as their representative so that coordinated planning can occur. At this point in project design the engineers and agronomists can outline all the possible technical options and donors and governments can define their goals and purposes. It may be evident that farmer priorities do not overlap at all with government and donor priorities so that a project designed on this basis is unlikely to meet government and donor needs. The technical options possible may not coincide with farmers' interests in doing small-scale irrigation, at which point decision-makers must decide whether to go forward with some other type of development.

Other Considerations

Small-scale private projects may be harder for the Bank to implement than traditional projects but the Bank is not without experience in numbers of activities spread over a wide area. In the past it has implemented Small Rural Operations Projects, Drought Relief Projects and others with small, scattered components. The Bank should build on these previous experiences. The Bank’s developing relationship with NGOs also opens up an avenue for implementing small-scale irrigation projects. The Bank and NGOs can use the NGOs’ strengths in dealing with social and environmental issues, understanding and interpreting the views, interests and culture of rural communities, channeling funds and information to project beneficiaries, and implementing projects at the grassroots level. At the same time the Bank can compensate for what are often NGO weaknesses with the Bank’s own particular strengths: planning, design, technical expertise in irrigation and agriculture, marketing and infrastructure. The Bank can also fund projects at a higher level and for a longer time than NGOs alone can.

These changes in emphasis mean that less funding will go for irrigation infrastructure and hardware than before and more for technical assistance, training, information dissemination and perhaps pilot projects. The Bank, however, should resist the temptation to invest in training centers and demonstration farms which, although they disburse money and provide visible evidence of intervention, have little impact on the farmer, as experience has shown. Instead the Bank should insist on applied field trials and on-site farmer training. These activities are harder to control and the impact is harder to measure than traditional ones. Monitoring is therefore important. A good initial data base to compare with end of project measures, and quick feedback of crucial data during project implementation can provide measures of project impact and efficacy. These need to be designed into projects 67.

67 Some projects have made too much effort to collect data for judging project performance. The APMEPU in the Kaduna, Nigeria, project took such a big, ambitious sample that even with computers (which frequently broke down) it was unable to analyze the data and issue a report until several months after project completion. Ambohibary in Madagascar gathered such vast amounts of data that it was not usable during project implementation, even though it contained vitally important facts. Other projects make minimal or no efforts to gather such information, the management seeing feedback as delaying implementation rather than as constructive. Sociological data gathered in early irrigation projects tended to be descriptive (the number of people belonging to such and such an ethnic group) rather than analytical—farming system, seasonal labor availability, income and cash flow, social groups and social tensions,—aspects that have far more effect on how farmers will react to irrigation. The Bank needs to determine the information it can use to monitor and modify projects during implementation. This means simplifying information for feedback to project implementors with "timeliness, accuracy, validity and experience (P 3627-UNII"). There is also considerable physical and social information already available in public archives and libraries of specialized institutes which, if used, would give a sound point of departure for project design.
This study has found that projects that went ahead with irrigation investment before or while waiting for the macro-economic climate to improve were a mistake, since the private sector expects immediate and preferably high returns. The Chad Lake Farmer Training Project and Nigerian ADP Projects as well as innumerable enterprising farmers and merchants have shown that once the technology is known, they can get it, legally or illegally. The Nigerian ADPs show that road construction can resolve the problem of market access. Thus market access and the knowledge and availability of technology are much smaller obstacles than the macro-economic situation, which affects the cost of the technology and its profitability to farmers and merchants.

The Plan Directeur de Developpement Integre pour la Rive Gauche de la Valle du Fleuve Senegal argues that "integrated development" is necessary but that "integration" does not necessarily mean that all the activities must occur within the same project. Integration can occur in space—i.e. by choosing to implement activities first in the most favorable regions—or in time. Integration in time implies several projects following the logical sequence of events that will make a project productive. The key is, of course, to know what the logical sequence of events is. The logical setting for integrated development of irrigation is to have:

(a) farmers who can achieve their goals most efficiently through irrigation and not some alternative;
(b) a macro-economic climate that will reward the farmers' and merchants' desires for low costs/high returns;
(c) accessible markets;
(d) available low cost technology;
(e) secure supplies of spare parts and inputs and adequate repair facilities.

With the economists' evaluation of the macro- and micro-economic frameworks, infrastructure and marketing experts can determine if it is possible and how long it will take to get access to markets and technology. If it is easily done in a short time, as in the Nigerian ADPs, then access could be included as a project component. But if it will take some time, infrastructure projects should slightly precede the irrigation project. Unless access to markets can be guaranteed, the infrastructure should not be included as part of the irrigation project but done before. Mopti Rice, Debi-Lampsar, South Chad, Niena Dionkele and Sategui-Deressia all failed in part because the transportation network that the project counted on was not realized.

If the preconditions for successful small-scale irrigation exist, the engineer and agronomist can design an irrigation project that will help the farmer and government realize their aims. A number of experts have recommended that the design process be reversed. Rather than begin with the design of the irrigation system based on what is technically optimal, they should begin with the participants and institutions responsible for implementation. Only after the strengths and weaknesses of each of these have been identified and the incentive structure clearly understood, should technical design begin. The process then can proceed in iterative fashion as governments and farmers decide which changes they are willing and able to make and what impact that will

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66 The World Bank, 1990, paragraph 3.22.
have on farmer participation and project execution 68." Then, with the design and with cost estimates intelligible to the farmer (not in thousands of dollars per hectare but in local prices or yields in local units of measure per native land unit) in hand, technicians and sociologists can consult with the farmers, discuss and modify the plan. Farmers who know the terrain well "can provide the designer with invaluable local knowledge on topography, soils, agriculture, climate and social conditions 69." The tendency to start with hardware needs to be reversed by reorienting the technicians to consult with rather than ignore the farmers. Once the final project has been proposed farmers should be given the time to reflect and accept or refuse to be included in the project 70. It would perhaps be helpful if the professionals at this point imagined the farmers as clients who expect them to design an irrigation system for them, not for an ideal maximization of water efficiency or yields.

In brief, project designers can help by making provision for the following aspects of an irrigation project:

(a) research into:
   - low cost technologies,
   - agronomy suited to the area 62, and
   - specific available water resources;
(b) dissemination of knowledge and technology;
(c) policy: investment climate and pricing;
(d) transportation and market infrastructure;
(e) environment:
   - drainage,
   - erosion control, and
   - water drawdown;
(f) funding for capital requirements.

Moris and Zalla note that "there has been enough experience with irrigation in Sub-Saharan Africa, and there is enough similarity in cultural context and experience with technology across the Sub-Continent, that we can say with confidence that planners who ignore previous performance are generally making a mistake. We cannot say with a great deal of confidence why

68 Moris and Thom, 1990, p. 481.
70 See, for the Irrigation Rehabilitation Project in Madagascar (Cr 1589), the Schema Directeur and Methodologie de Constitution des Associations des Usages de l'Eau sur les Petits Perimetres en Rehabilitation, World Bank, and Brown and Razakarivony, 1990, "Etude de Sociologie du Fonctionnement des Perimetres Irrigues", World Bank, for guidelines on how to proceed at this stage.
62 This should also involve a search for flexibility by which the farmer can move in and out of food crops and cash crops, giving him some food security, especially in times of drought, but also the cash needed for irrigation.
African farmers respond the way they do; but...we can predict with considerable accuracy how they will respond. In general, they will not plant at the optimum time, they will not weed as often or as timely as required, and they will not apply the quantities of fertilizer and/or plant protection materials recommended by technical scientists. Whether this is due to poorly conceived technical packages, farmers' unwillingness to give lower priority to traditional food crops, an opportunity cost of private capital in excess of 50 per cent per year, or a lack of trust in the ability of the system to deliver necessary inputs on time and in suitable conditions are open questions. We are much more sure that, unless a causal factor is correctly identified and effective action taken to overcome it, new schemes will not perform significantly better than established ones.

It is hoped that this paper has helped identify some of the causes of irrigation success and has identified effective steps that the Bank and other donors can take to institute new irrigation projects that will perform successfully.

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63 Moris and Thom, 1990, p. 482.
## WORLD BAND PROJECTS REVIEWED

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## WORLD BAND PROJECTS REVIEWED (continued)

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GLOSSARY

Aquifer: an underground water-bearing bed or stratum of earth, gravel or porous stone.

Bilateral aid agencies: official developed country agencies responsible for bilateral aid administration.

Economic rate of return: the rate of return on invested capital based on economic values.

Fadama: low-lying humid or seasonally inundated land.

Financial rate of return: the rate of return on invested capital based on market prices.

Flood plain: broad, fairly level area of land adjacent to a body of water which floods and recedes on a seasonal basis.

Food for Work: a U.S. Government program of food aid in which food distribution is based on work done by the recipients.

Gravity irrigation: distribution of water for farmland from a higher to a lower point by canals and ditches.

Ground water: water within the earth.

Irrigation perimeter: the area under irrigation in a given system.

Macro-economic framework: a country's overall economic policies, including the exchange rate regime, monetary and fiscal management, and rules governing external trade and the banking system.

Modern irrigation: cultivation using new or recently developed irrigation techniques.

Peri-urban irrigation: irrigation done near and around cities and towns.

Pivot Irrigation: distribution of water to farmland through a system of pipes and sprinklers moving around a central point.

Polder: a tract of lowland reclaimed from the water.

Pump irrigation: moving water from a low to high point by pump or subsequent distribution by gravity or other means.

President's Report: a World Bank document submitted to the Bank's Executive Directors as a basis for seeking project approval.

Project Completion Report: a World Bank document prepared at project completion that summarizes and assesses the project experience.

Recession farming: progressive planting of an area as flood waters recede.

Sahel: savannah bordering the southern Sahara Desert.
Staff Appraisal Report: a World Bank report prepared as a basis for evaluating the feasibility of a proposed project.

Surface water: water available above the ground in rivers, streams, lakes, pools, and swamps.

Traditional irrigation: irrigation using techniques passed from earlier generations.

Wadi: low lying, humid land close to a shallow aquifer.

Water Users Associations: a legally constituted group of farmers who jointly manage the irrigation of their perimeter.
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Kent, Lawrence, 1988, "Farmers' Marketing Cooperatives and the Commercialization of Cheddra Produce", CARE/Chad.


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