PERFORMANCE IMPROVEMENT STRATEGIES FOR SMALL RESERVOIR-BASED IRRIGATION SYSTEMS IN BURKINA FASO

16 - 28 October 1994

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Report after a visit to Burkina Faso

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TABLES

1 INTRODUCTION

1.1 This report presents the writer's observations and recommendations made during a visit to the Irrigation Management Project in Burkina Faso (PMI-BF) which is a collaborative project between the International Irrigation Management Institute (IIMI) and the Government of Burkina Faso, and is financed by the African Development Bank. This visit took place from 16 to 28 October 1994. Previous visits in May 1992, January 1993 and March 1994 have been the subjects of separate reports.

1.2 The terms of reference of the visit were :

a Review and comment on overall project outputs to date in relation to stated project objectives; recommend measures to minimize possible gaps between any of the objectives and the outputs (achieved and projected);

b Spend time with the project team members reviewing accomplishments and planned work -- it would be desirable to pay special attention to the institutional and socio-economic aspects, with a view to integrating and giving fuller meaning to the fairly extensive data already available related to hydraulics and agronomic aspects;

c Develop structure/contents of final report, paying particular attention to the question of identifying and articulating recommendations related to performance improvement -- the outcomes of the 1993 and 1994 national workshop as well as of the mid-term report may also be taken into consideration;

d Identify emerging areas of future work (in research and institutional strengthening), based on the work and experience so far -- this is in view of developing a set of issues and ideas for possible follow-on project(s).

REVIEW OF PROJECT FINDINGS

2.1 The project now has a remaining life of about one year, or at most 16 months, so further opportunities for observing current performance in the field are limited to the coming dry season, 94/95, and (perhaps) the wet season of 1995. It is necessary now therefore to review the state of our existing information and see (a) what data gaps remain to be filled, and (b) what additional studies may be needed so that we can have adequate explanations of the causes of the present performance levels. Especially we need to develop good interpretations of the causes of any performance deficits, because the final project recommendations must concentrate upon ways of eliminating these.

2.2 Table 1 proposes a list of performance indicators which seem relevant to the analysis of management performance at irrigation systems such as these ones. There are 27 items in the list. Some of them refer only to a specific type of system (e.g. rice systems) but each of these types is represented among the project's five sites. For each type of site there are 19 indicators in this list. That is probably enough; perhaps it is too many.

2.3 In Tables 2 to 18, I have tried to identify our present state of information, against this set of indicators. I have relied mainly on the annual reports for the 3rd year of the project. I feel sure that many of the gaps in these Tables can be filled in from other documents and reports which I have not had time to consult on this occasion.

2.4 These Tables deal with 13 of the 27 items identified in Table 1. Some of the absent items seem to me rather important, and efforts may have to be directed towards these during the remainder of the project. These items are discussed later, in Section 3 of the present report.

2.5 Table 2 shows the recorded amounts of land cultivated in each season, under rice or vegetables, on each of the five irrigation systems. In Table 3 these are converted into crop intensity percentages so that the systems can be compared.

2.6 It appears that the crop intensity averages about 160%, and has not varied much. Since the reservoirs which supply these systems have an average storage capacity of 56,000 m^3/ha, this level of utilisation seems somewhat low.

2.7 There are difficulties in compiling a crop intensity table. At Mogtédo we have a problem in deciding what is the base area. It was originally designed to be 93 ha, but spontaneous expansion by private individuals has increased the area actually used.

2.8 Earlier reports of the project have said that the total area is now 123 ha, but this year's reports say it is 108 ha. In Table 3 I have used the design area of 93 ha as the base, since that represents the government's investment in the project.

2.9 There may also be some land that is cropped twice in the dry season, at Mogtédo and at Savili. This is not shown in the records so far, except at Savili in 1992.

2.10 Table 4 shows the mean yields of paddy, and Table 5 shows the total annual production of paddy at each system, by combining the data of Table 2 and 4. It appears that the total production of paddy, from the four systems cultivating it, is about 1,850 tonnes/year and does not vary much. The yields recorded are rather disappointing. The overall average appears to be about 4,100 kg/ha. The figures recorded at Mogtédo especially seem weak.

2.11 In order to include the vegetable production in the analysis of performance, we have to calculate it in terms of value, not weight. This is quite difficult because the project reports are not giving much attention to data about marketing.

2.12 In Table 6 I have tried to make an estimate of the gross product value being obtained at each of the five systems. It seems to be about 200 million FCFA/year. However there are many unsatisfactory aspects about this Table. Since a Table of this sort must be the basis of any economic analysis of the schemes, I hope that the project team can improve it.

2.13 The major requirements for compiling a better version of Table 6 are better information about prices actually obtained by farmers (especially for each of the vegetable crops), and information about post-harvest losses, or about the percentage of the vegetable crops that can actually be sold. In order to compile Table 6 I have assumed that about 70% of the crops can be marketed, and on the basis of various items of price information I have assumed that the primary value of the vegetable crops averages about 650,000 FCFA/ha, so that the effective market earnings would be about 70% of this, or about 450,000 FCFA/ha. I hope that the project team can improve these crude calculations.

2.14 The impact of devaluation upon the economics of these systems is also an important question. I have assumed that, for the dry season paddy crop of 1994 at Dakiri and Mogtédo, farmers would obtain on average 110 FCFA/kg. Some detailed analysis of the changes in prices actually obtained is however necessary now.

2.15 In Table 7 these figures are compared in terms of gross production value (GPV) per developed hectare. The average seems to be about 600,000 FCFA per ha. per year, and we should probably expect this to increase to the range of 800,000 - 900,000 at least, under the impact of devaluation. It is interesting that the figure achieved at Savili appears to be the best. However I do not feel satisfied with the GPV figures I am using here. It is urgent that the socio-economic report about Savili (which was earlier promised for May 1994) is available soon for improving these estimates.

2.16 In Table 8 to 13, I have tried to examine how these aspects may be related with water supplies. There are no data about water used at Savili, and there are some doubts about items of data at Itenga, where it seems that the periods of water measurements do not coincide with the periods of crop irrigation.

2.17 Table 8 shows that the proportion of stored water in the reservoirs which is actually issued into the irrigation systems is quite small. The average annual irrigation quantities, as percentages of reservoir volumes, are as follows :

Dakiri	27.0%
Gorgo	34.6%
Itenga	30.9%
Mogtédo	37.8%

2.18 The reason for this low level of effective utilisation of storage is that the storage sites are rather flat and shallow, so the amount of water lost to direct evaporation and percolation from the reservoir is high. Since the effective utilisation averages just 32.6%, it appears that in order to get one cubic metre of irrigation water 3.07 cubic metres of storage volume must be constructed.

2.19 Table 9 and 10 show quite consistent performance data about these four systems. Water issued, into the systems, amounts to about 1,100 mm (11,000 m^3 per cultivated hectare) in the wet seasons and 1,550 mm (15,500 m^3/ha) in the dry seasons, with coefficients of variation of about 15%.

2.20 The productivity of this water, in terms of gross crop value per m^3 of water put into the systems, averages about 28.2 FCFA/m^3 in the dry seasons. These are not very satisfactory figures, especially in an environment where water is a scarce and limiting resource.

2.21 An appropriate target for water productivity should be at least 100 FCFA/m^3 in these circumstances. It is quite possible that the Savili system now approaches that level, and efforts should be made by the team to quantify this.

2.22 Tables 11, 12 and 13, combined with 8, show some principal elements of the water balance. Table 11 is the total evapotranspiration, assuming an irrigation duration of 100 days and transplantation date of 15 August or 1 January. Table 12 shows the effective rainfall. The project reports have not always recorded calculations of the effective rainfall experienced at each site and in each season, so the mean effective rainfalls, interpolated from FAO data, may have to be used.

2.23 ICRISAT data on potential evapotranspiration are substantially less than the FAO figures. I am not sure why. The ICRISAT data seem to me to be too low, so I have preferred to use the FAO data.

2.24 Based on these, Table 13 shows the Relative Water Supply (RWS) results. This is the ratio of water provided into the irrigation system (irrigation water plus effective rainfall) to the evapotranspiration needs. The evapotranspiration needs are based (as in Table 8) on a crop that is transplanted at the optimal date.

2.25 On average, the Relative Water Supply is 2.50. It does not seem to vary very much among the systems (coefficient of variation = 13.5%).

2.26 The main reason why the RWS is so high is probably the rather high percolation rate through these soils. The agronomy section's report, Table 18, shows that the percolation at Itenga is about 3.5 mm/d, and the field measurements at other systems seem to give indications in the same order.

2.27 The questions for the project are, how much reduction of RWS could be achieved by better management of water, and could this be translated into a larger area of cultivation (or higher crop intensity) at any of the sites?

2.28 The scope for improvements exists, but is probably not very great. If all the sites have percolation rates as high as Itenga, then I doubt that the Relative Water Supply can be brought below 2.0.

2.29 Efforts should be made to measure actual percolation at all the systems. I understand that a bell-type meter is being used. I recommend that it be abandoned. These devices are very difficult to install successfully, and usually give widely varying results, often very much larger than the true percolation for a number of reasons which are essentially due to the installation difficulties I recommend that the team should rely on direct observation of the rate of fall of water level in the fields, between periods of irrigation.

2.30 We do not have much information about the equity of water distribution within these systems. The variations of crop yield can sometimes be used as a surrogate to indicate whether water is well distributed, but it is also affected by several other factors.

2.31 Table 14 shows the coefficients of variation of yield, as recorded in the reports for Gorgo and Mogtédo. An appropriate target for this statistic would be around 25%, so these figures are rather high.

2.32 Some investigation of the effectiveness and equity of water distribution could be attempted by using Wijayaratna's Water Availability Index. This does not need highly trained observers. All that it is needed is to maintain a daily record, for a sample of fields, of whether or not there is standing water generally visible in the field. The method is described below in paragraphs 3.* to 3.*.

2.33 The lower segment of Table 14 shows the same data on equity, expressed as the Interquartile Ratio, which is the ratio of the average of the best quarter of the observed yields to the average of the poorest quarter. I am including this because for many users it is easier to understand than the coefficient of variation. However, as I do not have the primary data about the observed yields, I have simply converted the reported coefficients of variation into equivalent interquartile ratios by using the assumption that the primary data is log-normally distributed. I think this is a reasonably sound assumption, but I would recommend that the project team should compute IQR values directly from the primary data.

2.34 It appears that the IQR of yields is generally greater than 2, meaning that the most successful quarter of the farmers are getting more than twice as much crop as the least successful. The target coefficient of variation of 25%, which I suggested above in paragraph 2.31, is approximately equivalent to 1QR = 1.90.

2.35 Data about fees and management costs are the subject of Tables 15 to 17. These tables are almost empty because I could find few statements about these matters in the project reports at present. However I believe that more information is possessed by the project team, so these tables are presented as a foundation for improved presentation and comparison of the five sites.

2.36 Table 15 indicates the levels of irrigation service fees charged by the co-operatives. In Table 16 I have tried to indicate the farmers' likely "capacity to pay" by taking the ratio between the fee and the gross product value.

2.37 The co-operatives do not give only irrigation services to their members. They also give other services. They sell fertilizers and other chemicals to their members, and also seeds. They may purchase some of their members' crops, and re-sell them. They may make loans to their members. These activities bring profits to the co-operatives, so the irrigation service fee does not have to cover all of their management costs.

2.38 In Table 17 I have tried (using Mogtédo data only) to estimate the ratio between these management costs, and the gross product value. This ratio, if we can establish its value over the other four systems as well, will give us some indication of whether these organizations are managing in a cost-effective way.

2.39 According to the scanty data in Tables 16-17, the irrigation service fee is in the region 2-5% of GPV, and the total management expenditure by the co-operative (at Mogtédo only) is 7% of GPV. I would not consider these figures to be excessive. As targets, I would suggest that the fee for water service alone should not exceed 5%, and for all services a maximum of around 8% may be thought tolerable.

3 QUESTIONS TO BE CLARIFIED DURING THE FINAL YEAR

3.1 The main tasks for the team over the next 4-6 months should be :

- a Finalize our information about the current performance of the five systems
- b Fill in, as far as possible, any gaps that exist in the performance information.
- c Identify the main performance deficits
- d Develop explanations about the causes of these deficits, and if possible, obtain data for testing the validity of these explanations
- e Analyse the linkages which exist in the present organizational system, and their quality.

3.2 **Finalize performance data** In Tables 2 to 17 of this report I have tried to extract, from the project's own reports, values of a range of performance indicators. The Tables are not complete, and quite a large proportion of the values seem doubtful. For example, the most recent report of the hydraulic component gives lists of water flows, but they often do not cover all days of the crop season. Effective rainfall has not been reported for all seasons. My figures for the gross product value in vegetable crops are just guesses. These are examples. Almost all of the data in these Tables should be verified by the team, and gaps should be filled in wherever possible.

3.3 **Complete the performance information** The Tables 2 to 17 do not deal with all the performance items identified in Table 1. I recommend that the team should study Table 1 and decide whether they can provide or obtain data about any of the other items. Particularly important ones, from the management perspective, are the water availability index (see below), the capital cost of constructing these systems, and the labor inputs in person-days on each crop. We also need to get information about the present budget allocations by government for the operation and maintenance of these systems.

3.4 **Identify performance deficits** We should consider all these performance tables, and decide what performance targets seem to be possible. Sometimes, the existing data will give good indications about this. For example, Table 4 shows that the average yield of paddy, over all seasons and all sites, was 4,275 kg/ha/season. That seems to be an item for possible improvement. We might probably identify a "potential" yield level by looking at the yields of the best 10% of the holdings. Our data on inequity (Table 14) suggests that the coefficient of variation of yields may be around 35% - 40%. In that case, the top 10% of the holdings are probably achieving yields 50% greater than the average. We might, with some reasoning of that sort, propose a target mean yield of 6,000 or 6,500 kg/ha/season.

3.5 **Develop explanations of the performance deficits and test these explanations** Tables 18-20 are introduced in this report in order to show the kind of work that needs to be done in this area. Some of the project's reports say that weak observance of the cropping calendar is a cause of low yield performance. This is what I am calling an "explanation of performance deficit." Is it valid? If it is valid, how big is its influence? In Table 18 I have reproduced, from the project's reports, the observed dates when 50% of transplanting was accomplished, and the time interval between 10% and 90%. Table 19 shows the observed relationship, at Mogtédo, between yield and planting date.

3.6 We can estimate from these two Tables how much improvement in production could be obtained by compressing the transplanting period. At present, in Mogtédo, Table 18 tells us that most of the farmers try to plant in the best period, which is evidently 22-52 days after 1 July. They apparently know that it is better to be early than late. However the average duration of transplanting is about 50 days (between 10% - 90% completed), so some farmers do have significant yield losses.

3.7 I estimate from this information that, if all the transplanting could be accomplished in 30 days, with a median date of 37 days after 1 July, then the increase in production (at Mogtédo) could be about 8.8%. Thus it seems we have data to show that this explanation of performance deficit is valid, and an indication of its magnitude.

3.8 Another explanation of performance deficit is illustrated by Table 20. This deals with the problems associated with land levels. Surveys were done to identify areas which have difficulties of irrigation (generally that means insufficient command from the field channel) or difficulties of drainage. The yield effects of these have also been assessed. Combining these pieces of information it seems that the benefits of improving drainage at Mogtédo would be significant (21.3%) but little benefit would be felt at Gorgo or Itenga.

3.9 I recommend that, before the project finalizes its recommendations, more analyses of this type should be carried out, in order to verify the likely effects of the recommendations.

3.10 <u>Analyse organizational linkages</u> The project document requires us to make recommendations for improving performance based (among other things) on increased involvement of the farmers' organizations in management and maintenance. To see how the organizations' role could be improved, we need to examine what it is now. I suggest that one way of doing this is by developing a map of all organizations involved, both public and private; checking what services or other interactions each organization is supposed to have with the farmers' organization; and assessing the quality of these services. Mapping the linkages would be a good way of identifying those services which are especially defective in the present system.

3.11 Issues for discussion

In addition to the above tasks, I suggest that the project team should if possible formulate a joint attitude on each of the following management issues, before the final report stage is reached :

a What kind of improvements can we aim to achieve at these irrigation systems ?

b Are we able to identify any generic improvements, which can affect all, or large numbers, of systems; or will our recommendations only be specific to each site ?

c What can we say about the role of the CRPAs in managing these systems? Is it a satisfactory arrangement ? Are some CRPAs better than others ? Are some encadreurs more successful than others? If so what are the factors that can produce success ?

d What should be our attitude towards spontaneous expansions of irrigation systems ? It has happened at Mogtédo, and also at other systems (not in our set, e.g. Korsimoro, Tamassogho). Should we oppose it, or encourage it ?

e Are we satisfied with the present system of financing the co-operatives ? Can we say whether their financial health is similar in all cases, or are some performing better than others ?

f What should we say about democracy, transparency and accountability in these co-operatives ? By what process does a person become a member of the co-operative's bureau ? What information do farmers have about their bureau's activities, and how do they get that information ? Is there any financial audit process ?

g Has the devaluation of the currency had any effects (good or bad) on the performance of these systems ? Do we know what the magnitude of these effects is ?

h Is sedimentation of the reservoirs likely to be a serious future problem, or can we ignore it ?

i Can we make any recommendations about design principles for future small irrigation systems in Burkina Faso ? Can we identify ways of building systems at lower cost ? Can we say anything about reservoir size, location with respect to the watershed boundary, evaporation losses, and so on ? Do we have ideas for improving the usable quantities of water, above the levels indicated in paragraph 2.17 ?

3.12 Adequacy and equity of water distribution I have suggested previously that Dr Wijayaratna's Water Availability Index might be used, as a relatively cheap way of identifying whether there are problems of adequacy or equity of water distribution within an irrigation system. The following paragraphs give a short account of how to do this, using observers with a small amount of training. The method is suitable only for rice mono-crop systems. The essential principle is that in such systems the field should be continuously saturated. Any fall below saturation, for a period more than one day, is assumed to cause a yield loss.

3.13 There are two methods, which I will call here the simple method and the modified method. In either of these methods, a sample group of fields has to be chosen initially, and an observer will visit each of these fields once each day, throughout the life of the crop, at about the same time of day each time. The observer will make a visual assessment of the wetness of the field, according to criteria given in paragraph 3.15.

3.14 Thus the observer has to write down a single number (representing field wetness) for every one of the sample fields, every day. The number of fields in the sample depends on the number of observers and their mode of movement: twenty fields, distributed over an irrigation system, would be the minimum if we want to assess equity, and 40-50 would be better.

3.15 In the simple method the observer records whether there is, or is not, standing water, above the soil surface, visible in the field. In the modified method, the observer records the field wetness on a 4-point scale thus : visible water standing above the surface (3); soil surface saturated but no standing water above (2); soil surface not saturated (1); soil very dry and cracking (0). Some observer training is obviously necessary to make sure that these definitions are interpreted uniformly, especially at places where fields are not well levelled.

3.16 The data are used as follows. In the simple method, we give 1 point to each day on which there is standing water. When there is a group of days without standing water, we give 1 point to the first day of the group, 0.95 to the second day, 0.90 to the third, and so on, reducing by 0.05 each day, until standing water is observed again and the score returns to 1.0. When another dry period begins, we again give 0.95 on the second day and continue as previously described.

3.17 At the end of the season we multiply all these scores together. Thus the highest possible result is 1.0, meaning that there was no day without standing water, and the lowest possible is 0.0, meaning that at some stage there were 21 consecutive days without standing water, which is assumed to be enough to prevent any yield.

3.18 Generally the scores will lie between 0.0 and 1.0. The score is correlated with paddy yield potential. So the coefficient of variation of these scores, across the sample, gives us an indication of whether observed yield variations are due to irrigation deficiencies or to other causes.

3.19 We can treat the vegetative and reproductive stages of the crop life separately, because water deficits have more impact in the reproductive phase. Defining these phases could however give us some problems because farmers do not all use the same rice varieties. I suggest that it may be enough, for our purposes, to begin the observations 30 or 40 days after transplanting, and continue until irrigation ceases in the pre-harvest stage.

3.20 In the modified method, the daily score is either 0, 1, 2 or 3. At the end of the season we add (not multiply) these daily values. We can do this, as above, over a period beginning say 30 or 40 days after transplanting. If the field has standing water continuously over an observation period of (for example) 60 days, the score will be 180.

3.21 For simplicity of training the observer, I recommend that we try to apply the simple method, on samples of 30 fields, in Dakiri during the dry season of 1994/95. If it is successful, and if the project life is extended, the observations could be repeated in the wet season of 1995 at Dakiri, Gorgo, Itenga and Mogtédo.

4 DRAFT STRUCTURE FOR THE PROJECT'S FINAL REPORT

4.1 The final report of this project will, according to present plans, be written during the middle months of 1995, so it may use data up to the end of the dry season of 1994/95. It is possible that funds will be sufficient to request another no-cost extension, in which case the report writing might be deferred to about August - October of 1995, and some additional data of the wet season of 1995 might then also be used.

4.2 The final report will present the findings of the studies on the five sites. It then must derive sets of recommendations. I think that recommendations will be wanted at two levels : recommendations in respect of each of the five sites; and recommendations concerning general policies and practices for the larger set of such irrigation systems in Burkina Faso.

4.3 I suggest the following chapter list for the report :

1 Introduction
2 Project objectives
3 Description of irrigation in Burkina Faso
4 Description of the five study sites
5 Activities conducted under the project
6 Findings of the project
7 Discussion of the findings
8 Conclusions
9 Recommendations

Annexes

4.4 I shall summarise, in the next few paragraphs, the subject-matter which I envisage being contained in each of these chapters. Then, in paragraph 4.17, I suggest a more detailed list of contents.

4.5 I envisage that there should be one Annexe for each of the study sites, in which the site description, project activities, and findings for that site would be fully presented. Thus Chapters 4,5 and 6 will be condensed versions of these Annexes. The Annexes should record everything that the project has done, with all the tables of results, etc. Then Chapter 6 contains only what we consider the principal findings at each site, including the necessary tables and graphs (like Tables 2 - 18 of the present report) which present the performance of the five sites together.

4.6 There should also be Annexes for the Training and Information components. These would record all the activities undertaken in those components.

4.7 The Annexes should contain no discussion or explanation of the findings. The place for that is in Chapter 7.

4.8 Chapter 1 (INTRODUCTION) should introduce the project : duration, rationale, organizations participating, funding.

4.9 Chapter 2 (PROJECT OBJECTIVES) should just re-state, from the project document, the objectives and the expected results.

4.10 Chapter 3 (DESCRIPTION OF IRRIGATION IN BURKINA FASO) should provide the overall context. It should describe the national agricultural and food situation (production, consumption, imports, exports) and show the role that irrigation plays. It should describe the country's climate and water resources, and the various types of irrigation systems that have appeared so far, with maps. It should describe the policy background under which these systems have been established, and the existing institutional arrangements. This is the place where the legal texts should be described. (It may be desirable to present some of these texts as an Annexe.) There should be some description here of the social environment; rainfed/irrigated agricultural interactions; mechanisms available for providing inputs and marketing outputs; and the costs of irrigation. All of this Chapter should be purely factual, not expressing any opinions, and it should make extensive use of the outputs of others who have worked on the irrigation sub-sector.

4.11 Chapter 4 (DESCRIPTIONS OF THE FIVE STUDY SITES) is again purely factual. In this we introduce the five specific study locations, with site maps and sections on water, land, irrigation facilities farm community, crops, farmer organisations. This Chapter should not contain any of the project findings : it should state the sort of things that any professional visitor would expect to learn on a one-day initial visit to each place.

4.12 Chapter 5 (ACTIVITIES OF THE PROJECT) will describe what we have done during these four years. Methods of field data gathering should be described, but all findings should be retained until the next Chapter. In this Chapter there would also be summaries of training events, fellowships, published outputs, BRIAO, Namenegdzanga, the two national workshops, and the regional one. As noted above, it will be best to give all these materials completely in Annexes, then summarize and highlight them in Chapter 5.

4.13 Chapter 6 (FINDINGS OF THE PROJECT) will present the main results of the fieldwork. It will be built around a series of tables and diagrams, most of which will be presentations of our performance observations, and will present the results from all five sites together. This Chapter will also present the observations about institutional processes, fee collection, crop marketing and so on. Once again, the Chapter should give observed facts only, and should not try to explain the observations or give opinions about them.

4.14 Chapter 7 (DISCUSSION OF THE FINDINGS) is where we try to interpret the findings and give our opinions. The key aspects to be discussed will be performance deficits (we must say which of the performance items tabulated in Chapter 6 are, in our opinion, capable of being improved, and by how much); causation (we must try to offer explanations of why the performance levels are what they are); and transferability (we must discuss which features of performance and causation seem to be specific to the single site where they are observed, and which are likely to apply much more widely to many sites). I believe that this analytic chapter will be the most difficult one to write. I suggest that it be organized around subject-areas (water, crops, markets, farmers' organizations, public organizations, finance, human resources) but there is so much interlinkage that that structure may not be successful.

4.15 Chapter 8 (CONCLUSIONS) should state our final opinions about key issues. It will, mostly, be a re-statement, in short form, of views that have already appeared in Chapter 7. In Chapter 7 we may discuss all sides of a question; in Chapter 8 we would give our final view of the correct answer to the question. There will, I expect, be some general conclusions, and some that are specific to each site.

4.16 Chapter 9 (RECOMMENDATIONS) should state our recommendations, to the Government, about actions, or policy adjustments, which we think will bring about performance improvements. These again should, I expect, be partly general, and partly site-specific.

4.17 My idea of a more detailed list of contents is therefore as follows. It is still preliminary, and I would expect that changes will be found necessary in the light of the team's own information.

1 INTRODUCTION

2 PROJECT OBJECTIVES

3 DESCRIPTION OF IRRIGATION IN BURKINA FASO

National agricultural and food context
- Production
- Consumption
- Exports
- Imports

Role of irrigation in food supply
Climate and water resources
Existing irrigation types and locations
Laws and policies governing irrigation

Organisations

Public organizations

Farmers' organizations

Social environment of irrigation

Interactions of irrigation with rainfed agriculture

Financing of irrigation

Capital costs

Operating costs

Supply of inputs

Marketing of outputs

4 DESCRIPTIONS OF THE FIVE STUDY SITES

Dakiri

Gorgo

Itenga

Mogtédo

Savili

5 ACTIVITIES CONDUCTED UNDER THE PROJECT

Field data-collection

Training

Information

Workshops

Consultants' studies

6 FINDINGS OF THE PROJECT

Production and productivity

Water use

Costs of operations

Cost recovery

Effectiveness of organisations

7 DISCUSSION OF THE FINDINGS

Water
Land
Crops
Human resources
Farmers' organizations
Public organizations
Finance

Performance deficits
Causes of deficits
Transferability of findings

8 CONCLUSIONS

General

Dakiri
Gorgo
Itenga
Mogtédo
Savili

9 RECOMMENDATIONS

General

System operation
System maintenance
System design

General

Institutions
Finance

Specific

Dakiri
Gorgo
Itenga
Mogtédo
Savili

ANNEXES

Dakiri
Gorgo
Itenga
Mogtédo
Savili

Training
Information

Legal texts (?)

5 REGIONAL ACTIVITIES

5.1 It has, from the beginning, been envisaged that this project (like the parallel project being implemented by IIMI in Niger) would have regional implications. Although it is executed in one country, its findings and recommendations should be beneficial elsewhere in West Africa. The first step towards realizing this regional dimension will be the Regional Workshop, tentatively scheduled for August 1995, which is formally a part of the current project and will serve as a form for communicating and discussing the project's outcomes with other concerned agencies in the region.

5.2 I suggest that this Regional Workshop, and the similar one to be held some months afterwards under the PMI-Niger project, should be used as opportunities to consolidate and strengthen the West African Regional Irrigation Network, and to identify people and organizations in other West African countries who might wish to have some inputs from IIMI. The countries to be invited should be those which have rather similar conditions in central Burkina Faso, as regards terrain, water scarcity and so on. Therefore, I suggest that the invitation list should focus particularly on Nigeria, Niger, Mali, Chad and Ghana. I suggest also that IIMI offices in Asian countries with many small dams (especially Sri Lanka and India) could be invited to participate. If funds permit it, some semi-arid countries outside the West Africa region could also be invited. Countries with significant numbers of small dams would include Zimbabwe, Namibia, Tanzania and possibly Madagascar. I think the Regional Workshop should be bilingual.

6 POSSIBLE FUTURE ACTIVITIES FOR IIMI IN BURKINA FASO

6.1 The end of the PMI-BF project is now less than one year away. The question of subsequent activities for the IIMI country office is therefore now becoming urgent.

6.2 It may at a later stage be desirable for IIMI to be associated in some way with the implementation of recommendations of the PMI-BF project. From IIMI's point of view that would no doubt give a valuable opportunity to see whether these recommendations are successful ones. However, it is premature to speculate about work of that kind at present. Until the recommendations have been drafted and presented, and the Government of Burkina Faso has considered them, there cannot be an implementation phase. That might be reached about one year after this project ends. There is therefore a time gap that should be addressed now.

6.3 I suggest that IIMI should in this period consider possible involvement in other areas of the country, and in other types of irrigation. An appropriate mechanism for selecting options for further involvement would be a short project identification mission, of say two weeks duration, by a joint IIMI - Government of Burkina Faso team. I suggest that such a mission should be sent during the first half of 1995. The task of this mission would be to select two or (at most) three possible options for future collaborative work between IIMI and Burkina Faso.

6.4 Approaches to donors to fund such work could be done at a later stage. Because Burkina Faso has limited resources for providing counterpart support, it is not appropriate to initiate project selection with the donors : it must be done at the country level first, to ensure that IIMI's orientation is in harmony with national objectives.

TABLE 1

MAJOR INDICATORS OF MANAGEMENT PERFORMANCE

A PRODUCTION AND PRODUCTIVITY

In mono-crop systems :

- Annual production of the system
- Annual yield
- Weight of crop produced per unit of water put into the system
- Weight of crop produced per person-day of labour

In mixed-crop systems :

- Annual gross product value (GPV) of the system
- Annual GPV per developed hectare
- GPV per unit of water put into the system
- GPV per person-day of labour

B PROFITABILITY

- Annual GPV per irrigated hectare
- Annual net product value (NPV) per irrigated hectare
- Irrigation service fee (ISF)/GPV
- ISF/NPV
- Total costs of operation, maintenance and management/GPV
- GPV/Capital cost of the system

C **EQUITY**

Coefficient of variation
Inter-Quartile Ratio

applied to :

GPV/hectare
(for mixed-crop systems)

Annual yield
(for mono-crop systems)

Water Availability Index
(for rice-only systems)

D **RESOURCE USE**

Crop intensity
Relative water supply

E **SUSTAINABILITY**

Rates of change of any of the above parameters

Fee collection ratio

Land degradation ratio
(salinity and water-logging)

F **NON-AGRICULTURAL GOALS**

Mean household income
Incidence or prevalence of water-related diseases
Employment

TABLE 2

UTILISATION OF LAND

Units : ha

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI	TOTAL
SH 91						
PADDY	112.0	50.0*	48.0	108.0*	-	318.0
SS 91/92						
PADDY	93.6	-	-	30.0	-	123.6
VEGETABLES	18.4	-	16.53	46.6	32.03	113.56
SH 92						
PADDY	112.0	44.0	48.0	108.3	-	312.3
SS 92/93						
PADDY	102.4	-	-	34.0	-	136.4
VEGETABLES	9.6	-	8.00	50.7	27.40	95.70
SH 93						
PADDY	106.0	48.0	48.0	102.3	-	304.3
SS 93/94						
PADDY	105.5	-	-	57.0	-	162.5
VEGETABLE	5.0	-	14.47	41.6	(30.00)	(91.07)

Source : Rapport d'activités Année 3
Tables 19, 20, 12, 4, 1, 21

Notes :
1 Items marked * are doubtful
2 SS 93/94 data for Savili not yet available so this figure is assumed

TABLE 3

CROP INTENSITY

Units : % of base area

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI	TOTAL
BASE AREA (ha)	112	50	48	93	42	345
91/92	200.0	100.0	134.4	198.5	76.3	160.9
92/93	200.0	88.0	116.7	207.5	65.2	157.8
93/94	188.8	96.0	130.1	216.0	(71.4)	(161.7)

Source : Table 2

Notes :
1. Data in brackets are based on assumptions
2. Base area refers to the area developed under public investment

TABLE 4

YIELD OF PADDY

Units : kg/ha/season

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI (beans)
SH 91	4 500	3 979	4 977	3 690	-
SS 91/92	4 005	-	-		5 707
SH 92	3 667	5 050	5 106	3 893	-
SS 92/93	4 202	-	-		6 440
SH 93	3 651	4 611	5 162	3 331	-
SS 93/94					

Source : Rapport d'activités Année 3
Tables 19, 20, 15, 2, 21

Notes :
1 Data for SS 93/94 not available
2 Data for Mogtédo SS91/92 and SS92/93 not available

TABLE 5

PRODUCTION OF PADDY

Units : tonnes/year

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI	TOTAL
91/92	878.9	198.9	238.9	(520.0)	-	1 836.7
92/93	841.0	222.2	245.1	(559.3)	-	1 867.6
93/94	(819.9)	221.3	247.8	(571.6)	-	1 860.6

Source : Tables 2 and 4

Notes :
1 Data in brackets are estimates
2 Dry season yields at Mogtédo is assumed to be 4 050 kg/ha

TABLE 6

GROSS VALUE OF PRODUCTION

Units : millions of F.CFA

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI	TOTAL
SH 91	35.28	13.93	16.72	27.90	-	
SS 91/92	34.52	-	7.44	29.47	31.99	
YEAR 91/92	69.80	13.93	24.16	57.37	31.99	197.25
SH 92	28.75	15.55	17.16	29.51	-	
SS 92/93	34.44	-	3.60	32.45	30.88	
YEAR 92/93	63.19	15.55	20.76	61.97	30.88	192.35
SH 93	27.09	15.49	17.34	23.85	-	
SS 93/94	49.83	-	6.51	44.11	(31.00)	
YEAR 93/94	76.92	15.49	23.86	67.97	(31.00)	215.24

Sources : Table 2 and 4

Notes :

1 Assumed prices :

Paddy: 70 FCFA/kg before January 94
110 FCFA/kg after January 94

Beans: 175 FCFA/kg

Other vegetables: 450, 000 FCFA/ha

2 Assumed SS yields at Dakiri and Mogtédo, see Table 5 notes 2 and 3.

TABLE 7

GROSS PRODUCT VALUE PER DEVELOPED HECTARE

Units : '000 F.CFA/ha/year

	DAKIRI	**GORGO**	**ITENGA**	**MOGTEDO**	**SAVILI**	**TOTAL**
BASE AREA (ha)	112	50	48	93	42	345
91/92	623.2	278.6	503.3	616.9	761.7	571.7
92/93	564.2	311.0	432.5	666.3	735.2	557.5
93/94	686.8	309.8	497.1	730.9	(738.1)	623.9

Source : Table 6

TABLE 8

IRRIGATION WATER SUPPLIES

Units : 000 m^3/season

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI
SH 92		398.9	625.4	994.1	
SS 92/93		-	142.8	1 463.3	
SH 93	1 377.3	536.5	573.9	1 042.5	
SS 93/94	1 443.4	-	156.8 (201.2)		

Sources : Rapport d'activités de l'année III : Volet hydraulique
Tables 1-8, 10-12, and 16.1 - 16.6.

Note :

1. SH is assumed to be 1 June - 30 November
SS is assumed to be 1 December - 31 May

2. Itenga data for SH 92 began late on 27 August. Additional amount of water has been calculated for July - August, according to experience of SH 93

3. Itenga data for SS93/94 began on 30 December. The amount recorded may therefore be less than the amount of water actually supplied.

4. (Value in brackets is estimated on the basis of experience in SS92/93, assuming that actual start of season was about 1 December)

TABLE 9

WATER DELIVERED PER HECTARE

Units : mm/season

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI
SH 92		906.6	1 302.9	917.9	
SS 92/93		-	1 785.0	1 727.6	
SH 93	1 299.3	1 117.7	1 195.6	1 019.1	
SS 93/94	1 306.2	-	1 112.7 (1 427.8)		

Sources : Tables 8 and 2

Note :

1 This is the amount of water issued per irrigated hectare, not per developed hectare.

2 For Itenga SS 93/94 see Table 8 notes 3 and 4.

TABLE 10

PRODUCTIVITY OF IRRIGATION WATER

Units : F.CFA/m^3

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI
SH 92		38.98	27.44	29.69	
SS 92/93		-	25.21	22.18	
SH 93	19.67	28.87	30.21	22.88	
SS 93/94	34.52	-	41.52 (32.36)		

Source : Tables 6 and 8

Note : 1 For Itenga SS 93/94 see Table 8 notes 3 and 4.

TABLE 11

WATER CONSUMPTION BY CROPS

Units : mm/season

	DAKIRI	**GORGO**	**ITENGA**	**MOGTEDO**	**SAVILI**
SH	556.7	500.3	499.5	509.2	
SS	686.8	670.8	670.4	673.8	552.2

Source : Interpolation of FAO CLIMWAT data for Fada N'Gourma, Dori, Ouagadougou and Boromo.

Note :

1 SH requirement is assumed to be for 100 days of irrigation beginning on 15 August

2 SS requirement is assumed to be for 100 days or irrigation beginning on 1 January.

3 The above data are the total of E_{to}
Crop coefficient is assumed to be equal to 1.0 throughout.

4 At Savili SS is assumed to begin on 15 October.

TABLE 12

MEAN EFFECTIVE RAINFALL

Units : mm/season

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI
SH	169.8	215.9	215.9	217.0	228.9
SS	5.9	14.0	14.0	13.5	24.0

Source and assumptions same as for Table 11

ACTUAL EFFECTIVE RAINFALL

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI
SH 92					
SS 92/93					
SH 93	131.3	370.4	178.7	189.3	
SS 93/94					

Source : Rapport d'activités de l'année III : Volet hydraulique Tables 16.1 - 16.6.

TABLE 13

RELATIVE WATER SUPPLY

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI
SH 92		2.24	3.04	2.23	
SS 92/93		-	2.68	2.60	
SH 93	2.57	2.97	2.75	2.37	
SS 93/94	1.91	-	1.68 (2.15)		

Sources : Tables 9, 11, and 12

Notes :

1 Definition of Relative Water Supply :

$$RWS = \frac{\text{Irrigation Water} + \text{Effective Rain}}{\text{Evapotranspiration needs of crop}}$$

2 For Effective Rain, actual values are used if available, otherwise FAO mean values

3 For Itenga SS 93/94 see Table 8 notes 3 and 4

MEAN RELATIVE WATER SUPPLY = 2.501

TABLE 14

INEQUITY OF CROP YIELDS

Units : Coefficient of variation (cv)

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI
SH 91		0.41			
SS 92/92					
SH 92		0.36		0.438	
SS 92/93					
SH 93		0.23		0.430	
SS 93/94					

Source : Rapport d'activités de la section agronomie, mars 93 - avril 94
Tables 22, 8.

Units : Interquartile Ratio (1QR)

SH 91	2.72	
SS 91/92		
SH 92	2.41	2.90
SS 92/93		
SH 93	1.80	2.85
SS 93/94		

Note : These figures are derived from the CV data above, using the assumption that the crop yields conform to a log-normal distribution.

TABLE 15

IRRIGATION SERVICE FEES

Units : millions of F.CFA/year

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI
91/92					
92/93					
93/94	1.720			3.207	

Note : 1 These are fees charged. Actual collection may be different

2 The total fee charged at Dakiri amounted to 4, 914,000. This is an inclusive fee covering fertilisers as well as irrigation service.

It is assumed that the irrigation service component of the fee is 35%, as shown by the Mogtédo accounts.

TABLE 16

RATIO OF FEES/PRODUCT VALUE

Units : %

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI
91/92					
92/93					
93/94	2.24			4.72	

Source : Tables 15 and 6

TABLE 17

RATIO OF MANAGEMENT COSTS/GROSS PRODUCT VALUE

Units : %

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI
91/92					
92/93					
93/94				7.00	

Note :

1 According to the co-operative accounts, total expenditure for operation, maintenance and management by the co-operative were F.CFA 4,757,003.

2 The full cost of management would include also CRPA and government expenditure.

TABLE 18

OBSERVANCE OF CROP CALENDAR

Units : Days after 1 July or 1 January to accomplishment of 50% transplanting

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI
SH 91				27	
SS 92/92		-	-		
SH 92			39	44	
SS 92/93		-	-		
SH 93		55	15	40	
SS 93/94	43	-	-		

Units : Days between 10% and 90% transplanting

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI
SH 91				41	
SS 91/92		-	-		
SH 92			26	57	
SS 92/93		-	-		
SH 93		14	16	50	
SS 93/94	27	-	-		

Source : Rapport d'activités de la section agronomie, mars 93 - juin 94

Figures 12, 10, 8, 6a, 6b.

TABLE 19

RELATIONSHIP OF YIELD TO TRANSPLANTING DATE

Transplanting data (Days after 1 July)	Yield obtained			Mean, as % of optimal
	SH 92	SH93	Mean	
0 - 10	3 875	3 557	3 716	89.2
11 - 21	4 211	2 950	3 580	85.9
22 - 31	4 156	3 493	3 824	91.8
32 - 41	4 098	3 513	3 805	91.3
42 - 52	4 428	3 905	4 166	100.0
53 - 62	3 855	3 158	3 506	84.2
63 - 72	2 970	3 230	3 100	74.4
73 - 82	2 742	1 470	2 106	50.5
83 - 92	1 250	2 308	1 779	42.7

Source : Rapport d'activités de la section agronomie (mars 1993 à juin 1994) : page 19, table 8.

Note : These data were observed at Mogtédo

TABLE 20

YIELD LOSSES DUE TO LAND LEVELS

1 EFFECT OF LAND LEVEL ON YIELD

	MEAN YIELD ON LAND WITHO[illegible] LEVEL PRO[illegible]	MEAN YIELD ON [illegible]AND WITH [illegible]ODING PROBLEM	MEAN YIELD ON LAND WITH HIGHER LEVELS
MOGTEDO SH 92	4 141 (1[illegible]	[illegible] (65.4%)	3 872 (93.5%)
GORGO	4 794 (100.[illegible]	3 231 (67.4%)	4 458 (93.0%)

Source : Rapport d'activités de la [illegible]ction agronomie, mars 93 juin 94

Tables 7 and 23

2 EXTENT OF LAND LEVEL PROBLEMS

	DAKIRI	GORGO	ITENGA	MOGTEDO	SAVILI
% WITHOUT PROBLEMS		64.6	79.1	38.5	26.2
% WITH FLOOD PROBLEMS		4.2	8.2	50.0	-
% WITH HIGHER LEVEL		31.2	12.7	11.5	73.8
% WITH BOTH DIFFICULTIES		-	-	-	-

3 POTENTIAL YIELD GAINS IF LEVEL PROBLEMS WERE REMOVED

	DAKIRI	GORGO	ITENGA	MOGTEDO
RATIO OF POTENTIAL/ ACTUAL YIELDS		1.037	1.038	1.213

Note : The above table assumes that actual yields are 0.664 of potential on land with flood problems, and 0.932 of potential on land with high-level problems. These are the average relative yields observed, as shown in section 1 of this Table.