Report No. 15824

Irrigation O&M and System Performance in Southeast Asia: An OED Impact Study

June 27, 1996

Operations Evaluation Department

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### Abbreviations and Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>BWDB</td>
<td>Bangladesh Water Development Board</td>
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<td>ERR</td>
<td>Economic Rate of Return</td>
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<td>FCD</td>
<td>Flood Control and Drainage</td>
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<td>ID</td>
<td>Irrigation Department (Myanmar)</td>
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<td>IIMI</td>
<td>International Irrigation Management Institute</td>
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<tr>
<td>NEWMASIP</td>
<td>North-East Water Management and System Improvement Project (Thailand)</td>
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<td>NIA</td>
<td>National Irrigation Authority (Philippines)</td>
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<td>OED</td>
<td>Operations Evaluation Department</td>
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<td>O&amp;M</td>
<td>Operation and Maintenance</td>
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<td>PAR</td>
<td>Performance Audit Report</td>
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<td>PCR</td>
<td>Project Completion Report</td>
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<td>PRA</td>
<td>Participatory Rural Appraisal</td>
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<td>RID</td>
<td>Royal Irrigation Department (Thailand)</td>
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<td>RRA</td>
<td>Rapid Rural Appraisal</td>
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<td>SLORC</td>
<td>State Law and Order Restoration Council (Myanmar)</td>
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<tr>
<td>SAR</td>
<td>Staff Appraisal Report</td>
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<tr>
<td>WASAM</td>
<td>Water Allocation Scheduling and Monitoring program</td>
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<td>WDR</td>
<td>World Development Report</td>
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<td>WUGs</td>
<td>Water User Groups</td>
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MEMORANDUM TO THE EXECUTIVE DIRECTORS AND THE PRESIDENT

SUBJECT: Irrigation O&M and System Performance in Southeast Asia:
An OED Impact Study

Attached is an impact study of irrigation investments and operation and maintenance (O&M) in the humid tropics of Southeast Asia, prepared by the Operations Evaluation Department. The study covers six gravity-fed irrigation schemes, with reservoirs, in Thailand, Myanmar and Vietnam. Four IDA Credits and two Bank Loans supported these schemes, which were the sole or dominant components of the projects. All were approved in FY74–FY83 and closed by FY91. Project Completion Reports, Performance Audit Reports and an earlier Impact Evaluation Report provide a substantial baseline for this review. To provide perspective on the irrigation portfolio, the field studies included an IDA-supported flood control and drainage project covering three schemes in Bangladesh.

The study challenges common precepts about water management in the humid tropics, according to which major threats to the sustainability of irrigation investments arise from mismanagement by official agencies and distributive anarchy due to opportunistic behavior by farmers. Based on field surveys, the impact evaluation concludes that paddy-based irrigation projects are yielding returns of 7 percent or less, well below appraisal estimates. But in most schemes surveyed, the gap between appraisal expectations and actual results cannot be attributed to decaying infrastructure or distributive waste. Rather, it is due to the combined result of adverse price developments for paddy, excessively optimistic estimates of crop areas served, project design faults, and construction inadequacies. The flood control schemes present a different profile. There, the production impacts have come closer to appraisal expectations, but maintenance standards are deplorable and the sustainability of the structures and benefits is in doubt.

With that exception, field observations disclose broadly satisfactory public performance in O&M. In all the countries surveyed, vandalism and neglect affect mostly structures which are ill-suited to community needs, such as tertiary gates that inhibit the flexible operating protocols favored by farmers, inlets which induce excess flooding in the lower reaches, and embankments which prevent drainage. When siltation and weed infestation threaten irrigation, labor is readily mobilized to clean up watercourses, confirming that collective action will occur if substantial benefits broadly available to the community of irrigators are at stake. Water diversion by headenders is also not a major problem: the "free riding" chaos described by institutional economists is not noticeably present in the irrigation perimeters surveyed in Thailand, Myanmar and Vietnam. Within the constraints of engineering designs, tertiary systems distribute water efficiently (if not always fairly in terms of timeliness or reliability) through customary arrangements which tolerate significant advantages to headenders while allowing adequate water deliveries to tailenders.
This finding would be less surprising if all rather than the majority of the schemes could be classified as "water abundant." However, the same behavioral profile is presented in the two schemes where persistent water deficits preclude a large minority of farmers from reliable supplies. Thus, while formal systems of rotations are rarely practiced, available "social capital" facilitates cooperation at the local level.

Water distribution arrangements at the tertiary turnout are more problematic, since, in the schemes under review, responsibility for allocation lies with unfederated tertiary water user groups and official agencies. The operation of tertiary gates is frequently shared among agency field staff and farmers and is almost as frequently mishandled. Highly sophisticated measurement and allocation programs promoted by consultants have been abandoned, both in Thailand and Myanmar. They are premature for paddy cultivation, given the loose institutional arrangements and high water tolerance of rice. Field studies identified a wide variety of organizational procedures, including some reasonably well administered systems developed locally (Myanmar and Vietnam), or with targeted technical assistance from donors (Thailand), involving mixtures of hierarchical authority and user participation shaped by country traditions.

In all countries, cost recovery plays virtually no role in water management or O&M financing despite Bank conditionality. In the absence of financially autonomous irrigation associations, this result is not surprising. Given the lack of reliable and controlled deliveries, water can hardly be considered a toll good, especially when it is relatively abundant. Further, the "consumer surpluses" associated with declining paddy prices, and already transferred from irrigators to rice buyers, make further taxation of paddy cultivation politically unattractive.

The turning of the terms of trade against paddy growers in the early 1980s—after these projects were approved—casts a shadow over all plans for improved O&M. Unless higher-value cropping systems are put in place, the sustainability of these paddy farms is in doubt. Present standards of farmer O&M are also at risk. The modernization of Thailand's economy pulls farmers to the factories, even as low paddy incomes push them out. Vietnam and Myanmar (in that order) can be expected to follow the same route.

The study proposes specific adjustments in Bank irrigation lending practices for similarly situated countries. First, rehabilitation programs aimed at improved O&M must be more discriminating, focusing on the weakest activities and providing incentives to bring them to appropriate standards. Second, sophisticated water distribution and monitoring technologies should be put aside in favor of less demanding, more automatic control structures, at least until intensive, diversified cropping patterns are in place. Third, Bank projects should emphasize capacity building for effective water distribution associations, with priority accorded to federating user groups beyond the tertiary water course level. Hybrid organizational arrangements that take careful account of existing social networks and that combine community labor and official agency support should be piloted to improve maintenance of canals and gates. Fourth, the engineering of projects should take adequate account of hydrological, topographical, and social environments: participatory project design is important everywhere but should be mandatory in flood-prone, drainage-poor, densely populated areas. Fifth, government policy should favor crop diversification and intensification, supported by enhanced extension and marketing services; cost recovery exhortations should be toned down until water systems are reliable, remunerative crops are introduced, and volumetric water delivery becomes practical.

Most of all, the popular myths surrounding irrigation development in the humid tropics should be set aside, replaced by pragmatic concepts which bring together public irrigation agencies, local authorities, and civil societies to remove specific constraints and strengthen appropriate incentives.

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Preface

This is an Impact Evaluation Report on a cluster of six gravity irrigation schemes supported by the Bank in three countries of Southeast Asia (Thailand, Myanmar and Vietnam). The main objective was to assess agro-economic impacts at least five years after completion of the investment operations, and the influence of operation and maintenance (O&M) performance on the sustainability of those impacts. To gain additional perspective on O&M, the study also assessed O&M performance at three schemes covered by a flood control project in Bangladesh.

Prior to the study, Project Completion Reports (PCRs) had been prepared for the six projects that supported the nine schemes. Performance Audit Reports (PARs) had been prepared on two of those projects; two others were audited in tandem with this impact evaluation. Another one of the schemes in Thailand has been reviewed by OED in an earlier irrigation impact study, providing a stronger foundation for follow-up.

OED wishes to express its appreciation to the four national irrigation agencies that assisted with the evaluations: the Royal Irrigation Department in Thailand, the Irrigation Department in Myanmar, the Ministry of Water Resources in Vietnam, and the Bangladesh Water Development Board.
Evaluation Summary

Introduction

1. The objective of the study is to assess the agro-economic impacts of investments in gravity irrigation schemes in the paddy lands of Southeast Asia, and determine whether and how the quality of operation and maintenance services (O&M) influences the sustainability of those impacts. Six gravity irrigation schemes with reservoirs for water storage were selected in Thailand, Myanmar and Vietnam. Four were large schemes—at least 40,000 ha—and the other two were small tanks of about 1,000 ha. The six schemes, widely dispersed in the region, were chosen for variety and not representativeness. Nevertheless, the findings are similar at all sites suggesting that the lessons have wider application. An audit of a flood control and drainage project at three sites in Bangladesh was included in the study so as to identify differences in O&M organization and effectiveness between irrigation and flood control. Map 1 (page 10) shows all nine scheme sites.

2. Field work was carried out in three phases in late 1994 and early 1995. An OED impact study team comprising Bank staff and international and local consultants visited farmers and officials at the scheme sites and responsible public irrigation authorities. The field work had a "participatory" orientation, as interactive group and household interviews were arranged in all four countries. The field work was also carried out rapidly: on average one and one-half weeks at each site.

O&M Performance: the Current Paradigm

3. O&M performance by both agencies and irrigators on the large, government-operated, gravity-fed irrigation schemes in Southeast Asia is, with few exceptions, dismal. This conclusion confirms but goes beyond the frequent reports of degraded public infrastructure in developing countries, particularly irrigation structures. Measures to reverse the problem of "rusting, crumbling infrastructure" were central concerns of the Bank's World Development Report 1994—Infrastructure for Development.

4. Poor O&M and lowered benefits from irrigation investments are causally linked. OED's 1994 report A Review of World Bank Experience in Irrigation examined not only the Bank's record but experience in similar non-Bank projects throughout the world. The Review looked in particular at the problems of paddy irrigation O&M in the humid tropics of Asia. It focused on alarming behavioral patterns, that suggest irrigator resistance of unusual intensity to O&M design standards—degenerating into anarchy and chaos.

5. Social scientists have also paid increasing attention to the role of formal and informal associations of beneficiaries of public assets. Nowhere is this more evident than in the literature on irrigation, where researchers have attempted to define the characteristics of association that

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1. Thailand: Lam Pao scheme in the northeast, serving 50,000 ha; Maeklong right bank scheme, serving 40,000 ha.
Myanmar: Kinda scheme in the central dry zone, serving 71,000 ha; Kinmundaung tank in the central dry zone, serving 1,000 ha; Azin tank in the south, serving 1,200 ha.
Vietnam: Dau Tieng scheme northwest of Ho Chi Minh City, serving 45,000 ha.
promote improved O&M. Elinor Ostrom's seminal publication *Crafting Institutions for Self-Governing Irrigation* offers eight "design principles." Other lists of "conditions" for success have been prepared by researchers inside and outside the Bank. In the vanguard is the International Irrigation Management Institute (IIMI), established in Colombo, Sri Lanka in 1984 with international funds and a mandate to study all aspects of irrigation organization and management. IIMI has led the way in promoting the transfer of certain O&M responsibilities by public agencies to water user groups (WUGs). Whereas the literature conveys a sense of hope for improved O&M from greater farmer participation, it is less optimistic in its assessments of public agency performance prospects. Deep seated cultural features of irrigation bureaucracies are widely held to inhibit effective O&M work.

6. In short, the dominant paradigm is one of incompetent bureaucracies combined with non-existent or weak irrigator associations struggling, largely without success, to impose a sophisticated O&M routine upon opportunistic farmers, with the result that production benefits attributable to the irrigation are far below potential. Inevitably, this paradigm guided the design of the impact study.

**Agro-economic Impacts of the Six Schemes**

7. The predominant crop is paddy in all schemes, and there are many other similarities between them. The most important distinguishing factor is the degree of water abundance or scarcity at the level of the reservoir, compared with the area to be irrigated. Four of the schemes have more water than they use; the other two, in the central dry zone of Myanmar, have much less than planned.

8. At four of the six sites, including three of the large ones, the areas supplied by the irrigation systems are significantly less than planned. Over-optimism, engineering errors, lower than normal rainfall and failure to extend the tertiary canals are the leading explanations. They vary in importance from site to site. Cropping intensities are also substantially lower than expected at three sites and are falling at a fourth. Without a high level of water recapture by small private pumps on fields beyond reach of the canals at Dau Tieng in Vietnam, that scheme too would show much lower average intensities than projected. Only one scheme—a successful tank in Myanmar—has reached both its area and intensity targets. Paddy yields vary widely—between schemes and in comparison with expectations—but a weighted average for the wet and dry seasons at all the schemes is about 3.3 tons, or 85 percent of appraisal projections. However, even where soil conditions permit a shift to other field and specialty crops, farmers have not diversified out of paddy. In fact, the concentration on paddy has increased.

9. Reestimates of total scheme production of paddy, and of a few other major crops at the two schemes where paddy is not completely dominant, show output to be between 32 percent and 73 percent of appraisal estimates for five schemes (four of them are below 50 percent). The Myanmar tank is again the exception, but accounts for only 1,200 ha out of a total of 207,000 ha served by all six schemes. These production shortfalls undermine the economic rate of return for each scheme. The returns have also been driven down by the decline of the international price of rice between 1981 and 1986. Rice prices projected by the Bank in early 1995 for the mid- and late-1990s were only 30 percent of the prices projected when these projects were appraised. The small upturn in late 1995 has little effect on the outcome. Together the production shortfalls and lower prices result in rates of return at or below 7 percent for all schemes and negative for one.
Welfare Impacts

10. Smallholder irrigated paddy can no longer provide the basis for a growing or even stable household economy. Incremental and total farmer financial incomes from average size holdings range from about US$600 to US$2,000. For Vietnam and Thailand actual incomes are only irrigated 10–30 percent of appraisal estimates. The gap is lower in Myanmar, but mostly because appraisal projections were less ambitious. The implications vary. For example the accelerating rate of outmigration from the two Thailand schemes contrasts with the stability of farm communities in Myanmar. As economies expand, irrigated paddy will not be able to compete with the incomes to be had from other employment opportunities.

O&M Performance: in Practice

11. The OED field surveys concentrated on assessing the performance by agencies and irrigators in operating and maintaining the schemes. Observations were made of the condition of the canals and control structures, agency activity in allocating, distributing and maintaining the flow of water, and the strengths and weaknesses of farmer O&M, especially as managed through informal associations, their WUGs, and the few higher level federations of WUGs encountered. Overall, agency and irrigator performance appears substantially better than the image presented in the depressing paradigm described above and runs counter to allegations about farmer disinterest in maintaining the irrigation assets that serve them, about feuds over water supplies tending to anarchy, and about an insurmountable bias among agency engineers against O&M.

12. Even in the two water-short schemes, and on the ends of the distributary canals in the other schemes where periodic water deficits appear in spite of overall scheme abundance, relations between headenders and tailenders are more civil, accommodating and fair than the paradigm suggests. Advantaged irrigators do use their advantages, and other irrigators do complain. But the level of agitation seems nowhere to be alarming. The absence of a significant yield differential between the heads and tails of the watercourses underlies this low level of conflict, but it also suggests that water is reaching the tailenders.

13. This civility, and relatively fair sharing of water, has been accomplished despite the fact the WUGs—which are present on all schemes—are not functioning up to expected standards. The one exception is the internationally-assisted sections of the scheme at Lam Pao, Thailand. There, both the WUGs and the federated groups of WUGs organized along some of the distributaries meet the criteria laid down in the Crafting book cited above and clearly illustrate the improvements in the system and on the farms that follow effective organization. However, that level of organizational performance is unique among the schemes studies. Elsewhere at Lam Pao the WUGs accomplish their basic purpose, which is to keep the tertiary canals and watercourses open, and to assemble labor to help the agency keep the larger canals clear, but otherwise stimulate no larger group cohesion or participatory activity. In Myanmar the WUGs are subordinate to the village councils and also do not seek or achieve any higher purpose. In Vietnam the WUGs are barely more than arms of the provincial irrigation authority. In short, strong WUGs are not a primary cause of the relatively successful O&M activity observed in the schemes studied. Farmers cooperate to achieve at least basic O&M objectives regardless of the level of maturity of the formal organization.

14. The contrast with the flood control schemes is instructive. In Bangladesh there was no attempt to form user groups associated with the flood control structures. The character of these
structures, and the benefits they provide, is such that the beneficiaries do not even associate spontaneously to take care of them. The rate of degradation of the embankments, sluices and other equipment is much more alarming than on the irrigation schemes. Moreover, with no official stimulus to promote farmer association to protect scheme assets, even the small irrigation inlets that were installed in the embankments at two of the three sites were for the most part neglected. Flood control O&M better fits the paradigm than irrigation O&M.

**O&M Influence on Agro-Economic Impacts**

15. Do the lapses and failures of operation and maintenance that were everywhere observed contribute to lowering production on the five poorly performing schemes? Again, the answers are unexpected. The study reveals no substantial negative constraints on irrigated production attributable to poor performance in O&M. Those O&M operations which are essential to keep sufficient supplies of water flowing to the great majority of the fields are adequately carried out. Yet, it was the assumption that such a negative relationship did exist that prompted the study. In many other countries, and on many other schemes, the record is undoubtedly worse. But the study suggests that a more discriminating analysis of the O&M breakdown is warranted.

16. It is clear that some components of O&M are under control and others are not. Four parts of an O&M matrix are discussed: agency operations and agency maintenance, and irrigator operations and irrigator maintenance. Common weaknesses are agency inability to keep some of the larger distributaries clean of silt and weeds throughout the cropping season, and farmer indifference, neglect and destruction of tertiary gates. But these failures are not systemic and can usually be explained by budget constraints, scheduling problems and farm-level disincentives that require tailored and equally well "crafted" solutions.

**Other Issues**

17. Among other issues covered by the study are:

   (1) the dismantling of complex technological control systems imported in the 1980s by foreign consultants. In Thailand and Myanmar a computerized water allocation and monitoring program (WASAM) was adopted, but it proved to be too demanding on agency staff and the protocol and measuring devices have been abandoned;

   (2) the ongoing attempt by a follow-up group of consultants in Thailand to "modernize" the control system by simplifying WASAM and substituting weirs and gates that require less human intervention. There are two types of modifications—fixed structures that have no adjustments, and structures that adjust automatically to changes in water levels—each with its own advantages;

   (3) farmer rejection of rotations as well as gates. Rotations do occur, but they tend to break down under conditions of shortage when they are needed most. The biggest problem is not the sharing of water within a tertiary system, but between tertiaries;

   (4) the ability of the agency in one country—supported by the local administration—to bypass rotations altogether by simply cutting off tailend tertiaries. The irrigation agency informs the farmers in advance which of them cannot be supplied. In other parts of the world, shortages usually are shared equally; and
(5) the different degrees of success in mobilizing free irrigator labor to clean the larger canals. In Myanmar the authorities are able to gather large numbers of irrigating and non-irrigating farmers. Group work on distributaries is rooted in Burmese irrigation traditions.

Findings and Recommendations

18. The finding that dominates the study has little to do with O&M. Offering poor economics and low incomes, these paddy irrigation schemes face an uncertain future. Improved O&M performance will not rescue them. In fact, the study finds that this causality is being reversed. As the uncompetitiveness of paddy farming drives the younger members off the farms, and the older members who stay behind concentrate on the basic subsistence crops, social capital will erode and O&M standards are likely to suffer.

19. Based on the six schemes studies, a dozen recommendations are made grouped into four sets:

- **Sharpen the response to O&M failures:** by disaggregating O&M, identifying the poorly performing components, and dealing with disincentives specific to each, such as the tertiary gates that farmers below consider unfriendly;

- **Simplify the technology of infrastructure and operations:** by converting to fixed and automatic controls that need less human intervention and by supporting authorities who plan with the farmers to abandon equitable rotations by rationing water in emergencies;

- **Promote the transfer of management to farmers and their WUGs, judiciously:** recognizing that organizing user groups pays off, but accepting as well that there are some management responsibilities which immature WUGs cannot handle; and

- **Improve household earnings:** through diversifying cropping systems and supporting research, extension and marketing services keyed to specialty crops and integrated, high value farming.

20. The relevance of these recommendations beyond the selected schemes is uncertain, since they depend on cultural and institutional parameters which may be country-specific, and on engineering and agronomic considerations which may be project-specific. For example, comments on a draft of this report showed concern that the findings were at once both too rough and too forgiving on O&M performance in the region. For the moment, these recommendations are better viewed as hypotheses. Additional empirical work is needed to validate the range of countries and projects inside or outside the region for which these recommendations are appropriate. OED has proposed a regional workshop where validation would be one of the principal objectives.
Map 1

SOUTH/SOUTHEAST ASIA
OED IMPACT STUDY: IRRIGATION PROJECTS AND IRRIGATION O & M

- Kinda COMPLETED PROJECTS UNDER STUDY
- NATIONAL CAPITALS
- MAJOR RIVERS
- INTERNATIONAL BOUNDARIES

The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of The World Bank Group, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries.
1. Introduction and Background

1.1 The objective of the study is to assess the agro-economic impacts of investments in gravity irrigation schemes in the paddy lands of Southeast Asia, and determine whether and how the quality of operation and maintenance (O&M) services influences the sustainability of those impacts. The study was prompted in part by an expanding field of academic inquiry into the high rate of deterioration of public irrigation infrastructure, everywhere in the developing world, in response to inadequate O&M by agencies and farmers. It was prompted also by OED's recent study of irrigation programs worldwide, which highlighted the special characteristics of irrigation in the humid tropics, and the failings of O&M services, as two separate subjects warranting additional review. This study assesses both subjects for six gravity irrigation schemes, with reservoirs for water storage, in Thailand, Myanmar and Vietnam.

1.2 The Bank participated in only three such schemes in Myanmar and only one in Vietnam, and all four are included. The other two schemes were selected in Thailand, where the Bank has an older and larger portfolio of irrigation projects. The chosen two in Thailand are outside the river basin where the majority of Bank investments were concentrated, but they were the subject of two earlier OED reports which provide a foundation for follow-up research. The selection of schemes was subject to the condition that the investments had been completed at least five years ago. The three countries constitute a sample of experience in the region, but not a sample drawn purposefully to include a range of pre-identified levels of impact and O&M. The six schemes, widely dispersed in the targeted region (Map 1), were chosen for variety without guaranteeing representativeness. Nevertheless, the fact that the findings were relatively similar at all sites suggests that the lessons may have wider application.

1.3 An audit of a flood control and drainage project (FCD) at three sites in Bangladesh was included in the field work for the study. Irrigation was a minor component at two of the sites and not a part of the third. The purpose was to seek any obvious differences and similarities in O&M organization and effectiveness in protecting against excess water, and O&M aimed at managing limited water supplies.

1.4 Field work was carried out in three phases in late 1994 and early 1995. An OED impact study team comprising Bank staff and international and local consultants visited farmers and officials at the scheme sites and responsible public irrigation authorities. The team was assisted by government representatives everywhere, and in Thailand and Bangladesh by foreign and local staff of two donor-supported technical assistance programs. The field work had a "participatory" orientation, in the sense that group and household interviews were arranged in all four countries in a way to exploit as much as possible interactive interview design. At all irrigation schemes (other than Azin), between four and six sites ostensibly covering a tertiary or small group of tertaries were selected based on an hypothesis about representativeness appropriate to each scheme. Group sessions were organized with help from the irrigation agency and local government, with the instruction that leaders, headenders, tailenders, men, women and other characteristic irrigators be present. Wall maps were crafted by the participants of all homes,  

1. See Chapter 2.

canals, difficult maintenance sections and major gates. The maps gave shape to the discussion, where participants were encouraged to seek agreement on important issues. These sessions, running up to five hours, drew on participatory rural appraisal (PRA) techniques. The group meetings were supplemented by rides and walks along distributaries, tertiaries and field channels, by conversations with farmers and families in their fields and households, and contact with as broad a range of "key informants" as time allowed.

1.5 The field work was carried out rapidly: on the average one and one-half weeks were allocated to each of the major sites, partly to test the effectiveness of rapid rural appraisal methodology (RRA) in short-cutting the more extensive survey designs characteristic of earlier impact studies. No control cases were included, and many of the important statements about impact are made by comparison with appraisal projections, not with the farmers' original conditions.

1.6 The study differs from the standard impact design in one other important respect. Whereas the standard model covers the whole range of welfare impacts, including a full discussion of social, institutional and environmental change, this study is confined to agro-economic impacts. Within that limitation, it explores in some depth the key intermediate objective that ensures the sustainability of all of these improvements—O&M. Subsequent reviews of impact will be strengthened by a better understanding of the processes underpinning satisfactory O&M performance. Nevertheless, the neglect of social and other non-economic impacts limits the relevance of this study.

1.7 This volume includes four annexes, the first three describing separately the impact study results in Thailand, Myanmar and Vietnam. Annex A covers Thailand, concentrates on the Lam Pao scheme in the Northeast, but brings in corresponding observations from the Maeklong River schemes (in particular, the right bank) west of Bangkok. Annex B covers Myanmar, concentrates on the Kinda scheme in the north, but brings in observations from the smaller Kinmundaung and Azin tank sites in the north and southeast respectively. Annex C covers the Dau Tieng scheme near Ho Chi Minh City in Vietnam. Finally, Annex D contains an adaptation of the evaluation summary of the Performance Audit Report (PAR) of the three sites in the Bangladesh FCD project. The full audit reports of the Myanmar Tank Project and the Bangladesh Flood Control and Drainage Project II have been issued separately. This Overview skips all but the essential detail of the nine scheme sites and concentrates on a discussion of the salient features of the study domain. Exceptions to the generalizations are described in the annexes. Illustrative selections of maps for each annex are grouped at the end of the volume.

1.8 Since irrigation canal terminology differs from country to country, the Overview adopts a common nomenclature that distinguishes: the main canals; the primary and secondary distributaries; the tertiary canal systems, below the tertiary turnouts; and the networks of smaller channels which reach or nearly reach the farmers' fields. Where the distributaries discharge into small terminal command areas, it can be hard to distinguish tertiaries and field channels.

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4. Below means behind, or served from, the tertiary turnout, not further down the distributary.
5. The terms "watercourses" and "ditches" are not used in this Overview.
2. Operation and Maintenance: Summary of the Literature

A. O&M Performance

2.1 O&M performance by both agencies and irrigators on the large, government-operated, gravity-fed irrigation schemes in Southeast Asia is, with few exceptions, said to be dismal. This conclusion is consistent with the alarming reports of degrading public infrastructure of all categories in developing countries, and of irrigation structures in particular.

2.2 There is an expanding body of literature on the causes of and solutions for the failure of communities to maintain commonly-used structures installed by governments to serve them. This phenomenon is not unique to rural areas, but the case studies have been concentrated there. The pervasive nature of this problem is captured in the opening sentences of a recent book on infrastructure policy by Elinor Ostrom, the dean of this school of inquiry:

"As indicated by our subtitle, this volume addresses a practical, yet extremely complex, public policy issue confronting nearly all developing countries—the problem of insufficient maintenance of rural infrastructure facilities. Where maintenance is inadequate, public investments deteriorate long before their expected useful lives are completed. This premature deterioration in capital assets results in a further drain on the already scarce resources of low-income countries."

2.3 Measures to reverse this problem of "rusting, crumbling infrastructure" is a central concern also of the Bank's World Development Report 1994—Infrastructure for Development (WDR'94), which begins its search for solutions with the statement:

"Inadequate maintenance has been an almost universal (and costly) failure of infrastructure providers in developing countries."

2.4 WDR'94 looks at all infrastructure—power, telecommunications, potable water supply—as well as irrigation. Other Bank evaluative studies confined to the irrigation portfolio repeat the critique of O&M performance. Two reports dated 1981 on management issues in irrigation make that point:

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6. The original studies that anticipated this growing field of research dealt with the village "commons," and speculated on the conditions under which villagers could agree to collective action to prevent over-stocking and thus preserve the common pastures and woodlands for the mutual benefit of individual households. Clifford Hardin's 1968 article "The Tragedy of the Commons" (Science 162: 1243-48) was the one that most stimulated the subsequent debate. A partial listing of more recent studies dealing with the incentives governing private and institutional treatment of public infrastructure is provided by one of the 1995 papers presented in the Bank's annual conference on development economics (Ostrom, Elinor. "Incentives, Rules of the Game, and Development." in Bruno, Michael and Boris Plescovic. 1996. Annual World Bank Conference on Development Economics, 1995. World Bank, pp. 231-234.)


"Overall, water management in the set of irrigation projects under review was found to have received inadequate attention. Insufficient provision for the systems' operation and maintenance were made at appraisal; insufficient action taken during implementation."9

and:

"The study concludes that there are immense opportunities for improvements in the performance of irrigation projects through management reform and better water distribution."10

In both cases, these statements are placed on the leading page of the report.

2.5 A causal link between poor O&M and lowered benefits attributable to the irrigation investments is articulated in OED's more recent 1994 review of the entire irrigation portfolio, *A Review of World Bank Experience in Irrigation*. The Review examined not only the Bank's record but reports on experience in similar projects throughout the world. It concludes:

"The evaluations reveal pervasive problems in operation and maintenance, in cost recovery, and with users' groups. Of the three, O&M is the most important because it affects benefits directly."11

2.6 The *Review* looks in particular at the problems of irrigation O&M on paddy projects in the humid tropics of Asia, a subset of the Bank's portfolio which has attracted special interest in the last decade. The *Review*'s discussion of this regional record focuses on alarming behavioral patterns, that suggest these paddy projects face irrigator resistance to O&M design standards of unusual intensity. In the following quote, the *Review* refers to the highly reticulated gated systems popular in the region and common to all the irrigation schemes studied in this, subsequent, impact study:

"They were unsuccessful in a way that has contributed to the impression that all large gravity systems in the humid tropics degenerate into operational chaos, often accompanied by vandalism of the structures and illegal arrangements between some irrigators and public system operators."12

2.7 The characterization of chaos, and "anarchy," has its roots in a 1986 paper by Robert Repetto which was one of the first to examine the impact of rent-seeking behavior on irrigation system performance.13 His discussion of opportunistic behavior by agency staff as well as farmers matches other reports on rural public infrastructure of all types, including the seminal works of Ostrom. References to "free riding" (by farmers within the effective irrigation

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perimeter who do not participate in O&M but cannot be excluded from receiving water), "shirking" (by farmers who do participate, but contribute less than they promised and expect to get away with it), "moral hazard" (of farmers who neglect maintenance routines because accelerated deterioration will prompt earlier government intervention), and "corruption."

2.8 But for paddy irrigation schemes in the humid tropics a special set of circumstances dictate that anti-social behavior should not only be anticipated but be expected to prevail. The argument is that these paddy farmers—unlike their neighbors in the drylands of South Asia, who depend on irrigation for planting in any season, and thus restrict their plantings to expected deliveries of canal water—plant the wet season crop with the expectation of adequate rainfall. When the rains fail, as they often do for periods during the wet season, the paddy farmers take desperate individual or group action to defend their standing crops. They "vandalize" the gates and other structures which stand between them and the limited canal supplies. This "anarchy" model of wet season behavior has been described convincingly in several recent reports by Bank staff, and is treated exhaustively in OED's 1994 Review. It takes the characterization of behavior with common public assets—free riding, etc.—one step further.

2.9 In short, this paradigm established both the justification for and initial design of the impact study: which was to review a set of large scale gravity irrigation projects in Southeast Asia to try to assess the inadequacy of O&M performance, the reasons for it, and the implications for production on the fields that were to be irrigated.

B. Institutions

2.10 Responding to the concern for the degradation of public infrastructure, social scientists have paid increasing attention to the role of formal and informal associations of beneficiaries in reversing that trend. This has been nowhere more evident than in the literature on irrigation, where researchers have been attempting to define the characteristics of association that promote improved O&M by the irrigators. This line of research has expanded rapidly only in the last decade. The first deliberate attempt by government to involve irrigators in a major way is usually attributed to an experimental program undertaken by the Philippine National Irrigation Authority (NIA) in the mid 1970s to prepare farmers to take over smaller schemes in the NIA network that it could no longer afford to manage. Yet even in 1981 OED could report on irrigation management issues without even recognizing the future importance of this developing field of social engineering, as demonstrated by OED's casual introduction to the subject of farmer participation in that year's report:

"Farmers may play a useful role in operating irrigation systems."


Today the universal assumption is that farmers have to play a central role in operation as well as management or the irrigation scheme will not progress.

2.11 The study of success and failure of water user groups (WUGs), and the incentives and conditions that determine effective, collective farmer participation, has attracted scholars and practitioners across the globe. Ostrom's popular booklet *Crafting Institutions for Self-Governing Irrigation Systems*, offers eight "design principles." Her work is paralleled by other lists of "explanations," or "conditions" for success, constructed by researchers inside and outside the Bank. The lead in such investigations has been taken by the International Irrigation Management Institute (IIMI), established in Colombo, Sri Lanka in 1984 with international funds to study all aspects of irrigation organization and management, including the roles of both the irrigators and the agencies.

2.12 IIMI has led the way also in promoting the transfer of certain O&M responsibilities by agencies to WUGs where conditions are appropriate, up to full turnover of the entire scheme. Using this terminology, turnover would include transfer of responsibility for all assets, including the reservoir and headworks. It is usually confined to smaller schemes, although it reached its fullest expression to date in the thus-far successful turnover of the major public schemes in northwest Mexico. IIMI helped organize the International Conference on Irrigation Management Transfer in Wuhan, China in September 1994. In the context of this impact study transfer refers to both individual tertiary systems and collections of tertiary systems along a distributary. An alternative route to farmer participation in O&M is through cost recovery, and a common institutional arrangement is to transfer full responsibility for irrigation facilities behind the tertiary turnout to the farmers, and require farmer cash and/or labor contributions for costs to the agency of O&M of the rest of the system.

2.13 Whereas the literature conveys a sense of hope for improved O&M from greater farmer participation, the assessment of public agency performance and prospects for improvement are invariably grim. This judgment stems from cultural features of irrigation bureaucracies that are seen to inhibit dedicated O&M work by agency managers and staff. Central government irrigation officials are usually engineers, and are commonly described as more interested in building new systems than in maintaining existing ones. It is said that the task of overturning those preferences is daunting. Nevertheless, WDR'94 highlights this situation as one where change is essential if infrastructure is to be sustained:

"Where infrastructure is operated inefficiently and delivers poor service, the solution cannot be simply to tell suppliers to do more maintenance and to consult users. The weaknesses in infrastructure provision are inherent in the incentives built into current institutional and organizational arrangements, in which outputs and inputs are not closely..."

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20. See, for example, reports by the Technical Assistance team in the Bangladesh BWDB Systems Rehabilitation Project (Cr. 2099-BD), in particular: SRP Consultants of the Netherlands TAP, October 1993. BWDB Systems Rehabilitation Project: Status Report.
measured, monitored, or managed, and suppliers do not depend on user satisfaction for reward."  

The latter comment refers to infrastructure broadly. OED's 1994 Review cites a background study carried out for the WDR94 that compared the incentive structures in irrigation agencies in India and South Korea:

"The contrast is stark: the Indian organization has virtually no incentives for conscientious work,...while the Korean organization is full of both individual and collective incentives." 22

Bank and other reports on irrigation agencies in Southeast Asia describe institutions whose poor performance on O&M reflects the absence of any strong incentives for improvement: much closer to the Indian than the Korean example. 23

2.14 The rapid research style of the impact study did not allow for detailed examination of incentives and norms of WUG and agency activity. Nevertheless it was essential for the team to make a rough assessment of the quality of performance by both the farmer associations and the scheme authorities. As shown in Chapter VI, the observations were structured in a four-cell matrix, where agency and irrigator performance in both operation and maintenance were treated separately. The initial hypotheses (the "priors") were that the impact case studies would reveal the same characteristics that are alleged to prevail throughout the region. This implies performance levels below standards that guarantee adequate O&M and reasonably efficient uses of the irrigation water. The status of and progress with transfer and cost recovery was also assessed.

C. Contributing Factors

2.15 The initial paradigm governing the design of the impact study was of disinterested bureaucracies combined with non-existent or weak irrigator associations, struggling, largely without success, to impose a sophisticated O&M routine upon opportunistic farmers, with the result that production benefits attributable to the distributed irrigation waters are far below potential. That paradigm had to be adjusted to reflect three other factors discussed in the literature that can help depress farmer O&M performance.

2.16 Unreliability of Main Supply. Anthony Bottrall, the author of the Bank's 1981 report on management and organization of irrigation projects, emphasizes repeatedly that farmer follow-through on O&M below the tertiary turnout is highly dependent on the quality of the service provided by the agency at the turnout: the reliable provision of allocated water supplies. He claims the first condition for successful group action is that the farmers anticipate the benefits of a "collective good" that would otherwise be withdrawn, in particular a predictable schedule of

water delivery. Agency inefficiency reflected in variable supply destroys the confidence and weakens the farmers commitment to O&M.

2.17 *Inappropriate Technology and Faulty Construction*. These are two other factors explaining poor O&M performance that work independently of the chaos paradigm. On the one hand, the reticulated gated structures under manual control that have normally been installed in Bank-financed schemes in the humid tropics to control water levels and water flows are alleged to be ill-suited to the demands of small farmer paddy irrigation in either the wet season or the dry season. This has been a recurring theme in critiques by the Bank’s own staff of the Bank’s traditional design. On the other hand, the canals, the structures or both have been badly constructed, usually due to contractors short-cutting the design specifications with the connivance or indifference of the supervising agency. In either case the system performs poorly and no amount of O&M can fully recover scheme potential. Farmer response to these faults is to circumvent the inappropriate structures and to reduce their commitment to maintenance.

2.18 *Declining Profitability of Irrigated—Especially Paddy—Farming*. This factor has entered the literature with increasing prominence since the early 1980s. Unfortunately, the implications of the declining profitability of paddy farming have not been incorporated in the discussions of O&M, transfer and cost recovery. Some of OED’s recent reports have followed this deteriorating trend. A good example is the PAR on the Thailand Irrigation XI and XII projects, which calls into question the "increasingly implausible assumptions about net impact." OED’s 1994 Review returns to this subject frequently, highlighting the need to diversify out of rice "in a world of low rice prices" (p. 105). A 1991 report by the International Food Policy Research Institute refers to a series of econometric studies that attempted to explain the trend of public irrigation investments in four countries of South and Southeast Asia (Indonesia, Philippines, Thailand and Sri Lanka), concluding that the most important causes of shrinking investments were the decline in the world rice price and the increasing costs per hectare of new irrigation development.

2.19 This impact study tries to examine the strength of each of these factors in determining both the quality of O&M and the influence of O&M on production.

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26. OED, December 21, 1990. Report No. 9205. This was source material for the author’s (Robert Burns) subsequent journal article (footnote 15). The quote is from p.783 of that article.

D. Influence of O&M Performance on Production

2.20 There are many references in the literature to the depressing effects of inadequate O&M on production. An example from OED's 1994 Review was given in para. 2.5. There and elsewhere the causal and positive relation between improved O&M and improved production is taken for granted, a reasonable assumption given that the operative variable—the supply of water—is usually in short supply and the more that can be channeled to the farmers' fields the better the harvest. Nevertheless, the reports OED examined on O&M, WUGs, transfer and improved technology do not provide any quantitative evidence of the impact of varying levels and qualities of O&M. What is missing is an anatomy of O&M, that identifies which components are likely to impact the most—in the short and long term—when agency and irrigator performance falls short.

2.21 In the absence of any guidelines for examining the relationship, OED set up a hypothetical list of six patterns of suboptimal O&M behavior which could be depressing total irrigated crop production, namely:

(a) inappropriate and erratic rotation practices at all levels of turnout to subsidiary channels. This includes a concern about the agencies' failure to continue whatever sophisticated control system had been installed;

(b) overusing water on the fields, particularly but not exclusively on paddy;

(c) inadequate maintenance of the irrigation structures—regulators, gates and other controls—resulting in inefficient distribution of available water;

(d) inadequate repair of the irrigation canals, resulting in excessive losses in conveyance;

(e) insufficient cleaning of canals and watercourses, also resulting in losses in conveyance to the fields; and

(f) supporting inefficient cropping patterns, especially by supplying water to paddy in seasons and fields where larger areas of crops with lower water requirements could otherwise be cultivated.

2.22 Chapter 6 refers to these factors in trying to arrive at an assessment of overall impact of O&M performance.
3. Scheme Sites and Infrastructure

A. Thailand

3.1 The Lam Pao Scheme in Northeast Thailand covers about 50,000 ha supplied from east and west bank main canals below a reservoir on the Lam Pao River, about 90 km east of the regional center of Khon Kaen. The scheme is managed by the Royal Irrigation Department (RID). The Bank participated in two projects, approved in FY74 and FY79, for Stages I and II of the irrigation works (not the dam). The loans, for $7.0 million and $17.5 million, each covered several sites in the Northeast of which Lam Pao was the principal operation. Stage II was completed in 1986. Paddy still dominates everywhere; the pace of crop diversification has been disappointing. The reservoir capacity exceeds design requirements, and the designed tertiary grid is complete. Nevertheless, structural limitations and inefficiencies in delivery cause some tailend shortages. OED issued a PAR on Stage I in 1982 and an Impact Evaluation Study of the whole scheme in 1990. Lam Pao is presently supported by the NEWMASIP technical assistance project for irrigation infrastructure rehabilitation financed by the European Community (EC) and based in Khon Kaen. NEWMASIP assistance to the OED Impact Study team allowed it to lead off with Lam Pao to test field methodology.

3.2 The Maeklong Right Bank Scheme covers about 40,000 ha supplied from two main canals on the right bank of the Maeklong River below a diversion weir just south of Kanchanaburi. An initial Bank-supported project financed the diversion dam (and some construction on the west bank). Subsequent projects financed construction of two multipurpose dams in the Maeklong headwaters. The project under review, approved in FY79 for $80.0 million, financed extension of distributaries already built by RID with government funds on the east bank and intensification of tertiary and on-farm work. This project (Thailand Irrigation Project XI) was completed in 1986. The system is fed from the river by the diversion weir with little storage: and flows are controlled at the two dams. Paddy dominates everywhere, as expected. Water supplies in the reservoirs are well above scheme demand, though releases from the dams are determined by electricity demand and water shortages to irrigation occasionally occur. OED issued a PAR on the project in 1990, which also discusses the development of the portfolio of Bank-supported irrigated projects in Thailand.

B. Myanmar

3.3 The Kinda Irrigation Scheme was incorporated in a multipurpose project that financed a dam, a power plant and transmission line, and canal construction to cover 79,000 ha below the reservoir 90 km south of Mandalay. The scheme is managed by the Irrigation Department (ID). The project strengthened existing run-of-the-river diversion schemes originally built a thousand years earlier in the central dry zone, and extended the scheme on the west bank to former drylands. The project was approved in FY80 for $90 million, and was completed in 1991. Paddyland dominates everywhere, even in the extension which was planned for cotton and other irrigated field crops. The expanded irrigation infrastructure is over-dimensioned with respect to

28. In this document, "1986" (for example) refers to the calendar year and "FY86" to the fiscal year.

29. See footnotes in the annexes for the full citations.
reservoir supplies, and it appears that about 8,000 ha of the design command area—all in the west bank extension—will never be adequately served. OED has not carried out an audit, but a Project Completion Report (PCR) covering the multipurpose project was issued in 1991.

3.4 The *Kinmundaung* and *Azin Tanks* were the only two works financed by the Bank's Tank Irrigation Project, which was intended to initiate a series of Bank-supported multiple-tank projects but was never repeated. The project was approved in FY83, executed by ID, and completed, after long delays at Azin, in 1990. The Kinmundaung tank was designed to provide supplementary wet season supply to all, and dry season supply to over half, of 2,000 ha in nominal command. The irrigation works are over-dimensioned in relation to inflows from the watershed to the tank, and the proportion of nominal command which will never be served is larger than at Kinda. Paddy still dominates in both seasons, despite plans for cotton and other field crops in the dry period. The Azin tank was designed to provide dry season irrigation to 350 ha of upland orchards and 800 ha of lowland paddy. Monsoon crops have adequate rainfall and did not need supplementary supplies. The tank is properly dimensioned and cropping targets have been reached. A water supply component for the town of Mudon near the Azin scheme was also completed but consumer demand has grown very slowly and presently amounts to only 15 percent of appraisal projections. A PCR was issued in 1991, and OED's PAR in 1996.

C. Vietnam

3.5 The *Dau Tieng Scheme* covers 60,000 ha on the right bank of the Saigon River immediately below a dam 65 kms northwest of Ho Chi Minh City. The Bank's credit was approved in FY79 for $60.0 million, and funded construction of the dam and the first phase of irrigation infrastructure. This phase was completed in 1986, and subsequent government investments have expanded the distributary grid from the east and west main canals to cover the 60,000 ha nominal command area. Responsibility for implementation of the project and management of the scheme was shared between agencies of the central Ministry of Water Resources and the Irrigation Management Companies of Tay Ninh and Ho Chi Minh City Provinces. Construction of tertiaries is well behind schedule, and only 45,000 ha are actually supplied with water. Paddy dominates: though groundnut is an important second crop, as elsewhere the pace of diversification into other crops has been disappointing. The reservoir supply is larger than required for the existing scheme, but other indirect uses downstream from Dau Tieng add to the benefits attributable to investment in the dam. OED issued a PAR on the project in 1991.

D. Bangladesh

3.6 This FCD project was the second in a series of four projects supported by the Bank investing in medium scale flood control schemes. The three sites are scattered over the country, one each in the northwest (*Chalan Beel*, 38,000 ha), southwest (*Satla Bagda*, 21,000 ha) and northeast (*Hail Haor*, 19,000 ha). The first two subprojects were traditional polders. The third was intended to provide protection against certain flood threats to crops grown around the permanent lake in the depression (*haor*), but the works were later recognized to be miss-sited and the subproject will never serve its original purpose. The project was approved in FY81 for $27.0 million equivalent, and completed in 1989. It was implemented by the Bangladesh Water Development Board (BWDB), which is responsible for all public FCD and irrigation schemes in the country. As suggested above, OED's intent in incorporating this FCD project in the review
was to observe behavior of officials and irrigators in the operation and maintenance of embankments and flood control structures—at Chalan Beel and Satla Bagda. A PCR was issued in 1991, and OED's PAR in 1996.
4. Operation and Maintenance: Systems and Performance

A. Agency Level

4.1 The operational systems for water allocation managed by public agencies depend in the first instance on the adequacy of water supply. Continuing deficits are experienced at two of the Myanmar sites, out of six irrigation sites in the study. There, the Irrigation Department cuts off farmers it cannot supply: it makes no attempt to allocate equally to all farms through rotations. Elsewhere, the agencies allocate water proportionally to areas under command and try to meet the expected requirements of the prevailing cropping pattern.

4.2 Measured against the allocation plan, the operational performance of public agencies on the mains and distributaries is acceptable. Since rotations below the tertiary turnouts, and responsibility for dealing with localized scarcity, have been handed over to the irrigators at all sites studied, the agencies avoid most claims of unfair treatment. And since most schemes have adequate water, this position—once removed from decisions on distribution within the terminal command areas—has not reflected poorly on agency performance. Incidents of occasional discrimination against a tertiary group were reported at OED's group sessions, but there was no evidence of pervasive discontent or of arbitrary and discriminatory rule. It is important to distinguish between performance against annual plans, and against the original appraisal design. The lack of effective canal command over the entire areas originally expected to receive water in four of the six sites means the agencies will never be able to catch up with appraisal targets, even if water use is made more efficient. In two cases this is due to error in estimating inflows to the reservoirs; in two cases to social factors inhibiting completion of the tertiary systems.

4.3 The OED team had no opportunity to observe how the agencies in Thailand and Vietnam would react to conditions of severe water shortage, but it is probable they would enforce rationing when necessary. RID's instructions to all field staff at Lam Pao to limit water applications to household uses and fish ponds in the 1993/94 dry season is an example. Other evidence from the same year's drought in Thailand—in the Chao Phraya basin—when RID pressed the paddy and orchard farmers to take responsibility for dealing with unavoidable cuts imposed by RID in releases from the river, suggests that these government agencies do intervene in emergencies.

4.4 The prevailing maintenance systems provided by the agencies are similar in scope and operate down to the tertiary turnout. Ambiguity over responsibility for the structures at those turnouts may explain a disturbingly high level of negligence in maintaining the tertiary gates themselves. Dau Tieng is different. There, responsibility is shared by the central (headworks and mains) and provincial (distributaries) irrigation companies. Maintenance programs down to but not including the tertiary gates seemed everywhere responsibly designed and organized. The Maeklong scheme maintenance program is less impressive, although there, as at the other sites, the water users help the agency in carrying out essential cleaning. Kinmundaung is a special case, because the maintenance program is tailored only to the areas that are expected to receive water: the water deficit drives all water and work decisions. In contrast with all these irrigation sites, the maintenance program of the Bangladesh Water Development Board for its FCD schemes is unimpressive, the structures are in poor condition, and the O&M budget is seriously under-funded.
4.5 Agency maintenance performance on irrigation structures is good everywhere, at least when evaluated against requirements for carrying out the operational plan. Dams, main canals, and cross check and gated structures are in good order, except that most measurement devices have been removed or allowed to deteriorate.

4.6 The record of the agencies in cleaning canals they are responsible for is compromised by problems peculiar to each of the three primary schemes (Dau Tieng, Lam Pao and Kinda). Silt and weed build-up is not adequately handled in certain sections at each of these sites, deficiencies that are partly attributable to design flaws (such as insufficient gradients, and hence low water velocities in the canals) that prevent easy solutions. The weed problem at Kinda is the most serious, though this disadvantage is partly offset by ID's exceptional capability to mobilize village labor. Cleaning is less of a problem on the Maeklong right bank, and is not of concern at the two tanks in Myanmar.

4.7 The sustainability of O&M performance at all three major sites must be qualified. At Dau Tieng, once the central and provincial governments cut the prevailing subsidies on O&M—a likely prospect given the present cost-cutting drive in all public authorities—the provincial companies will have to curtail services. The lack of effective irrigator associations will make it difficult to offset budget cuts with farmer contributions. At Lam Pao, good performance can be attributed to simultaneous arrival of an activist senior RID project manager and an expatriate technical assistance team in the early 1990s. Conditions on the older, unassisted, sections of the Lam Pao scheme are worse. At Kinda, ID's routine maintenance is undermined by its inability to eliminate illegal uses of and cuts through the embankments despite the tight controls of the state administration. OED observed several serious breaches.

4.8 This said, BWDB maintenance performance on the Bangladesh polders is much worse than at all other sites. There, serious deterioration of embankments and some of the regulators and sluices is visible, prompting dire predictions about failing structures not heard elsewhere. The problem is attributable partly to the professional incentives at BWDB, which favor civil engineering skills over water management skills. It is also attributable to the greater difficulty of organizing beneficiary participation for protecting flood control structures: the "returns" to cooperation are less evident than in irrigation.

4.9 Donors have grappled with O&M in both Thailand and Myanmar, and through consultancy arrangements have sought to establish sophisticated measurement and control systems for water allocation and distribution. The Water Allocation Scheduling and Monitoring computerized program (WASAM), a Dutch consultant's system, was introduced first to Thailand at Maeklong, and later carried to Lam Pao. The same program was introduced at Kinda. The full model has been abandoned at all three sites. A much less ambitious model, with calibration, measurement and tailored releases limited to the mains and their gates, is being perfected now by NEWMASIP at Lam Pao. The long-term viability of these control systems, even after all operators have advanced on the learning curves, is still in doubt. The failure of romijn gates and the Automated Maintenance Planning Process at Maeklong may be a warning of widespread rejection of sophisticated gated control systems. This subject is picked up again in Chapter 7.

4.10 Despite these failings, the overall impression of agency systems and performance on the irrigation schemes is messy but substantially better than the images reflected in the literature. These impressions contradict allegations about relatively low priorities attached by agency
management and staff to O&M as a whole, and a pervasive and corrupting engineers' bias toward construction and rehabilitation.

B. Irrigator Level

4.11 The analysis of irrigator O&M performance must distinguish not only between operation and maintenance, but also between canals and gates. In short, farmers show themselves to be competent to maintain their canals, at all sites—i.e. to keep water moving when needed. However, farmer operation, maintenance, and protection of gated structures in many stretches of the canal grid is deficient.

4.12 Tertiary and watercourse canals usually disappoint the observer looking for mint conditions. But farmers seem keenly aware of the limits beyond which weed growth, siltation and injury to canal walls reduce water flow, and are prepared to work collectively, either organized or spontaneously, to do cleaning and repair when serious shortages threaten. What looks like a weed-choked canal at the end of the pre-monsoon cropping season may be totally transformed by manual cleaning and reshaping immediately before transplanting or broadcasting rice for the rainy season. Thus field observations refute the notion that irrigators are not prepared to maintain canals at serviceable standards.

4.13 One factor that would mar this satisfying picture is continuous, conspicuous, uncontrolled and excessive exploitation of the water supply by advantaged irrigators, especially headenders. Although complaints by the disadvantaged can be heard at all sites (except Azin), the level of hostility was nowhere so high as to suggest headenders are disposed or allowed to exploit their positions excessively. Complaints are often calendar-specific, i.e. about holidays, or special days when irrigation supplies are abnormally but predictably affected by reduced releases from the reservoirs. There are also situations where the disadvantaged are blocked from full participation anyway—by being situated away from the canal infrastructure (Dau Tieng) or by being at tail ends of mains where supplies are clearly deficient (Kinda, Kinmundaung). The tailenders' acceptance of the disadvantages of inferior access due to physical location reduces the potential for dispute. But there seem to be custom honored thresholds which headenders will not violate—in the common interest.

4.14 Again, Bangladesh is an exception. At Satla Bagda, where 450 irrigation inlets have been installed in the polder embankments, the gradient is so shallow that headender irrigation on the "watercourses" results in tailend flooding. There is no equitable solution for all farmers in this case, and outright headender action to let water in can lead to violence. The usual outcome, however, is for the irrigation inlets to be disabled or abandoned. Once again, this suggests that social pressures prevent headenders from taking undue advantage of their position.

4.15 The defining visual characteristic at all but one of the schemes (Azin) is the poor condition of the project-installed gates at and below the tertiary turnout. But this condition is not the result of the usual reasons cited for low-level maintenance—inadequate budgets, lack and ignorance of mechanical skills, moral hazard (footnote 14, page 15), or simply an indifference to timely maintenance. The poor condition of the tertiary gates, and indeed most of the masonry gates on the field channels below the tertiary turnout, is a reflection of operational decisions by farmers not to use them for their design purpose—to ration water to the users below the gates. A gate is rarely friendly to such users, especially in paddy lands where flooding is preferred. The gates were installed to serve users elsewhere along the supplying canal. Without human
intervention to protect that goal—either by enlightened and disciplined farmer association, or by dedicated and respected officials—the gates and their function degenerate.

4.16 The Anarchy Paradigm. There was some evidence in the study area that the incidence of gates broken by farmers at and below the tertiary turnout was higher in the wet season. But concentration of abuse in that season was nowhere so high as to lend conclusive weight to the paradigm described above (para. 2.7). The image of anarchy—every family for itself—is overdrawn. In all schemes studied, the social penalties associated with individualistic behavior are not substantiated, partly because water is usually not so scarce for such behavior to create major discomfort to other participants. Thus, headenders refrain from egregious exploitation and tailenders do not resort to physical retaliation. This is as true for the farmers in the two Myanmar schemes with an overall absolute shortage (relative to design) as it is in the so-called "surplus" schemes. "Anarchy" is a useful concept to explain some of the influences on irrigator behavior. But in the study domain it is not the dominant pattern. Rather, a loose kind of cooperation obtains, under which minor infractions are tolerated and substantial latitude offered to headenders—within bounds.

4.17 There is another, milder form of the anarchy paradigm that applies to relationships between tertiary units. Agency performance in distributing water through the distributaries is generally good, as is farmer performance with distributions within the tertiary systems. But there is a gap in between, in the allocation of water supplies from the secondary distributaries to the tertiaries. That interface does not seem to be well, or at least consistently, managed in the schemes under review. Neighborhood cohesion, and the other social forces that ensure reasonable cooperation within the tertiary system, are too weak to guarantee equitable water sharing arrangements between tertiary units. The public agencies, to the extent they have removed themselves from this level of administration, have left a void.

4.18 There are several reasons. First, the harmony within a tertiary group that is seen to be in every member’s self-interest does not embrace neighboring groups. Second, in all schemes in the study, the public irrigation agency is formally responsible for operation of the tertiary gates, but has either turned management of the gates over to the WUGs or shares it with them. Since in most cases formal irrigator associations above the individual tertiary WUG do not exist, the discipline that in principle should be provided by the agency to ensure equitable treatment is missing except where strong local officials (the "zonemen") are determined to enforce it. The more common case is for agency field staff to avoid imposing rotations, unless the water shortage is so severe as to make action unavoidable. Since most of the schemes have surplus water, rotations between tertiary systems do not normally provoke conflict and the issue recedes in importance. A broken gate at one tertiary turnout does not invite retaliation by other tertiary groups. Myanmar reaches the same point even in the face of water scarcity by cutting off the lower reaches of the schemes and ensuring adequate water for the rest (para. 4.23). But when the "collective" interests of neighboring tertiary units are challenged, the systems in this sample cannot respond as well as in countries where higher-level water users' institutions are formally organized.

C. Water User Groups

4.19 Nominal WUGs exist everywhere in the command areas of the six schemes. Everywhere they have responsibility for managing O&M below the tertiary turnout. In principle, transfer is not an issue at this level. Similarly, everywhere the public agencies retain ultimate
responsibility for operating and maintaining the tertiary gates, but these jobs, especially the operation of the gates, are usually shared under formal or informal arrangement with the WUG.

4.20 The recent experience in those parts of Lam Pao under technical assistance programs, and comparable results in parts of the Maeklong scheme and along the older Kinda canals, would seem amply to support the claim that well-administered, well-supported water user groups can be effective in improving the general level and distribution of benefits among members. But they are the exceptions. The study sample presented OED with a much larger set of experiences on newer schemes, or extensions of older schemes, where the WUG play only a minor role in determining the rules of water-sharing and rotations. In this sense, transfer is by no means complete.

4.21 At Dau Tieng, the "WUG" are not much more than the local arm of the provincial irrigation authorities. They are not organizations representing irrigator interests, and the infrequent rotations that are carried out are administered by those authorities. Discussions with farmers there showed little interest in or experience with taking collective action to secure mutual benefits, except for clearing the watercourses. The fact that many of the farmers in this scheme are relatively recent arrivals, come from different parts of the country, and speak different dialects, helps explain the lack of cohesion. There has never been any external assistance at Dau Tieng aimed at consolidating participatory action by farmers within a tertiary perimeter on common irrigation problems.

4.22 Group action is also weak in the tertiary systems in Lam Pao which have not received technical support from either of the two recent donor-assisted programs. The state of decay of all structures in these non-assisted systems contrasts strongly with the assisted systems, and group discussions with the OED team revealed the same indifference to mutual support—apart from group canal cleaning crusades—that was evident at Dau Tieng.

4.23 At Kinda and Kimmundaung in Myanmar, the two sites with permanent water shortage, the Irrigation Department backed up by the State Agriculture Supervisory Committees and the Village Tract Law and Order Restoration Committees imposes a rationing system that guarantees supply to the majority of farmers but cuts off the rest and seemingly cannot be subverted. Annex B suggests that this example of heavy-handed hierarchical behavior is—at least on irrigation schemes—the manifestation of conventional rural social order dating back to the Burmese dynasties. Unlike Vietnam, the WUG in Myanmar do represent the farmers, but at these two sites, when water scarcity becomes critical the major decisions on water distribution have already been taken by the authorities and the WUG get involved only in local issues.

4.24 The only examples in the study of formal federated activity above the WUG level are in the assisted areas of Lam Pao, where the NEWMASIP team of local and international consultants, RID staff and local community assistants has been able to create a successful framework for collaborative farmer action along the secondaries. Similarly, some areas at Maeklong are distinguished by enlightened action by irrigators' cooperative associations embracing many WUGs. At Kinda, "watercourse" leaders along some of the "tertiaries" select one amongst themselves to take leadership along the whole of the tertiary. This arrangement has proven to be effective, especially on the longer canals of the old right bank scheme, and the first step toward formal association.
4.25 An interesting example of informal federated action is on the longer distributaries of the right main canal system at Kinda. There, WUG combine to protect mutual interests. Groups of WUGs on the lower half of the distributary contribute to a common fund to pay about 50 guards to police the upper half tertiary turnouts when these gates are supposed to be shut during the dry season on an upper/lower rotation. This illustrates the point made by participation experts that associations—and WUGs themselves—work best when all members share an objective that benefits everyone. Groups whose purpose is only to ration fixed water supplies among members, some of whom have advantaged positions, are harder to sustain.

4.26 In short, despite the relative youth of most of the groups on these schemes, their weakness vis à vis public authority, and the absence of federative associations, O&M performance by the farmers in keeping their parts of the scheme running has been rated satisfactory. This implies there are other viable organizational models for implementing plans for water allocation than improved WUGs. Farmers in this sample of schemes have proven themselves competent to assemble when necessary to take care of their canals irrespective of the maturity and independence of their "Group."

4.27 Corvee Labor. One other feature of the Myanmar cases that distinguishes them from the other schemes is the ability of the authorities to mobilize labor for campaigns for cleaning the larger canals. Annex B discusses the serious problem with weeding that has developed on the left main canal at Kinda with the proliferation of a hitherto insignificant weed species at that scheme. The masses of persons which ID has been able to muster without pay to assist in weed removal have enabled the agency to keep most of the left bank canals full of water. The example has broader interest to the study, since it supports the case for federating WUGs to tackle common problems. The Royal Irrigation Department in Thailand could not organize farmer participation at that scale without paying for services. Federated WUGs could.

D. Cost Recovery

4.28 Cost recovery plays a minor role in the study domain. In Thailand, the government, despite decades of discussion and agreements with the World Bank and Asian Development Bank to impose water charges on irrigators, continues to operate a "free water" policy. Farmers at Lam Pao and Maeklong presently pay nothing for the use of water and, at Lam Pao, nothing for the facilities. Elsewhere in Thailand, where the irrigators were part of a land consolidation scheme that reorganized farm boundaries in order to install an intensive network of canals, the farmers do pay for part of the capital costs. That is not the case at Lam Pao. The Maeklong right bank project was constructed after less intensive consolidation and the farmers there pay a smaller capital charge.

4.29 In Myanmar, the irrigators pay both a water tax and a land tax based on acreage farmed. The land tax is paid by all farmers. However, the rates of both taxes are so low as to serve little purpose in revenue generation and no purpose in water rationing. At present farmers pay the equivalent of $10 and $2.50 per acre per year for the water and land taxes. Government argued and the Bank accepted that a compulsory crop requisition program at prices lower than the market served the purpose of cost recovery. Nevertheless, there is no direct relation between the tax implicit in the crop requisition program and the costs of the irrigation scheme—the link the two Banks had intended.
4.30 At Dau Tieng, as in all Vietnam, farmers are obliged to pay for contracts with the irrigation authorities for water promised and delivered. In principle all irrigators sign contracts. But because the two provincial irrigation companies operative at Dau Tieng cannot guarantee delivery, because the WUG are seen more as tax collectors than farmer representatives and have no moral authority over members, and because many farmers are still not connected to the tertiary grid, the majority of water users pay nothing. Only 15,000 ha out of 45,000 ha benefiting from scheme water were covered by contract in the dry season of 1995/96. Note that the contracts pay for water received. Farmers are not required to repay capital costs at Dau Tieng.

E. Comparisons with Flood Control

4.31 Review of O&M conditions on two Bangladesh flood control subprojects reveals several interesting differences between FCD and gravity irrigation investments. These differences may be country specific (para. 6.2). Some informants in Bangladesh claimed that the strong patron/client relationship that exists at all levels of society has conditioned farmers to wait for government intervention. However, the nature of the findings suggests a wider relevance.

4.32 First, maintenance standards and performance by the agency and the farmers are lower than on the irrigation schemes covered by the study. As pointed out above (para. 4.25), irrigating farmers gather more readily if the objectives are shared by all. Proper maintenance of the regulators, sluices, drains and embankments on FCD polder schemes usually benefits all members. Yet collective farmer action does not materialize. This may be because the benefits of cooperation are less tangible and certain. They are reaped only when floods appear and they are not equally shared. In such circumstances, hierarchy must fill the void left by inadequate participation.

4.33 Unfortunately, the Bangladesh Water Development Board has until very recently made no effort to organize farmer groups to provide maintenance. BWDB does organize WUGs on the irrigation schemes it builds and manages. But on its FCD schemes, which are much more numerous than its irrigation schemes, it has ignored the potential of farmer institutions. A technical assistance team working under the umbrella of the on-going, Bank-supported, Systems Rehabilitation Project, has initiated farmer group formation for O&M on pilot schemes included for rehabilitation, with very good results. Elsewhere on polder schemes, such groups do not exist. In the other three countries, with gravity-fed irrigation, the groups have varying levels of effectiveness but exist everywhere. The Bangladesh experience provides a good demonstration of unsatisfactory O&M in the absence of both formal farmer participation and of effective public sector management.

4.34 Finally, where irrigation inlets are installed in the FCD embankments at the Satla Bagda polder, groups have not formed spontaneously to organize the sharing of the irrigation waters. In this case, however, opening the inlets to help the headenders causes flooding on the lower reaches. This is the opposite of the typical headender problem in an irrigation scheme, where tailenders are deprived. But the outcome is much the same: winners and losers cannot be expected to come together to protect a public asset. And when gains of headenders lead to actual losses by tailenders, the investment is not used or may even be destroyed even though "on the average" it is a productive asset.
5. **Agro-Economic Impacts**

5.1 Annexes A, B and C compare appraised and actual irrigated areas, cropping intensities, cropping patterns, yields and incremental production on the six gravity schemes in three countries. They estimate the representative irrigator's incremental and total financial income from the irrigated fields, to assess the benefits to the farm families from participation. They also recompute economic rates of return (ERR) based on the appraisal models to determine any shortfall from original projections. The Staff Appraisal Report (SAR) and impact ERR reestimates are limited to the costs associated with the Bank's projects. They do not purport to represent in all cases returns to investments in the entire scheme, including the attributable costs of headworks and reservoirs which the Bank did not finance under the projects. The following paragraphs summarize the discussions of each of these factors.

5.2 The prevailing cropping pattern is paddy, and there is a substantial correspondence between the case studies. The sample of six schemes presents a consistent pattern for most factors, so that a "story" of paddy-based irrigation schemes in the humid tropics of Southeast Asia emerges.

A. **Agricultural Impacts**

5.3 **Irrigated Area.** At four of the six schemes the area supplied by the irrigation system is significantly less than the design area (Table 5.1). Both Kinda and Kinmundaung suffer from a substantial shortage in rainfall over the last decade. But, the record also points to over-optimism at design about inflows to the reservoirs. The projections were particularly off the mark at Kinmundaung, where the actual area supplied is half that planned. Dau Tieng and Maeklong fall short for other reasons. At Dau Tieng, construction of the tertiary network has stalled and the area effectively watered is 63 percent of the design area. On the Maeklong right bank, 20,000 ha out of the 66,000 ha targeted for the "consolidation" program were denied project investments after the farmers voted against it. A substantial part of the "no" vote area receives water now, but without guarantee, and only from the older distributaries by field-to-field flooding or pumping. They are not included in RID scheme estimates. Another 6,000 ha were dropped from the irrigation program altogether, for other reasons, and receive no water.

30. This omission affects the two Thailand schemes, for which the costs of the storage dams are excluded, the water supply at the scheme headworks is not costed, and the ERRs are therefore inflated. The Bank does not have data on the costs of the dam at Lam Pao.
Table 5.1: Irrigation Area, Intensity, Yields and Production

<table>
<thead>
<tr>
<th></th>
<th>Area</th>
<th>Intensity*</th>
<th>Yields</th>
<th>Production^</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SAR</td>
<td>OED</td>
<td>SAR</td>
<td>OED</td>
<td>Wet</td>
</tr>
<tr>
<td></td>
<td>ha</td>
<td>%</td>
<td>%</td>
<td>tons/ha</td>
<td>SAR</td>
</tr>
<tr>
<td>Thailand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lam Pao</td>
<td>49,000</td>
<td>49,500</td>
<td>160</td>
<td>150</td>
<td>3.8</td>
</tr>
<tr>
<td>Maeklong</td>
<td>66,000</td>
<td>39,500</td>
<td>200</td>
<td>160</td>
<td>3.5</td>
</tr>
<tr>
<td>Myanmar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kinda</td>
<td>79,000</td>
<td>71,000</td>
<td>160</td>
<td>117</td>
<td>4.0</td>
</tr>
<tr>
<td>Kimmundaung</td>
<td>2,000</td>
<td>1,000</td>
<td>150</td>
<td>122</td>
<td>4.2</td>
</tr>
<tr>
<td>Azin</td>
<td>1,150</td>
<td>1,150</td>
<td>100</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>Vietnam</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dau Tieng</td>
<td>72,000</td>
<td>45,000</td>
<td>226</td>
<td>250</td>
<td>3.8</td>
</tr>
</tbody>
</table>

a. Using actual command area as denominator
b. Paddy yields: averages for wet and dry season
c. Tons of paddy production, or paddy plus weighted paddy equivalents (see Annexes for Kinda and Dau Tieng). OED estimates of actuals as percentage of SAR projections. The Kinda estimates do not correspond to the other three columns because of shortfalls in nonpaddy crops.

Source: Annexes A-C

5.4 At all four sites the PCRs assumed that the design area would eventually be reached, and, again in all cases, before 1996. The impact review has had to sharply reduce those projections. Dau Tieng is the only site where it is reasonable to expect some further, though slow, expansion. However, as explained in Annex C, the current area irrigated of 45,000 ha is retained in the analysis of benefits.

5.5 Cropping Intensities. Intensities have also fallen substantially short of appraisal projections at three schemes (Table 5.1). At Dau Tieng, the smaller area effectively irrigated results in intensities that are higher than planned. Part of that good performance is attributable to unexpected, and increasing, recapture of water in fields distant from the canals. At Lam Pao, the cropping intensity came close to the SAR target of 160 percent, but has recently declined and some observers expect it to decline further. Azin is the only scheme which meets area and intensity targets.

5.6 Cropping Pattern. On almost all of the Maeklong right bank (the rest was in sugar), and in the Azin lowlands, paddy was expected to approach 100 percent of plantings in the dry as well as wet seasons. Elsewhere, paddy was expected to dominate both seasons only in the lowlands. In the sandier, better drained uplands under scheme command, even during the monsoon season, other traditional field crops like groundnuts, cotton and sesame predominated. Diversification into specialty crops such as chilies, watermelon and babycorn was also anticipated. 31

31. These were not best guesses: in most appraisal farm plans these nonpaddy crops were essential to the economic justification. They generally provided higher net margins and were needed to rescue the poor returns, calculated at appraisal, to most paddy plantings. For example, cotton was introduced in appraisal plans as a major crop on the left main canal at Kinda in order to bring the ERR well above ten percent. The Agriculture and Rural Development
5.7 Diversification out of paddy failed to occur at any scheme. In recent years there has been a tendency in recent years to increase the proportion dedicated to paddy. At Dau Tieng farmers have shifted from groundnuts to paddy; on the Maeklong right bank the few sugar growers have been uprooting the cane and substituting paddy; and at Kinda there has been a decline in the cotton area on the previously irrigated right main canal without any compensating cotton planting on the left main canal. At Kinmundaung, none of the expected 3,500 ha of dry season plantings were planned for paddy; in fact, of the approximately 500 ha that ID has managed to supply in the dry season, most of it has been assigned to farmers agreeing to plant paddy in support of government's rice export campaign.

5.8 **Yields.** Paddy yields are below projections at all but one site (Table 5.1). A weighted average based on scheme size was computed for the Overview, to provide a yield estimate representative of all the study sites. Compared to 3.86 tons/ha projected at appraisal, 3.34 tons/ha were actually reported, 85 percent of the expected yield. In two countries wet season yields were expected to and did exceed dry season yields; in Myanmar the reverse was true. Other crop yields are discussed in the annexes, in particular groundnuts in Dau Tieng (above SAR projections), and fruit at Azin (no reliable estimates yet, but the trees are maturing well).

5.9 **Production.** Table 5.1 also shows for the six sites the ratio of actual and appraised estimates of paddy production. In the cases of Dau Tieng and Kinda, production figures include paddy plus weighted paddy equivalents of other major crops. Except for Azin, the actuals are well below SAR values, reflecting the shortfalls from plans for either or both area commanded and intensities. For Kinda and Kinmundaung, the actuals are 40 percent or less of the appraisal figures. Some field crops and all specialty crops are not incorporated in the analysis, for lack of data.

B. Farmer Financial Benefits

5.10 The annexes give OED's estimates for most of the schemes of both incremental and total net incomes from the irrigated fields, based on the average size of the holdings. The analysis is cued to paddy, but, for Dau Tieng and Kinda, includes also paddy equivalents of some other irrigated crops. Specialty crops were again omitted from the analysis. Off-farm and non-farm incomes are excluded. Thus, the overall financial position of the family is not captured. Nevertheless, since for most farmers at all the sites paddy was and remains their basic economic activity, the analysis gives a good idea of the size of household earnings.

5.11 The table shows the total net income from irrigated paddy, not the incremental income over pre-project rainfed paddy income. This is done to emphasize the point that in most cases the paddy incomes are not only well below appraisal estimates but so low as to defeat one of the

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Department (AGR) at the Bank was suspicious of these introductions, especially the large scale of the plans in areas where the resident farmers were unfamiliar with the crops. But the introductions were made in the farm plans nevertheless.

32. This omission results in a more favorable comparison of actual achievements with appraisal projections, because the shortfall in production from the projections for these other crops was even larger than for paddy.

33. This means that farmers who have concentrated on chilies and watermelon at Lam Pao, for example, and may be benefiting substantially by occupying those market niches, are not represented in the analysis.
key, implicit objectives of the project, which was to create a viable, attractive household
economy that could compete with other job opportunities.

5.12 Table 5.2 summarizes the results of the analyses as presented in the annexes (the table is
supported by Appendix 1 to the Overview). Per hectare as well as full-size farm incomes are
shown, since the average holdings vary by site. They range between one hectare at Dau Tieng
and 3.5 hectares at Maeklong. The table also shows SAR estimates of family incomes from
irrigated farming, on farms of comparable size to OED average-size farms for each site. The
SAR estimates have been inflated to 1995 financial prices, expressed in dollars.

<table>
<thead>
<tr>
<th>Country</th>
<th>Farm</th>
<th>Hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thailand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lam Pao</td>
<td>2,055</td>
<td>590</td>
</tr>
<tr>
<td>Maeklong</td>
<td>6,100</td>
<td>1,750</td>
</tr>
<tr>
<td>Myanmar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kindaa</td>
<td>2,965</td>
<td>2,010</td>
</tr>
<tr>
<td>Kinmundaung</td>
<td>1,975</td>
<td>670</td>
</tr>
<tr>
<td>Azin</td>
<td>1,320</td>
<td>1,580</td>
</tr>
<tr>
<td>Vietnam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dau Tieng</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lowland</td>
<td>5,645</td>
<td>570</td>
</tr>
<tr>
<td>upland</td>
<td>5,875</td>
<td>1,050^c</td>
</tr>
</tbody>
</table>

a. Paddy and paddy equivalents.
b. Paddy and paddy equivalents.
c. Incremental, not total farm income. The difference is small.

Source: Appendix 1

5.13 At both sites in Thailand, households presently earn from their irrigated plots only about
a third of the projected incomes, including home consumption valued at farm gate prices.\(^{34}\) The
SAR projected a net family income of about US$2,000 for a two ha diversified farm; OED
estimates the typical 2.2 hectare family is netting a little less than US$600. Annex A discusses
the implications—of these low earnings at Lam Pao—for the stability of that farming system. It
describes the elements of the rapidly industrializing Thai economy that cause the so-called "push
and pull" forces prompting family members to abandon dry season cropping, or farming
altogether, and look for other employment.

5.14 For Kinda, Table 5.2 shows a net income of about $3,000 at appraised for a two hectare
farm, and an actual average of $2,000 for a three hectare farm. That ratio, about two-thirds of
expectations, holds for Kinmundaung as well. At Azin, farm incomes are now reckoned to
exceed SAR projections by about 20 percent. Thus, compared to Thailand and Vietnam,
Myanmar incomes are closer to expectations. That is mostly because appraisal expectations

\(^{34}\) Assuming per capita annual consumption of 250 kg of rice in Southeast Asia, a household of six persons would
withhold 2.5 tons of paddy (the equivalent of 1.5 tons of rice) each year. See Mitchell, Donald O., and Merlinda D.
were less ambitious. But it is also due to price relationships. Per hectare incomes in Myanmar exceed those in the other two countries, a reflection of the relatively favorable farm gate rice prices, and input/output price structure.

5.15 The most dramatic differential is at Dau Tieng, where the present one hectare, irrigated, paddy farmer earns a net income of less than 10 percent the amount projected at appraisal (for a two hectare rainfed farmer entering one of the proposed 150 ha cooperatives). This result is due to a number of factors—inflated appraisal projections being the most important. The appraisal report for a new Bank-supported irrigation project for Vietnam, of which one component will complete another scheme on the Saigon River 30 km downriver from the tailend of the Dau Tieng scheme, has departed radically from the inflated coefficients of the 1978 SAR for Dau Tieng. It projects average incremental earnings on one hectare of $400 per family, roughly the same as OED's ex-post calculation (see Annex C, Appendix 3). The push and pull forces in southern Vietnam are weaker than in Northeast Thailand. But at these low family earnings industrialization is likely to be as much a threat to the sustainability of irrigation schemes on the Saigon River as it is at Lam Pao—unless the value added on the scheme can be substantially increased.

5.16 These financial analyses are based on 1995 farmgate prices of paddy and other important crops quoted by agricultural and irrigation staff. Thus differences in family incomes emerge in part both because of varying physical performance and because of different levels of real farmgate prices. OED estimated some comparator price ratios, to see whether there were indeed substantial differences in the level at which the local economy rewarded its paddy producers. In particular, the ratios of the paddy price per ton to the costs of (a) a ton of urea and (b) the average daily wage for field labor were computed. The variation in the ratio of output to input prices across the three countries is one indicator of the incentives facing the progressive paddy planter. The real rural wage is so different in the three economies that the paddy/wage price ratio is certain to have a different impact on farmer decisions to plant different crops, to recruit labor, or to find work off their own farms. Table 5.3 show that the ratios are significantly higher for Myanmar than for Vietnam and Thailand. This finding is consistent with Myanmar's superior position in net paddy incomes shown in Table 5.2.

<table>
<thead>
<tr>
<th></th>
<th>Paddy/Urea</th>
<th>Paddy/Wage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thailand</td>
<td>.51</td>
<td>39/1</td>
</tr>
<tr>
<td>Myanmar</td>
<td>.82</td>
<td>263/1</td>
</tr>
<tr>
<td>Vietnam</td>
<td>.49</td>
<td>110/1</td>
</tr>
</tbody>
</table>

Source: Annexes A-C

C. Economic Rates of Return

5.17 The reestimated ERRs for all six schemes are low and, in one case, negative. Five of them are affected by both the decline in the international price of rice, since the period in the late 1970s and early 1980s when the appraisal farm plans were prepared (Figure 5.1), and lower than expected production (except at Azin).

35. Average daily wages in 1995 in the vicinity of Lam Pao/Thailand, Kinda/Myanmar, and Dau Tieng/Vietnam were US$3.75, $.50, and $1.20.
5.18 Table 5.4 compares actual and appraisal estimates. Actual figures not only fall short of SAR projections by substantial margins, but are all well below ten percent. Kinmundaung's ERR is below zero because the project could not supply half its design command area.

5.19 The rice-price decline is illustrated in Figure 5.1. It shows that forecasts throughout the period of these five project appraisals (the SARs are dated 1978-82) were all to be proven overly-optimistic, the first major jolt hitting in that last year 1982. The 1980 projections and 1995 mid-year estimates for the 1995 rice price (both in 1990 dollars) are in the ratio of exactly three-to-one. By 1987, not only the rice price projections had bottomed but the optimism had disappeared.

Table 5.4 Economic Rates of Return

<table>
<thead>
<tr>
<th></th>
<th>SAR</th>
<th>PCR</th>
<th>OED Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thailand</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lam Pao</td>
<td>26.0</td>
<td>12.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Maeklong</td>
<td>35.0</td>
<td>8.2</td>
<td>3.6</td>
</tr>
<tr>
<td>Myanmar</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Kinda</td>
<td>21.3</td>
<td>14.0</td>
<td>7.4</td>
</tr>
<tr>
<td>Kinmundaung</td>
<td>13.6</td>
<td>12.3</td>
<td>Neg</td>
</tr>
<tr>
<td>Azin</td>
<td>12.3</td>
<td>7.3</td>
<td>6.0</td>
</tr>
<tr>
<td>Vietnam</td>
<td></td>
<td></td>
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<tr>
<td>Dau Tieng</td>
<td>17.0</td>
<td>4.9</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Notes:
- Lam Pao: Stages I and II Consolidated
- Maeklong: Right Bank (Irrigation XI)
- Kinda: Includes power component (24% of actual project costs).
- Azin: Includes Mudon town water supply (28% of actual subproject costs).
- Dau Tieng: Stage I. The PCR text says 4%, the PCR table produces 4.9%.

Source: Annexes A-C.

5.20 There has been a small upturn starting at the end of 1995, but not enough to rescue the economic rating of the original investments. The Bank's end-of-year 1995 rice price projection is 17 percent above the 1995 price projected at the beginning of the year. The Bank's Commodity Price and Analysis Unit expects that rise in the profile to settle back within two years, to a level only about 2 percent above the earlier long term projection.

5.21 The viability of most of these investments was profoundly damaged—twice. The declines in production and prices were each enough to drive the ERRs to low levels. For example, for Dau Tieng the PAR (issued in 1991) showed that substituting the SAR rice prices for actual prices lifted the ERR reestimated for the PCR from five percent to only six percent.

36. The ERR reestimates are not based on a full reconstruction of the project costs, farm models and price relationships. Instead, they use the ERR structure presented either in the SAR (Myanmar), PCR (Dau Tieng) or Impact Evaluation Report (Lam Pao). Where power (Kinda) and water supply (Azin) components were included in the projects, PCR reestimates for these components were retained. The basic procedure, spelled out in the three Annexes, was to adjust the cost and benefit streams by known changes in the values of the major variables in the analysis, such as areas, yields, costs, etc.

37. For example, the Kinda projection, made in 1980, for rice prices in 1990 and thereafter, converted to 1990 dollars, is US$700/ton. The actual mid-year 1995 price, also in 1990 dollars, is US$237/ton.
International Rice Prices: Actuals and Bank Forecasts

- Actuals
- Forecasts

Year

1990 US $/mt
0 100 200 300 400 500 600 800 1000 1200 1400
Substituting the SAR production projections for actual production, while retaining actual rice prices, lifts the PCR’s from 5 percent to 8 percent. The undiluted effect of the rice-price decline is suggested by the Azin estimates, where the ERR has slipped from 12.3 percent at appraisal to 6 percent in 1995 despite good performance in production. The implications of these low ERRs for the sustainability of this sample of paddy irrigation projects is a subject addressed in Chapter 7.
6. Influence of O&M Performance on Agro-Economic Impacts

6.1 This study of a group of six irrigation schemes does not reveal any substantial, area-wide, negative constraint on irrigated production attributable to poor performance in O&M, by either the agencies or the irrigators. It was the assumption that such a relationship did exist that prompted the study in the first place: to identify the problem and try to explain it. As indicated in Chapter 2, the literature on degrading structures under public ownership in developing countries is impressive. It suggests that in many countries, or at least in many irrigation schemes, the record is worse.

6.2 The only serious examples of degraded structures that depressed production were found in the two flood control polders in Bangladesh, where the O&M standards of the public authority are inadequate, the beneficiaries behind the embankments do not participate in O&M, and the rate of decay of the physical structures is visible and alarming (Annex D). Inadequate maintenance reduces the effectiveness of the regulators and drainage sluices penetrating the embankments at Chalan Beel and Satla Bagda, resulting in a negative impact on farms located in the shadow of these structures because of reduced drainage and flood congestion. Inadequate cleaning of the natural drains traversing the polders has the same effect. The loss in integrity of the embankments themselves increases the risk of a breach or larger failure with advancing age or another overwhelming flood. But this singular experience for Bangladesh does not provide any basis from which to generalize to the rest of the study area.

6.3 The favorable judgment on O&M in the study sample can be defended on each of the four components analyzed in the study: Operation and Maintenance considered separately for the Agencies and the Irrigators. That two by two matrix has the following elements:

6.4 Agency Operations. Public agency operational plans and performance for the reservoirs, and for water distribution through the main and distributary canals, are at each site acceptable. This judgment is based on the area under effective command: it does not penalize present performance for over-dimensioning the schemes at inception. The failure to adopt the demanding technical standards of WASAM and other sophisticated measurement/allocation protocols also does not reverse the conclusion. The one area of weakness is in enforcing irrigator-organized rotations through the tertiary turnouts, mentioned below.

6.5 Agency Maintenance. Maintenance performance on the dams, major canals, regulating structures and gates down to but not including the tertiary turnouts is also judged to be adequate at all six sites—the most impressive finding of the review. This judgment is necessarily based on a limited number of observations at each scheme, but the consistency of the observations was clear. Despite low budgets in all three countries, the engineers and their field staffs appear to be keeping up with minimum requirements. The exception is the silt and weed problems that have overwhelmed the agencies at certain stretches of the main and primary distributaries at Dau Tieng, Lam Pao, Maeklong and Kinda. The agencies are attacking these problems: there is no evidence of indifference or lack of concern. But the down-time for desilting and deweeding in the middle of the irrigation season is not costless, and the agencies have yet to find methods to gain control within limited budgets. The blockages do have an impact on downstream water supplies, but, given the prevailing condition of surplus at three of these four sites, the effect on
production is small. The Kinda left main canal weed problem is especially severe, but low flows through that canal are determined by water shortage at the reservoir and do not result in a net loss to irrigation.

6.6 Irrigator Maintenance. Irrigator performance varies according to whether one is examining the channels or gates. There is no evidence that irrigators fail to keep their supply canals (tertaries, watercourses, ditches) open when they need water. Formal and informal, group and individual action is taken as necessary to permit adequate flow. Although tailenders would appear to contribute more time to the tertaries and watercourses than headenders—as expected, since they benefit more than the headenders—the local rules and controls function well enough and headenders do join the groups. This cooperative response to requirements for cleaning and minor repair is combined with significant rent-seeking behavior in exploiting access to water. Larger, expensive repairs to the canals are less easily handled, but in such cases the public agencies usually intervene.

6.7 The major problem is with irrigator maintenance of the gates. But, as mentioned above and discussed next, this is not a result of a failure, but an unwillingness, to maintain. It is a reflection of operational decisions, not of ignorance or indifference to keeping beneficial physical assets in working condition.

6.8 Irrigator Operations. This is where the main problems of O&M performance are concentrated: the irrigators' behavior in regulating and/or assisting with the allocation and distribution of water made available by the agencies in the secondary distributaries for the channels below the tertiary turnouts. Farmer organized rotations have not worked well, even in periods of water stress when they are most needed to ensure equitable access. The stronger WUGs, for example the ones assisted by NEWMASIP, have a better record in preventing overuse by headenders. But a pattern of abuse reappears at five of the six sites—Azin excepted—and it does not seem to matter whether the overall scheme water supply is plentiful or scarce.

6.9 However, the issue is not whether the rotations do not work but whether that failure reduces total production. The equity question should be set aside. At all five sites, there is no compelling evidence that the failure to arrange rotations that allocate available supplies according to proportional requirements of the cropping systems on each farm, or proportional to land holdings, or in equal amounts per family, have reduced scheme-wise production to a substantial degree. The most interesting case is Dau Tieng, where headender extravagance is widely admitted but the tailenders are compensated by their ability to recapture drainage and the level of complaint is low. At Lam Pao, overall supplies are adequate to serve most tailenders as well as "overusing" headenders. There are exceptions, but these are pockets with special geographic or topographical limitations and have little influence on overall system performance. At Maeklong, the exceptions and complaints are even fewer. At all three schemes in Vietnam and Thailand, yields reported by farmers and agency staff on tailender paddy fields are almost the same and in one case higher than on headender fields, strong evidence that the water is getting through despite the failure of formal rotations. In Vietnam this applies even to tailenders without access to groundwater.

6.10 The two water deficit schemes in Myanmar also fail to demonstrate that the absence of farmer-controlled rotations has placed a significant constraint on production. At Kinda and Kinmundaung, water rationing imposed by ID has substituted for farmer rotations in periods of
water stress. The agency limits available supplies to sections on the upper reaches of the schemes for which ID has determined supplies are adequate. The study sample does not include cases representing behavior and impacts, under conditions of severe stress, where the agency has been unwilling or unable to impose a solution and permitted anarchy to reign at and below the tertiary turnouts. Even if it had, whether the free-for-all would diminish total production is not at all certain.

6.11 What is probable is that the cultivation of paddy by headenders and tailenders alike, in the uplands as well as the lowlands, uses more water than financial or economic conditions can justify in relation to alternatives. This is the first and only one of the six plausible "patterns of suboptimal O&M behavior" listed in para. 2.21 which OED confirmed in the field. If the headenders at Dau Tieng, on the left main canal at Kinda, or the favored blocks on the right canal at Kinmundaung could be induced to diversify away from paddy in the dry season, larger areas of other field crops could be irrigated instead, with a potentially large positive effect on the value of total production.38 A partial exception is Lam Pao, where soils are marginal and the yields of most other field crops are low. Thus, the economics of O&M may be inextricably linked to the prospects for diversification.

6.12 In short, none of the four elements in the matrix of O&M show a pattern of poor performance which results in major and sustained losses of production. There is even a possibility that the imposition of planned rotations, especially if they enforced equal allocations, would have a detrimental effect. Such sharing of water among all farms within the design command areas of Kinda and Kinmundaung would certainly do so. Reducing the flows to headenders at Dau Tieng would not mean that the savings would automatically go to tailenders. Because of canal configurations, some of those savings would flow to the end of the main canals and distributaries and be lost to the scheme altogether.39 Discharges from the Maeklong main canals limited by the WASAM formulas to strict requirements of standing crops would have the same effect: water would pass through the mains to the end of the scheme.

6.13 The very concept of headender "waste" can be challenged. First, because "overuse" of water defined in terms of an excess over the standing crop evapo-transpiration requirements ignores the other legitimate reasons for flooding paddy, especially weed control and thus reduced labor costs. Second because water "overused" at the headend may reappear lower in the scheme or basin and thus not be wasted.

38. Unless rice prices rise to the levels expected, in the late 1970s, for the mid 1980s (see Figure 5.1).
39. Though not to the river basin as a whole.
7. Findings and Recommendations

A. Findings

7.1 The findings were unexpected. The intention had been to determine whether lower than desirable standards of O&M performance—which was an operating hypothesis driving the study—had had an appreciable effect in also driving benefits downward, and thus jeopardizing farmers' incomes as well as investment rates of return. That scenario is upset by three prominent findings: that O&M performance is better than expected, that weaknesses in O&M have had no appreciable impact on production to date, and that the financial and economic impacts have been seriously eroded by shortfalls in production and prices, such that the sustainability of these schemes is jeopardized by factors that have nothing to do with O&M.

7.2 In fact as these schemes evolve O&M is likely to be the dependent variable. The sustainability of O&M performance will depend more on improved scheme returns arising out of diversification than those returns depend on O&M. That may already be the situation in Thailand.

7.3 The six irrigation schemes display similar patterns of O&M behavior and irrigation impact in Southeast Asia. Although representativeness across the region cannot be assumed, the fact that the patterns are relatively uniform across the sample suggests the lessons have broader applications.

1. Operation and Maintenance

7.4 O&M performance by the public agencies managing the schemes is at least adequate and in some cases good. The knowledge and hands-on involvement of field engineers from the two provincial irrigation services at Dau Tieng, the aggressive reforms promoted by the Royal Irrigation Department's new project manager at Lam Pao, backed up by a European Community technical assistance team, and the intelligent management of scarce supplies by the Irrigation Department at Kinda, are impressive. Weed control in the mains and distributaries falls short of optimal effectiveness, but the authorities are aware of this problem and struggling to overcome it. Low budgets prevent the massive use of hired labor. Since cooperative behavior already ensures a modicum of maintenance when most needed, further progress can be expected as associational efforts bear fruit.

7.5 In Thailand and Myanmar the agencies did not adopt the high-tech water measurement and allocation program (WASAM) promoted by consultants. Also, an unfamiliar overshot gate requiring excellent controls upstream (romijn gate) introduced at Maeklong on a pilot basis was not used elsewhere. The demand on agency staff and irrigators for data collection, calibration of devices and control of flows proved to be beyond their capabilities and interests. With hindsight the outcome appears to have been inevitable, raising a question about the realism of the foreign consultants' plans and the Bank's support for them. These experiences give the impression of donors and technical assistance teams using the region as a testing ground to try out new designs, with encouragement from agency headquarters, without a realistic assessment of local management capacities or irrigator incentives. Especially in an age when governments are reducing their involvement in irrigation management, more consideration should be placed on
technologies which require little management attention. WASAM has been scaled back at Lam Pao in an attempt to reorganize around the manageable components—an attempt that appears to be succeeding.

7.6 Sophisticated water delivery systems that depend on centralized calculations of irrigation targets based on an assessment of crop water requirements, as reported in Thailand, tend to lack complete information to derive accurate targets. The information which is most often lacking or inaccurate is data about variable seepage and percolation, return flows, alternative water sources for some blocks, spatially variable rainfall, and variations in plant requirements at different stages of growth. Where such unaccounted factors render irrigation targets unacceptably inaccurate, water distribution is made on the basis of qualitative judgments by field staff or interference by farmers. This makes the water delivery system uncertain and hampers the ability to monitor actual distribution performance. The best becomes the enemy of the good.

7.7 There is a tendency for foreign experts to recommend control structures designed for stable water levels in environments where frequent fluctuations of discharge at the intake are amplified down through the irrigation system as water passes more and more adjustable gates. The gates do not function as intended. This was the case at Maeklong, where WASAM was mounted in combination with the romijn gates, to the detriment of both.

7.8 There is no evidence at the six sites that the quality of original construction was so poor as to frustrate subsequent maintenance programs. There were design engineering errors, especially at Dau Tieng. But many were spotted and corrected before construction and the rest are being dealt with gradually. Some of the original works at Lam Pao suggest that initial construction was of low quality, but the agency and two consecutive technical assistance teams have been busy "rehabilitating" them.

7.9 O&M performance by the irrigators can be evaluated at two levels. Assessed against engineering design, it rates poorly. The irrigators demonstrate a willingness and capacity everywhere to keep the channels below the tertiary turnout clean enough, and in a good enough state of repair, to keep the water supplies moving. But they have allowed the calibrated gated structures—essential to measure discharges under controlled delivery—to degenerate, opting instead for unobstructed flow. But, assessed against the irrigators' collective self-interest, irrigation system performance is high. The tendency to destructive anarchy reported in the literature was not evident in this sample of schemes. The degeneration of the gates below the distributaries on these schemes is not the result of poor maintenance standards, but of operational decisions to let that function lapse. This is the case also in Bangladesh, where limited use of structures is related to their utter lack of social feasibility.

7.10 Social pressures along the channels within a tertiary system appear in this sample sufficiently effective to guarantee the headenders' participation in canal cleaning, and prevent them from exploiting their advantageous locations for abstracting water excessively. Farmers complained at all schemes (except Azin) about abuse, but the complaints were usually not the sort to hint at violence. The fact that four of the six schemes were water abundant means that most farmers along the watercourses were benefiting from the projects, and explains why they tolerate the absence of gates and rotations above their own turnouts. For the two schemes suffering from water scarcity, both in Myanmar, the agency steps in when necessary to enforce rationing.
7.11 Water distribution has been relatively fair, avoiding serious dispute within the tertiary systems. This is reflected in paddy yields which do not seem to have been affected by lack of rotation. Yields at the tail are everywhere reported to be at least close to if not equal to or above those at the head, even where groundwater is not available. Other evidence that water management is working rather well are the high water-use efficiency ratings calculated by OED for the three major schemes—the two stages at Lam Pao (dry season only), both the right and left main canals at Kinda, and the east main canal at Dau Tieng. In that order the ratings are 43, 52 and 44 percent. These are good scores. The IFPRI report referred to in para. 2.18 says, "water use efficiency in surface irrigation schemes in developing Asia in many (if not most) cases vary between 25 and 40 percent."  

7.12 Several types of water user associations with differential effectiveness are included in the sample. At Dau Tieng the WUGs are little more than extensions of the provincial agencies and participation is low. At the other extreme, the associations sponsored by the consultants at Lam Pao are fully participative and increasingly effective. There and at other sites there is evidence that WUGs with broad participation and strong leadership enhance the efficiency of water distribution and use, and that weak WUGs are associated with poorer O&M performance. The unassisted associations at Lam Pao are examples of the latter.

7.13 But weak WUGs do not always condemn schemes to inefficiency. Intelligent interventions by public agencies to ration water according to availability, combined with cooperative action by farmers everywhere, inside or outside formal associations, to keep the channels open, compensate for relatively ineffective associations. Dau Tieng and the left main canal at Kinda are examples of two different approaches to effective government intervention: in the first by provincial irrigation authorities exercising full control, and in the second by a national irrigation agencies backed up by formidable local offices of central government.

7.14 The study shows that equitable treatment is less evident on the longer tertiaries and among tertiary systems on the same distributary. Headend command areas, rather than headend farmers, present the greatest challenge to fair distribution. At this level associations and formal federations of primary WUGs can make a substantial difference. It is interesting that at Lam Pao, as the associations of WUGs sharing the same secondary canals gain strength, the functions and prominence of the watercourse WUGs themselves tend to diminish. This is predictable, because once the association of WUG leaders has determined an appropriate water-sharing formula, or cleaning schedule, meetings at the lower level can be dispensed with. In the study, "turnover" of O&M responsibility from the agencies to the irrigators in coming years will have to focus in coming years on these systems of tertiaries. At the Vietnam and Myanmar sites, irrigators already have responsibility for the tertiaries, but turnover of higher-level systems is not yet under discussion.

7.15 Governments should encourage WUGs and their associations to become farmer organizations with broader mandates than irrigation O&M. Such organizations require a wider base of financing and a broader set of services in order to induce the farmers to support the organization—than can be done within a sole focus on O&M. The WUG has to be seen by members to offer "collective goods" otherwise inaccessible. Where a dependable supply of water at the tertiary turnout is provided regardless of WUG activity, participation is less likely to flourish.

7.16 There is a tendency—best illustrated at Dau Tieng—for foreign experts to first design and construct irrigation systems, for donors and governments to finance them, and only then for attempts to be made to try to organize farmers to assist with tertiary development. Experience elsewhere confirms that this is an ineffective way to organize farmers to take over responsibility for financing and developing tertiary networks, or managing irrigation, and leaves farmers without a sense of ownership or responsibility for the system. Farmers should be organized first, or at least brought into the design and implementation processes, and then persuaded to enter into agreements for partial financing, approval of designs, participation in construction, and management after completion of the construction project.

7.17 Failure of government to involve farmers in design have had disastrous consequences in Bangladesh. Similar consequences are seen at Dau Tieng. First, the development of the tertiary systems by the provincial authorities has practically stalled and there is no organized protest group representing those farmers who remain unserved to put pressure on the agencies to complete the job, to persuade village authorities to cede land essential for water passage, or to take over construction. Second, farmers in advantageous locations get early access to irrigation giving them the perception of an abundant supply. Though they gain important experience with irrigated agriculture, it is based on an unrealistic supply situation. This fosters habits, perceptions, and relations with officials that have hindered expansion of the irrigated area.

(2) Agro-Economic Impacts

7.18 Command areas and/or cropping intensities are well below appraisal projections at five of the six schemes. The exception is Azin, at 1,000 ha the smallest scheme. Paddy yields are also below projections, at five of the schemes, but only by a factor of about 15 percent on average for monsoon and dry seasons taken together. While continued improvements can be expected, the interval between project completion and this study corresponds to the interval before "full development" in appraisal terminology and thus the comparisons of estimates at impact with projections at appraisal are valid. Total production falls commensurably with areas, intensities and yields. For Lam Pao, Kinda and Dau Tieng actual production of paddy (and paddy equivalents of groundnut and other field crops) are, in that order, 73, 36 and 47 percent of SAR projections.

7.19 Production losses are compounded in the economic analysis by the collapse in the price of rice since the early 1980s, after of all these projects had been appraised. In constant prices, the price of rice in 1995 was two-thirds below the price projected in 1980. The decline in the rice price could have been more easily absorbed if farmers had adopted the diversified cropping pattern planned for four of the schemes. Instead, they grew more paddy. Table 5.4 shows the recomputed economic rates of return for the six Bank-supported components of the schemes. They all are below eight percent, and one is negative.

7.20 Thus, by Bank standards, guided by opportunity costs, these have been uneconomic investments. The main explanation is the smaller than projected increase in value added. Even if the 1980 projections of the rice price had been realized, a combination of lower than expected...
production and lack of diversification have undermined the economic viability of the investments.

7.21 For the borrowers, however, ERRs between 4 and 7 percent are acceptable given the visible signs of substantial improvements in intensification and yields over large areas previously rainfed, and the external regional and social benefits of the investments not captured by rate of return estimates. The governments are satisfied that the projects are successful, with the possible exception of Kinnundaung, and are clearly committed to sustaining all of them.

7.22 The most serious threat to all the schemes comes from their modest impact on projected family income. Net household incomes from irrigation on the average-size farms are shown in Table 5.2 to range from about US$600 to US$2,000, depending on the size of the farm, local market prices for paddy, and the extent of diversification out of paddy. The farms in the poorly drained lowlands constrained to a paddy-paddy rotation have net incomes at the lower end of that range. Such incomes may not be attractive enough to keep the families, and especially the youth, committed to farming. The industrialization of the Thai economy and the modernization of its society are straining the motives and reducing the incentives for people to stay on their two-to-four hectare holdings, at Lam Pao as well as Maeklong. Dau Tieng has so far not been subjected to push-pull forces of the same intensity, but as the Ho Chi Minh City economic pole continues to expand, the irrigators on this scheme will also start to migrate. Economic conditions in Myanmar are less advanced than in the other two countries, and, without alternative employment, the present irrigators must accept whatever their farms can provide. Their position is eased by the fact that input/output price ratios are more favorable than in the other two countries.

7.23 What is the future of these paddy-based irrigation schemes in Southeast Asia supported by stored water? Do new starts, or even the rehabilitation of old schemes, make sense? The answers depend mainly on whether the country exports or imports rice and is likely to continue to do so. There is more justification for importing countries to encourage production, provided costs are relatively low. There is less justification for exporting countries to continue to promote paddy farming. The objective must be to diversify the irrigated farms away from double cropped-paddy. Thailand is the largest rice exporter in the world. The NEWMASIP team in Northeast Thailand has concluded that only the most basic expenditures on rehabilitation at Lam Pao, cutting back on costs of institutional development, can be justified economically as long as paddy predominates. The relation between low paddy prices and rising wages (see Table 5.3) suggests the trend is irreversible. NEWMASIP maintains that only after a major shift in farm activity toward integrated, high value cropping systems can household enterprises achieve incomes competitive with nonfarm employment. Myanmar and Vietnam are also rice exporters, and face the same adverse output/input price trends as Thailand in the near (Dau Tieng) and far (Myanmar) future.

(3) Relationship Between O&M and Impacts

7.24 As discussed in Chapter 6, no significant negative influence of suboptimal O&M performance on agricultural production is detectable in the schemes examined. The study was originally conceived to examine that hypothesis, of a negative relationship. But the findings are that O&M performance is quite good, and that whatever weaknesses there are in O&M they are not such as to depress overall production and family earnings on the schemes.
7.25 The one exception is the failure to achieve diversification out of paddy. By concentrating available water on paddy, when diversification to other crops with lower moisture requirements would have permitted a larger area to be irrigated—often with higher value crops—the irrigators have maintained traditional farming systems at the expense of the economy. This report attributes these losses to public policy, and not to poor operational performance.

7.26 The decline in the competitiveness of irrigated paddy farming is bound to affect farmers' commitment to O&M. There is evidence from the water-short Myanmar schemes that farmers within the design command area who do not get enough water reduce their contribution to collective cleaning and repair. The same result can be expected if family members seek alternative employment and turn away from double cropping. At Lam Pao, farmers who let their land lie fallow in the dry season do not join the working groups. Even families that continue to farm must contend with husbands and young adults leaving the fields and the wives and older members taking up the slack. Such trends imply a shift back to subsistence production, and less interest in or ability to do good O&M. Dry season production will be the most seriously affected by these changes, but the monsoon labor profile is also changing and with it attitudes to O&M. This is why at the beginning of this chapter the point was made that O&M’s influence on production now seems less important than production’s influence on O&M.

7.27 The Thailand examples preview the future of the other schemes, and it is worth following NEWMASIP’s lead in speculating how these changes will materialize. Paddy/paddy rotations in the three countries are likely to persist only as a basis for the household’s subsistence. Diversification, especially on the better drained lands, can rebuild the incentives for many of the farms, not solely in the direction of substitute grains and other field crops but integrated farming systems featuring small stock and fish as well as specialty crops. But it is likely that unless government intervenes with effective extension and marketing services, ribbons of modern, all-season farming will develop along the major distributaries while the hinterland will be used intensively for monsoon paddy and fallowed in the dry season. Some families will leave farming in any case. The extension services should not be broad based, poorly informed squadrons of under-motivated high school graduates. Rather they must have staff competent to deal with the integrated systems, specialty crops and other niches the market surveys identify.

B. Recommendations

7.28 Despite the limitations of the sample, the following dozen recommendations may have operational relevance.

7.29 Sharpen the Response to O&M Failures. O&M is often treated as an indivisible set of agency and irrigator activities, that are carried out poorly and require concerted remedial actions. The study suggests that performance across the set is not uniform, that agencies as well as irrigators do well at certain functions and fail on others, and that some of those failings are more easily explained by systemic disincentives than by anarchy, moral hazards, bureaucratic disinterest or other features of the popular paradigm. For example, the anatomy of irrigator O&M on other projects is likely to support the study’s finding that farmer maintenance of local channels is usually good, and of gates poor, and that efforts to exhort the farmers to rise to a higher level of O&M achievement by keeping the gates in working order are unlikely to succeed. Hence the first recommendation is:
1) **Disaggregate O&M, identify the poorly performing components, and deal with the specific disincentives.** Exhortations to agencies and irrigator groups to take O&M seriously should be replaced by tailor-made prescriptions based on intensive local consultation with farmers and officials.

7.30 **Simplify the Technology of Infrastructure and Operations.** The highly reticulated, gated, water distribution systems that depend on reliable rotations should be simplified whenever there is an opportunity for "modernization." Agency and irrigator attraction to, tolerance of, or ability to administer complex systems is finite. Ideal distribution formulas, flow measurements and democratic rotations sometimes have to give way to second-best solutions. Among them:

2) **Conversion to "modern" control structures,** including where appropriate either fixed or automatic weirs, gates and regulators;

3) **Rationing of water supplies to pre-specified distributaries in seasons of acute shortage,** as a more efficient alternative than relying on voluntary inter-tertiary rotations. This may require farmer agreement to an annual operational plan that includes carefully crafted contingent language satisfactory to tailenders in the event of shortage. Trying to maintain voluntary systems in times of stress is an invitation to anarchy, at least in immature irrigation societies; and

4) **Withholding of water from recalcitrant WUGs.** Most agencies claim authority to prevent release of water to a tertiary system or subsystem pending completion of pre-season cleaning and other O&M responsibilities. This weapon seems to be rarely used, but it is effective and easily defended. Again, prior agreement by farmers may be required, the objective of intelligent participatory discussion. The threat creates that "collective good" that only groups can acquire and that prompts farmers to organize and participate. The Bank should take a proactive position in recommending this weapon be used, since it eases decisions for WUGs to complete their assignments.

7.31 **Promote Management Transfers to WUGs, Judiciously.** Advocacy of transfer and WUGs should not be driven by simplistic and politically correct assumptions about inefficiencies of public agencies and presumed benefits of beneficiary participation. The study suggests that transfer is likely to have very different levels of impact depending upon whether the assets and responsibilities transferred are within the tertiary system, at the tertiary gate, or along a section of the distributary with all its tertiary turnouts. In paddy irrigation schemes where responsibility for channel cleaning and minor repair is already in the hands of farmers, but the WUGs are weak or nonexistent, the payoff to investing in institution building limited to O&M of the tertiary system alone is uncertain. That cannot be said of highly diversified irrigated cropping systems, where micro-control of water distribution is required. Transfer of O&M specifically for the tertiary gates is likely to be frustrated, since paddy farmers below the gates do not want them. Achieving better O&M at the tertiary gates is more likely to follow as a consequence of the association of tertiary WUGs along a distributary. These points translate into four more recommendations:
5) Where not already the case, responsibility for cleaning, routine maintenance and minor repair of tertiary canals, channels and associated structures should be transferred to farmers. They will handle these jobs collectively with a modicum of encouragement and support;

6) Transfer of O&M of tertiary gates to irrigators is not advised, in the absence of other measures to improve the incentives for paddy farmers to participate in closing gates to restrict their own water supplies. The agencies soon tire of installing new gates that disappear after several months. Policing farmer performance is likely to be as demanding on the agency as O&M was; and

7) Institution building concentrated on organizing federations of associated WUGs is likely to have a high payoff. They can administer rotations from the distributary, overriding selfish behavior of individual WUGs. This will also simplify the work of the WUGs.

8) Flood control and drainage schemes, where purposeful development of user associations and transfer of functions have been ignored, are prime candidates. The program should be centered initially on the structures which offer local farmers immediate and recognizable benefits: smaller sluices, the inlets, etc.;

7.32 Improve Household Earnings. The collapse of incomes from paddy farming threatens both the household and scheme economies. It is difficult to envisage a recovery in international rice prices, or governments subsidizing local market prices. Measures must be taken to elevate irrigated farm technology to increase productivity and household incomes, including:

9) Promote diversification systematically and aggressively. This may include restructuring channel architecture to permit mixed cropping;

10) Support the development of research, extension and marketing services oriented to diversified cropping, including specialty crops and integrated on-farm systems. For these paddylands, investments in these institutions can have a higher payoff than investments in narrowly-focused WUGs. Ideally, the WUG should expand to incorporate extension and marketing functions;

11) Remove restrictions that prevent acquisition of rights to farm by persons intent on modernizing the business: controls on rental and sale of irrigation properties, on contract work, or on produce sales. Government should anticipate that many present scheme occupants will eventually want to migrate, and sooner than that may try to rent the fields in the dry season; and

12) Abandon cost recovery. The farmers who agreed to the terms of these schemes at start-up are now paying substantial penalties because of the collapse of international and local rice prices. Their losses are reflected in consumer surpluses far larger than even full recovery of capital as well as O&M costs would provide. Imposing cost recovery on these paddy farmers is more likely to drive them out of farming than into diversification, especially those with few or no cropping options.
7.33 The relevance of these recommendations beyond the selected schemes is uncertain, since they depend on cultural and institutional parameters which may be country-specific, and on engineering and agronomic considerations which may be project-specific. For example, comments on a draft of this report showed concern that the findings were at once both too rough and too forgiving on O&M performance in the region. For the moment, these recommendations are better viewed as hypotheses. Additional empirical work is needed to validate the range of countries and projects inside or outside the region for which these recommendations are appropriate. OED has proposed a regional workshop where validation would be one of the principal objectives.
### Incremental and Total Paddy Incomes: per Farm and per Hectare

(financial prices in 1995 US$)

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**Source:** SARs and Annexes A, B and C.

**Notes:**
- n.a. "Without" project conditions poorly defined.

- Lam Pao: SAR (Oct/1978)-2 ha diversified farm; Table 6.3, page 31. OED-typical farm, 2 paddy crops, 50% dry season intensity.

- Maeklong: SAR (Nov/1979)-4 ha paddy farm; Table 6.3, p35 OED-typical farm, 2 paddy crops, 60% dry season intensity.

- Kinda: SAR (May/1980)-2 ha diversified LMC farm; Annex 3, Table 11, p 129. OED-Left Main Canal farm, 2 paddy crops; formerly 1 rainfed paddy crop.

- Kinmundaung: SAR (Nov/1982)-2 ha paddy farm; Annex 4, Table 2a, p85 OED-priviledged farm, 2 paddy crops; formerly 1 rainfed paddy crop.

- Azin: SAR (Nov/1982)-2 ha paddy farm, 1 irrigated crop; Annex 4, Table 2b, p 86. OED-typical paddy farm, 2 crops, 1 irrigated; formerly 1 rainfed paddy crop (rainfed yield of 3.7 tons/ha taken from SAR).

- Dau Tieng Lowland: SAR (July/1978)-150 ha cooperative with 2 paddy crops; Table 6.3, p38. OED-priviledged farmer with 3 paddy crops, formerly with 1 rainfed paddy crop.

- Dau Tieng Upland: SAR-150 ha cooperative with 3 groundnut crops; Table 6.3, p38. OED-priviledged farmer with 2 groundnut crops, plus 1 paddy crop; formerly with 1 rainfed paddy crop.
IRRIGATION O&M AND SYSTEM PERFORMANCE IN SOUTHEAST ASIA:
AN OED IMPACT STUDY

REVIEW OF THE LAM PAO AND MAEKLONG RIGHT BANK IRRIGATION PROJECTS
THAILAND

June 27, 1996

Operations Evaluation Department
Acronyms and Abbreviations

**Bank**  World Bank  
**CPD**  Cooperative Promotion Department  
**CHO**  Constant Head Orifice  
**EC**  European Community  
**EEC**  European Economic Community  
**ERR**  Economic Rate of Return  
**GR**  Glutinous Rice  
**HYV**  High Yield Variety  
**IER**  Impact Evaluation Report  
**IFAD**  International Fund for Agricultural Development  
**LG**  Lateral Group  
**LMC**  Left Main Canal  
**MOAC**  Ministry of Agriculture and Cooperatives  
**NEWMASIP**  North-East Water Management and System Improvement Project  
**MGR**  Non-Glutinous Rice  
**O&M**  Operation and Maintenance  
**OED**  Operations Evaluation Department  
**OFD**  On-Farm Development  
**OFWM**  On Farm Water Management  
**PAR**  Performance Audit Report  
**PCR**  Project Completion Report  
**RID**  Royal Irrigation Department  
**RMC**  Right Main Canal  
**SAR**  Staff Appraisal Report  
**TA**  Technical assistance  
**USAID**  United States Agency for International Development  
**WASAM**  Water Allocation Scheduling and Monitoring Program  
**WUG**  Water User Group
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This report was prepared by Edward B. Rice (Task Manager), with support from Robert Yoder, Jayantha Perera, Annemarie Brolsma, Sinee Chuangcham (Consultants) and Tassanee Ounvichit (RID), who visited these projects in October 1994 and March and June 1995. Afi Zormelo and Megan Kimball provided administrative support.
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1. Introduction

A. Background

1.1 The Lam Pao and Maeklong Right Bank irrigation schemes in Thailand were selected as part of OED's impact study of gravity-fed irrigation projects, with storage, in the humid tropics of Southeast Asia. Other gravity-fed schemes were selected in Myanmar and Vietnam. A flood control and drainage project in Bangladesh was added to the regional study, to widen the thematic perspective on problems of operation and maintenance (O&M).

1.2 The Bank financed two projects supporting the Lam Pao scheme. Credit 461-TH for the Northeast Thailand Irrigation Improvement Project was approved for US$7.00 million in February 1974, made effective in October 1974, and closed in March 1981 with a cancellation of US$0.05 million. The project covered rehabilitation and expansion of three gravity-fed schemes, of which Lam Pao was the largest (see end-Map 2). This subproject is referred to as Lam Pao Stage I, and covered the northern area of the scheme, closest to the existing dam (completed in 1968 without Bank support). It was implemented, as were all the other Bank-supported operations discussed in this report, by the Royal Irrigation Department (RID). A Project Performance Audit Report (PAR), that included the Project Completion Report (PCR), was issued in November 1982.1 Loan 1630-TH for the Northeast Irrigation Project II was approved for US$17.50 million in November 1978, co-financed by IFAD with the same amount, made effective in April 1979 and closed in March 1986 with cancellation of US$2.20 million. The project covered rehabilitation and expansion of three gravity-fed schemes, two below one dam not included in the first project. The third, the Lam Pao subproject, is referred to as Stage II, and covered the southern area of the scheme. A Project Completion Report was issued in December 1988.2 No PAR was prepared, but OED carried out an impact evaluation study of Stages I and II in 1988/89, issuing an Impact Evaluation Report (IER) in March 1990.3 The Lam Pao study was one of a six-country series of impact studies on irrigation projects carried out by OED in the period 1987-90.

1.3 The Bank has financed five projects supporting irrigation development of the Maeklong River basin, starting in 1965. The first financed equipment to construct a diversion weir near the provincial capital of Kanchanaburi and canals to provide supplemental wet season irrigation to the left bank. Two hydro-power and storage projects followed in 1974 and 1980 on tributary rivers further north in the basin. The fourth project, the subject of this report, supported rehabilitation and expansion of facilities built with government funds after 1965 to provide year-round water supplies to the right bank of the Maeklong River below the weir (Map 3).4 It allocated a smaller amount of funds for a second irrigation subproject (Pattani) in the far south of Thailand. Loan 1787-TH for Irrigation Project XI was approved for US$80.00 million in

4. That progression of activities—from diversion for wet season supplies, to storage, to year-round supply—repeated the Bank's experience on the Chao Phraya. See para 1.6.
December 1979, made effective in April 1980, and closed in June 1986 with a cancellation of US$25.6 million. A fifth Bank project was approved in 1981, to support, exclusively, rehabilitation and expansion of the northern section of facilities on the left bank of the Maeklong River. A PAR covering both the right and left bank operations (and Pattani), that included the two PCRs, was issued in December 1990.\(^5\) Though the present report deals with the right bank of the Maeklong scheme, some of the comments relate to activities on the left bank or both banks.

1.4 The primary subject of this impact study is the Lam Pao irrigation scheme. It is OED's second impact study of Lam Pao, with field work carried out six years after the 1988/89 study. That review, as reflected in the report title (see footnote 3), examined impacts across the board. This review has a narrower perspective. The report focuses first on O&M performance, second on agro-economic impacts, and third on the influence of O&M on those impacts. However, given improvements in scheme performance at Lam Pao since 1989, the second look in 1995 provides a lesson, on the limitations of any "impact" study, quite independent of the irrigation and O&M themes.

1.5 The discussions of O&M and impacts of the Maeklong scheme are shorter and concerned mostly with similarities and differences compared to Lam Pao.

1.6 The northeast and Maeklong irrigation programs supported by the Bank were sideshows compared to the central stage of Bank activity in the development of Thailand's irrigation potential. The Bank concentrated the bulk of its funds, over 31 years of lending starting with the first diversion dam in 1950 (and one of the Bank's first irrigation projects anywhere), on developing the irrigation potential of the Chao Phraya River, the grand river of central Thailand (Map 4). Altogether the Bank has financed 6 irrigation operations on the Chao Phraya, including diversion schemes and year-round irrigation, plus multi-purpose dams. The expansion of irrigation structures on the upper and lower plains has now over-committed all available storage in the basins that feed them. The Lam Pao and Maeklong schemes distinguish themselves from the Chao Phraya history because they still have abundant water in storage, in relation to the capacity of irrigation structures. Unless the canals at Lam Pao are enlarged again, its surplus position will continue. The Maeklong River, by contrast, has been connected by transfer canals to the western edge of the Chao Phraya system, so that schemes on the Maeklong will eventually have to compete for its water with irrigation schemes and other users in the lower Chao Phraya basin.

1.7 The 1990 PAR on the two Maeklong irrigation projects starts with an excellent history of Bank involvement in irrigation and storage in Thailand, and the evolution and economics of the country's rice exports. The reader can also refer to that document, and to the various PCRs and PARs, for the implementation experience of the Lam Pao and Maeklong schemes. Project implementation is not discussed here. This report does make reference where useful to the Lam Pao IER and Maeklong PAR.

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B. Characteristics of the Command Areas

1.8 Lam Pao. When the first project was appraised in 1973, northeast Thailand had a population of about 12 million out of a country total of 39 million, and accounted for about one third of Thailand's land area. Despite this, its share in GDP was about 16 percent with per capita income only one quarter of that prevailing in the central region and one half of that in the rest of the country. Recent estimates show that those differentials have closed, but not by much. Northeast household incomes are still about a third of those in the central plains. This was to be the largest irrigation scheme in the northeast, and the first Bank project specifically designed to support government's efforts to develop the region. At appraisal there were about 20,000 families living in the command area of the full design.

1.9 Warm temperatures throughout the year and a five-month monsoonal wet season May-October are the dominant climatic characteristics of the project area. The average annual rainfall is 1,400 mm. But total rainfall, the start and end of the wet season, and rainfall distribution, are all unpredictable. The onset of the wet season can vary by about two months (April-June). Also, the erratic distribution of wet-season rainfall results in frequent 10 to 15 day periods without rain—especially in the middle of the monsoon—which can significantly reduce paddy yields in the absence of supplemental water.

1.10 The unpredictable start to the wet season has important implications for reservoir management. Runoff into the reservoir does not occur until soil profiles in the catchment have been saturated, some time after the onset of the rains. This means that if the monsoon is delayed there may be no significant runoff until August, after the desired sowing dates for rice nurseries, direct seeding, and even transplanting. At worst, it may miss the mid-season dry spell, one of the main constraints to rainfed cropping. Among the principal objectives of the irrigation scheme is to provide water to paddy fields during this dry spell, to reduce stress levels on the rice crop. If the dry spell occurs when the reservoir is low, this tactic will not be possible. However, whatever water is retained in the reservoir at the end of the dry season for wet season rice nurseries, land preparation and rainless periods faces evaporation losses.

1.11 Dry season uncertainties can be even more problematic. Farmers generally do not know until a few weeks before the optimal planting time at the beginning of the dry season when RID will release water. This is potentially distressing for non-paddy crops. The main climatic problem for cash crops is the short duration of the cool season (mid-November/mid-March). Crops have to be planted early to avoid having seed-set and fruiting in the extremely hot period from March onwards. If a farmer, for example, wants to grow tomatoes under contract, he should plant seedbeds starting in late October.

1.12 The reservoir has been full up to planned irrigation supply in most years. But in the few years when it has not reached that mark, and water is still being released to finish the wet season paddy crop, the farmer does not know (and RID may not be able to tell him) how much water will be available by the time he has to transplant the seedlings at the end of November. Or, RID may close the canals for maintenance as soon as the wet season rice irrigation is completed, thus interrupting water supplies. Also, a typhoon may approach, and RID cannot permit the reservoir to get too full in the event the catchment receives excessive rainfall. Farmers are slowly adapting to cultural practices for early dry season cropping, but the delay in some years in notification from RID, and the farmers' tendency to maximize wet season paddy yields, mean that they generally start the cultural operations for the dry season crops too late for optimal
yields. If, at the end of the wet season, a labor contractor offers several thousand baht to the family to cut sugar cane, or the farmer has a chance to work on a construction site in Khon Kaen, he often opts for the certain cash. As discussed below (paras 4.20 ff), those pressures are increasing. Most of these uncertainties can be addressed through competent management of the reservoir, a skill which has been improving.

1.13 Low floodplains, and slightly undulating terrace lands at higher elevations, are the typical landform. Clay and clay loam soils of poor natural fertility are found in the low-lying areas, but sandy soils with low organic matter content also occur throughout the project area. In general, the soils of Lam Pao are marginally adequate for rice and poor for most non-rice crops—low in nutrients, deficient in micro-nutrients as well, low in pH and poor in structure. Longitudinal slopes in the direction of riverflow are very flat—about 0.5 meters per kilometer. Transverse slopes from the terraces to the river channels are steeper. Most of the cultivable land in the valleys within the project area has been cleared of vegetation and developed for wet-season paddy. During the monsoon, the accumulation of rainfall and surface run-off favors paddy cultivation but precludes cultivation of dry-foot crops. Cassava and kenaf are grown on the terraces and patches of higher ground, which are generally at too high an elevation to be irrigable.

1.14 The traditional household economy is based on cultivating glutinous rice on approximately 3 ha of inherited land. Dependent on the rainfall regime, in some years more rice is produced than required to meet the subsistence needs of the family. Once the subsistence margin is assured and a new crop is about to be harvested, the surplus is sold for cash, augmenting the occasional cash income from selling retired draught animals. In the past, this cash was used mostly for ceremonies and festivities, and for making donations to the village temple. Garments, agricultural implements and household utensils were mostly produced at home.

1.15 In the two decades preceding dam completion in 1968, things had begun to change. The impact of modern communications, including the transistor radio with commercial advertisements punctuating the programs and the increased accessibility of the expanding road network, had led to some modernization in the rural areas of the northeast. Shirts, trousers, watches, bicycles and a whole range of items formerly regarded as luxuries were rapidly becoming necessities. These new needs could only be met with ready cash and the household economy gradually became monetized. Young people began to leave the village for the towns, and those who remained experimented with cash crops. Kenaf, and subsequently, cassava were planted in the uplands as sources of cash income.

1.16 Nevertheless, even with the arrival of irrigation waters, the typical paddy-based household in the Lam Pao area has remained deeply conservative. The risk-minimizing behavior puts priority on the subsistence wet season rice crop. Risk-minimizing strategies are reflected not only in concentration on subsistence production, but also in low use of inputs and a planting routine split into different periods. These strategies are rational in economic terms, taking account of the high risks and modest potential returns. There is a tradition in the northeast for members of farm families to take off-farm employment in the dry season, and this may be preferred to cropping in the dry season, even when water is available. Compared with the Maeklong area, however, rates of out-migration are still quite modest.
1.17 **Maeklong.** By the late 1970s, it was clear that the large-scale irrigation development of the Chao Phraya had gone too far. Too big an area was served by irrigation infrastructure in relation to upstream storage capacity. In the 1980s attention then turned to the water-surplus Maeklong basin, where the main diversion dam (1965) and the first upstream storage dam (1974) were already in place (Map 3). The Maeklong basin, situated immediately to the west of the Chao Phraya basin and the second largest rice producing area in Thailand, covers an area of 27,700 km². The Maeklong's two main tributaries, the Kwae Yai (the "River Kwai") and Kwae Noi join at Kanchanaburi to form the main river, some 90 km from the sea. The project area, about 100 km west of Bangkok, is a long belt of alluvium floodplain bounded on the east by the Maeklong River and on the west by the right bank canal.

1.18 The climatic features of the project area resemble those at Lam Pao. The tropical and monsoon climate with its warm temperatures throughout the year provides a 12-month growing season. The mean annual rainfall is about 1,000 mm with 85 percent—the same fraction as at Lam Pao—occurring between May and October during the southwest monsoon. Dry periods of up to ten days are not uncommon, especially in June and July, and wet season rain-fed paddy frequently suffers significant yield reductions due to both late planting and periodic drought. In the dry season, irrigation is essential to ensure a paddy crop.

1.19 The Maeklong service area is generally flat with the exception of terrace lands to the extreme west and the levee soils along the right bank of the Maeklong to the east. The land slopes gently from north to south and from west to east with a slight rise to the right bank levee, which has created a natural depression. This low-lying area is extensive, easily served by field-to-field flooding, and the traditional center for paddy culture in the region. Flooding from the Maeklong has been largely eliminated by the construction of the dams on the Kwae rivers and other upstream flood protection works.

1.20 The predominant soils occupying about 75 percent of the Maeklong right bank project area are heavy clays with a generally high nutrient status and ideally suited to rice. Sandy loams occupy about 10 percent of the project area. These coarser textured soils, presently planted to sugarcane, are fertile and well suited to a wide range of upland crops. Transitional loams occupy the remaining 15 percent of the project area and are suitable for both rice and upland crops. The Maeklong plains, and more particularly the left bank, is the center of Thailand's sugar milling industry.

1.21 There were about 22,000 families in the project area at appraisal in 1979. The average farm size was about 3 hectares, the same as at Lam Pao. Approximately 50 percent of the Maeklong farmers were exclusively owner-operators and a further 40 percent were landowners who rented additional land from other farmers. Only ten percent were tenant farmers who operated under various share, cash and labor exchange arrangements. Rental and tenancy ratios were higher than at Lam Pao.

1.22 In fact the economy of the floodplains south of Kanchanaburi was substantially more monetized and developed than the conditions at Lam Pao in the late 1970s. The proximity of the dynamic industrial center of greater Bangkok has stimulated both the migration of farm-family members to Bangkok and the establishment of satellite industrial zones along the transport corridors from Bangkok to Kanchanaburi and from Kanchanaburi south through the project area. Not surprisingly, these developments have influenced the pace and direction of development of the irrigation scheme.
2. Lam Pao Scheme: Structure and Efficiency

A. Lam Pao, as Supported by the Bank

2.1 The Lam Pao dam was completed by RID in 1968—with support from USAID and the U.S. Bureau of Reclamation. It has a height of 33 m above the riverbed and a crest about 8 km long. The catchment area of the dam is 5,900 km². It creates a reservoir of 2,460 Mm³ capacity, of which 1,350 Mm³ is allocated to water designated for irrigation and 1,110 Mm³ is kept for flood control. Irrigation canals were built in the period 1968-73 to serve an area of about 18,000 ha on both banks of the river downstream of the dam.

2.2 Completion and improvement of this system was referred to as Stage I. It was initiated by RID and the Bank in 1974 as part of the Northeast Irrigation Improvement Project. Stage II, supported by the Northeast Irrigation Project II, extended construction of main, lateral and tertiary canals, and main drains, for irrigation of a further 31,000 ha.

2.3 The present service area totaling 49,500 ha is situated along two main canals, one on each bank of the river, and extends south to the confluence of the Lam Pao River with the Lam Chi River (which flows east to the Mekong). As completed, the right main canal (RMC) with a total length of 92 km equips an area of 37,000 ha. Twenty-nine laterals and some farm turnouts are supplied from the RMC. The left main canal (LMC) of 67 km in length, equips an area of 12,000 ha, with 17 laterals as well as farm turnouts. Flow control is exercised upstream at the Lam Pao dam; upstream water level control is achieved through regulator structures (16 on the RMC and 11 on the LMC) consisting of weirs associated with manually operated gates. The distribution system of laterals supplying the original area was rehabilitated in the Stage I project; the distribution system for the second stage was new construction. Total length of the laterals is 282 km, and 174 km for sub-laterals—a low density of 9.2 m/ha. All laterals were lined, the sub-laterals were not.

2.4 Given the low density of the distribution system, the tertiary network was much longer: 2,200 km (average density of 44.4 m/ha), all unlined. Most delivery offtakes to the tertiary systems are constant head orifices (CHOs), though there are some single undershot gates in the older area. There were 1,129 turnouts at the time of the OED impact evaluation in 1988/89, one turnout for each rotational unit of approximately 43 ha. Distribution to the farms is both direct from the tertiaries and field to field. Initially, one in three fields was due to have direct supply from the ditches. That ratio had increased to two in three by the end of the 1980s.

2.5 Under the two projects, 192 km of drainage works were rehabilitated or newly constructed, with, again, a low density of 3.9 m/ha. A road network comprising 664 km of new roads was constructed, of which 100 were main roads.

2.6 The conveyance and delivery canals—as dictated by the original design predating Bank involvement—were dimensioned to provide supplementary irrigation for paddy on demand throughout the command area in the wet season, and for a mix of paddy and upland crops occupying at most 60 percent of the command area in the dry season. The fraction 50 percent dry season cropping intensity was a general parameter built into the design of all three
subprojects supported by the first Bank project. For the second project, the ratio for Lam Pao was raised to 60 percent. Given that there is excess water in the Lam Pao reservoir, most of which has to be released into the river and lost to irrigation, the original conveyance system appears to have been "under-dimensioned." This was probably intentional, as USAID and RID both believed in the 1970s that dry season cropping intensities above 60 percent were improbable throughout the northeast. Experience at Lam Pao supports that assumption (see paras 4.2-4.5 and 6.4). There is no doubt the main canals are under-dimensioned with respect to the reservoir, and that the additional flexibility for water management that larger canals would have provided has been sacrificed. And it is now accepted that the dominant physical constraint on increasing dry season cropping—should recent trends be reversed—is the capacity of the main (and to a lesser extent lateral) canals. As explained below, weeds and silt exacerbate the shortfall in dry season supply.

2.7 The terminology of the canal system as used in this report follows the convention in Bank appraisal and completion reports for Thailand. The two "main" canals on either bank convey the water to the distributaries, called the "lateral" and "sublaterals." These supply the "tertiaries," which are the farmers' principal watercourses. In Lam Pao, the tertiaries are called "ditches." Field channels take the water from the tertiaries to individual fields. These channels have no special name, though they are sometimes referred to as "sub-ditches."

B. Lam Pao, as Upgraded

2.8 The IER described the condition of the irrigation infrastructure in 1989 as generally unsatisfactory, especially considering that "the rehabilitation works undertaken under Stage I are only eight years old while the new works constructed under Stage II have been in operation for less than five years" (IER, para 2.07). There was special concern for the integrity of the dam. A continuously present wet layer in the dam suggested potentially dangerous seepage from the reservoir. Also, the spillway gates were not operational and had to be kept open. Both factors reduced the storage capacity to about 70 percent of its maximum. The IER noted that the civil works and water control structures in both the conveyance and distribution networks were also in poor condition. In the tertiaries, little or no maintenance and few annual repairs were being made to the earthen ditches. The drainage system was incomplete, resulting in flooding at harvest time. Only the road facility built together with the irrigation infrastructure received a positive review. The IER also implied that the quality of the construction was as much to blame as inadequate O&M. The PCR, which was prepared at the same time as OED's field observations for the impact study, was less detailed in its criticism but concerned nonetheless about inadequate O&M, erratic and insufficient water supply and efficiency rates half those expected at appraisal.

2.9 When the IER team was in Lam Pao in 1988/89, the European Economic Community (EEC) was already getting in position for what was to be the first of three sequential assistance programs to rehabilitate and modernize the structures and operational procedures at Lam Pao. All had their origin in EEC's agreement with the Thai Government to provide technical and other support to diversify the northeast's agricultural base, in order to reduce cassava exports to Europe (cassava chips competed with European animal feed suppliers). Improved irrigation was central to that strategy. The first of the three, the Chi Basin Water Management Improvement Project, was financed by EEC, was purely technical assistance, and was not limited to the Lam Pao scheme. The second, the On Farm Water Management Project (OFWM), was financed by government and Dutch bilateral aid, was a mixture of government-supported construction and
donor-supported technical assistance (TA), and was restricted to Lam Pao. In particular, it selected 13,000 ha, broken into small blocks of 300 ha scattered over the whole of the scheme, for participatory tertiary intensification. The farmers were expected to contribute to design of canal layout and O&M, though not to investment costs other than labor inputs. The three operative years of OFWM were 1990-1992.

2.10 The third project in the series, with the title North-East Water Management and System Improvement Project (NEWMASIP), was again funded by government and the (renamed) European Communities (EC) and comprised a mixture of government- and EC-supported construction and EC-supported TA. It limited its work to Lam Pao, two other large schemes, and seven medium-size schemes in the region. NEWMASIP's six-year contract extends from 1991-1997. The lead consultant is the same Dutch firm that implemented OFWM. Its terms of reference are broader than OFWM, and include intensified activity with Water User Groups and their apex organizations, and diversification of household incomes apart from irrigated agriculture. Funds were available for repair and remodeling of main and lateral canals as necessary to supply the selected tertiaries, as well as rehabilitating and/or constructing the tertiaries. The objective now is to provide direct access to all fields wherever possible, with a minimum of 70 percent access in any one section. At Lam Pao, NEWMASIP has limited its targeted operations to 16,000 ha divided into several large blocks, all concentrated in the Stage I area. In practice it has concentrated on tertiaries covering only 10,000 ha.

2.11 Wherever feasible NEWMASIP is converting the old water level and flow control structures in the canals to models that are simpler to read and adjust: duckbill weirs to regulate levels in the larger canals, single undershot gates backed up by broadcrested weirs at the tertiary turnoffs, and movable check boards in concrete slots closing the tertiaries below each subditch outlet. These structures require less frequent adjustments than the ones they replace, or no adjustments at all.

2.12 As discussed below, the OFWM and NEWMASIP activities, in collaboration with a new and vigorous RID management team, have substantially improved the condition of structures and operational procedures at Lam Pao. Where OFWM or NEWMASIP had been or is operating (there was no overlap) it is appropriate to consider this collective activity a new project: a rehabilitation of the relatively young Bank projects. In fact the areas are identified in that manner: the NEWMASIP laterals, the OFWM laterals and the "Bank" (or RID) laterals. Of the 49,500 ha in the Lam Pao scheme, 23,000 ha or just under 50 percent have benefited from the recent European assistance.

C. Water Availability and Efficiency

2.13 Rainfall. The average annual rainfall for the period since 1978 was 1,350 mm. Much of the rain falling on the command area during the rainy season from May through October drains into the river and is not available for use by the crops. Lam Pao Irrigation Project records show the estimated effective rainfall to be in the range of 350 mm to 450 mm during the rainy season and 25 mm to 60 mm during the dry season.

2.14 Reservoir Storage. At appraisal, the average annual runoff at the Lam Pao dam site, now captured by the reservoir, was estimated to be 1,540 Mm$^3$. The only period of water shortage in the reservoir in the first eight years of operation was a result of 35 percent below normal rainfall
during the 1993 rainy season. Consequently, during that dry season it was possible to release water into the main canals only for domestic use and to maintain existing fish ponds.

2.15 Out of the 2,460 Mm$^3$ storage available in the reservoir, a minimum of 1,110 Mm$^3$ is reserved for flood management. In most years, excess water is released to the river during the rainy season to preserve storage capacity for floods. Lam Pao reservoir managers aim to end the rainy season with the reservoir filled with 1,350 Mm$^3$ of water in storage. This was achieved about half the time in the past eight years. It is flood control rules and timing of rainfall that establish how much of the runoff is stored in the reservoir.

2.16 Crop Water and Irrigation Requirements. The average annual temperature in the area is 27°C and the average annual open pan evaporation is 1,760 mm. Including losses for land preparation and infiltration, a rice crop is estimated to require about 925 mm of water. The crop water requirement is nearly the same in the dry and rainy seasons. Groundnuts, corn, and vegetables grown in the dry season in 1993 required an average of about 500 mm of irrigation.

2.17 Using 384 mm as the estimate of effective rainfall in the rainy season, and assuming that rice is planted on the entire 49,500 ha command area, 268 Mm$^3$ of irrigation water must be delivered to meet the crop water requirement. Similarly in the dry season, 200 Mm$^3$ are required if 30 percent of the area is planted with rice and 30 percent with peanuts and corn with 38 mm of effective rainfall. At 100 percent overall irrigation efficiency, this crop mix at 160 percent cropping intensity requires an annual delivery of 468 Mm$^3$ of irrigation water. At a realistic 40 percent overall irrigation efficiency, 1,145 Mm$^3$ of water is required. Based on these estimates, and with the exception of the 1993/94 drought year, water stored in the reservoir at the end of the rainy season always exceeded the next year's annual irrigation needs.

2.18 Water-Use Efficiency. Table 2.1 presents the overall irrigation system efficiency for the dry and rainy seasons. For the four latest dry seasons recorded, 1989/90-92/93, the average efficiency was a respectable 43 percent. The PCR (1988) reckoned that the best dry season efficiency that could be expected was 30 percent, about half the appraisal projection of 58 percent. Two years later the 1990 IER report estimated dry season efficiencies averaging 23 percent for the two years preceding its field review, 1986/87-87/88. OED's procedure for estimating efficiency in 1995 has been roughly the same as for the IER, so that the improving trend would appear to be a real phenomenon. The appraisal projection of 58 percent was exaggerated and out of line with Bank experience in Thailand and elsewhere. Given the general water surplus situation of Lam Pao, the overall irrigation efficiencies are in the expected range and acceptable. This measure, however, does not indicate if all farmers received adequate water. Nevertheless, although data on equity in irrigation delivery is not available, farmers interviewed indicated there were no major problems. As shown later, headend and tailend yields are about the same.

6. This is based on the design where it was assumed that dry season rice would be grown on 30 percent of the land and non-rice crops on 30 percent, giving an annual cropping intensity of 160 percent. According to Lam Pao scheme managers, groundnuts require about 590 mm of water and vegetables 460 mm. An average 500 mm was used to estimate the dry season non-rice crop water requirement.

7. There was practically no cropping in 1993/94.
Table 2.1: Lam Pao—Irrigation Efficiencies and Cropping Intensities

Table 3. Lam Pao Irrigation System cropped area, cropping intensity, and overall irrigation system efficiency.

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<tbody>
<tr>
<td>Total rice crop area (ha)</td>
<td>48,702</td>
<td>48,811</td>
<td>48,875</td>
<td>49,158</td>
<td>49,060</td>
<td>49,163</td>
<td>49,464</td>
<td>49,489</td>
<td>49,344</td>
<td>49,230</td>
</tr>
<tr>
<td>Total crop water requirements (mcm.)</td>
<td>450.98</td>
<td>451.99</td>
<td>452.58</td>
<td>455.20</td>
<td>454.30</td>
<td>455.25</td>
<td>455.08</td>
<td>458.27</td>
<td>456.92</td>
<td>455.87</td>
</tr>
<tr>
<td>Total Rainfall (mm.)</td>
<td>916</td>
<td>974</td>
<td>920</td>
<td>1069</td>
<td>1273</td>
<td>990</td>
<td>745</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
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<tr>
<td>Effective rainfall (mcm.)</td>
<td>366</td>
<td>390</td>
<td>429</td>
<td>352</td>
<td>434</td>
<td>445</td>
<td>398</td>
<td>246</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Net Farm Water Requirement (mcm.)</td>
<td>85</td>
<td>62</td>
<td>23.13</td>
<td>103.45</td>
<td>20.27</td>
<td>10.02</td>
<td>56.67</td>
<td>212.31</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Total Water Supply (mcm.)</td>
<td>311</td>
<td>400</td>
<td>435.95</td>
<td>399.98</td>
<td>402.27</td>
<td>346.40</td>
<td>462.71</td>
<td>499.48</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Overall System Efficiency (%)</td>
<td>27%</td>
<td>16%</td>
<td>5%</td>
<td>26%</td>
<td>5%</td>
<td>3%</td>
<td>12%</td>
<td>43%</td>
<td>n.a.</td>
<td>n.a.</td>
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<tbody>
<tr>
<td>Crop area (ha)</td>
<td>3,701</td>
<td>7,477</td>
<td>13,354</td>
<td>23,000</td>
<td>19,746</td>
<td>22,185</td>
<td>24,700</td>
<td>547</td>
<td>13,612</td>
<td>16,000</td>
</tr>
<tr>
<td>Rice (ha)</td>
<td>172</td>
<td>2,532</td>
<td>6,752</td>
<td>17,281</td>
<td>14,677</td>
<td>18,230</td>
<td>21,247</td>
<td>33</td>
<td>10,496</td>
<td>10,400</td>
</tr>
<tr>
<td>Other crops (ha)</td>
<td>3,529</td>
<td>4,945</td>
<td>6,602</td>
<td>5,719</td>
<td>5,068</td>
<td>3,955</td>
<td>3,453</td>
<td>514</td>
<td>3,116</td>
<td>5,600</td>
</tr>
<tr>
<td>Total crop water requirements (mcm.)</td>
<td>22</td>
<td>52</td>
<td>101</td>
<td>193</td>
<td>165</td>
<td>191</td>
<td>216</td>
<td>3</td>
<td>115</td>
<td>129</td>
</tr>
<tr>
<td>Total Rainfall (mm.)</td>
<td>n.a.</td>
<td>51</td>
<td>82</td>
<td>134</td>
<td>50</td>
<td>22</td>
<td>131</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Effective rainfall (mcm.)</td>
<td>25</td>
<td>40</td>
<td>70</td>
<td>25</td>
<td>11</td>
<td>64</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Net Farm Water Requirement (mcm.)</td>
<td>28</td>
<td>61</td>
<td>123</td>
<td>140</td>
<td>180</td>
<td>152</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Total Water Supply (mcm.)</td>
<td>96</td>
<td>236</td>
<td>261</td>
<td>247</td>
<td>359</td>
<td>372</td>
<td>424</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Overall System Efficiency (%)</td>
<td>n.a.</td>
<td>12%</td>
<td>23%</td>
<td>50%</td>
<td>39%</td>
<td>48%</td>
<td>36%</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
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</table>

CROPPING INTENSITY

| Dry season | 7.5% | 15.1% | 27.0% | 46.5% | 39.9% | 44.8% | 49.9% | 1.1% | 27.5% | 32.3% |
| Rainy season | 98.4% | 98.6% | 98.7% | 99.3% | 99.1% | 99.3% | 99.9% | 100.0% | 99.7% | 99.5% |
| Annual | 106% | 114% | 126% | 146% | 139% | 144% | 150% | 101% | 127% | 132% |

Notes:
1. Dry season area in 1995/1996 is the RID planned crop area.
2. Efficiency calculated using crop water requirements, cropped area, planting schedule, crop factors, evaportranspiration, and effective rainfall information prepared by the Lam Pao Operations Office.
3. Cropping intensity calculations are based on 49,500 ha as the developed area.
2.19 In the drought year of 1993, the overall rainy season efficiency was, again, a respectable 43 percent. However, in water-abundant years (i.e., all but 1993 in the recorded period), there was excess runoff in the rainy season that had to be released to the river to reserve storage for flood protection. With abundant water, overall wet season efficiency ranged from 5 percent to 27 percent in the preceding five years, reflecting the opportunity to use extra water to reduce field-level irrigation management and weeding costs. Without beneficial downstream use of the water saved, improving overall system efficiency has little relevance as a performance measure. Saving water by increasing efficiency only increases the volume that must be released directly to the river.  

2.20 In the dry season, efficient water use has more relevance in Lam Pao for two reasons. First, water saved can be stored and used for early release or during a drought in the next season if necessary. Second, the limited main and lateral canal capacities restrict the area that can be irrigated. Improving the distribution and field application efficiencies translates into capacity to expand the cropped area in the dry season. As shown below, however, the incentives for expansion are in doubt.

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8. Douglas Vermillion of the International Irrigation Management Institute comments: "As governments shift their emphasis toward management at the river basin level, where there is scarcity of water at that level, efficiency in one system may help or hinder water access to downstream systems, depending on the return flow. It will become increasingly important in the future to have good information on patterns of return flow or recharge along river basins and this information will determine where and to what extent efficiency at the level of a single system is a relevant performance measure" (Personal correspondence, January 23, 1996).
3. Lam Pao Scheme: Operation and Maintenance

A. Team Visits

3.1 The OED impact study team visited six lateral canal command areas (Map 2). Two of the laterals visited had no external assistance subsequent to the two Bank-supported projects, but benefited from whatever contribution RID has made to system maintenance subsequently. One of these, located on the LMC near the head of the system, was a short lateral in considerable disrepair. The other was a large sub-lateral in the center of the system taking water from one of the longest laterals. While many of the gates were damaged, most were still being used. However, farmers reported somewhat erratic water distribution performance during times of water shortage. Two other laterals benefited from the OFWM project and both were in the tail of the system, i.e. in Lam Pao Stage II. One on the LMC was in reasonably good repair and much better condition than the "Bank" LMC lateral visited near the head of the system, which was of similar size. The other was in the very tail of the RMC. The two laterals visited that were assisted by the NEWMASIP projects were on the RMC near the head. They had the advantages of recent improvement of structures and adequate water from the main canal all year.

3.2 The team was especially concerned with the effectiveness of the Water User Groups (WUGs), and of the lateral groups where they existed, at each site. It used the following six criteria to evaluate a group's strengths and weaknesses. Had water supplies been scarce, ineffective WUGs would have stood out more sharply:

- degree of involvement in carrying out regular maintenance and in helping RID respond to serious disruption of the irrigation supply;
- physical condition of the lateral and tertiary infrastructure;
- diversity of agricultural activities in the wet and dry seasons;
- ability of the group to raise funds for maintenance and other necessary expenses;
- extent of rules and regulations governing group behavior;
- clear group structure and the active involvement of members along with the leaders in water management and maintenance of the system; and
- degree of group management of its affairs, including water management at the lateral, tertiary and field levels.

3.3 The team did not revisit the villages surveyed by university staff recruited for OED's 1988/89 impact study. That study had retraced the steps of an even earlier evaluation team, that had monitored initial progress of Lam Pao activities from 1970-76 based on repetitive interviews in six villages within the Stage I area and six "control" villages on the borders of the scheme.  

9. The 1970-76 study was sponsored by the UK Ministry of Overseas Development and carried out by a team from the School of Oriental and African Studies, University of London, under the direction of Ronald C. Y. Ng. The final
OED in 1988/89 returned to all but two (both control) of these villages, and added five more in the Stage II area. The village sites for both surveys are identified on Map 2. With the interesting developments under the OFWM and NEWMASIP programs, OED felt it was more important in 1995 to select sites that would give representation to these initiatives, to draw comparisons with the "Bank" laterals.

**B. Operational Performance**

1. **By the Agency**

3.4 *The Royal Irrigation Department.* RID, established in 1902, was transferred to the Ministry of Agriculture and Cooperatives (MOAC) in 1973. It is the largest government agency in Thailand, and commands 60 percent of MOAC’s budget. It is responsible for construction of all public irrigation schemes (as well as flood control and drainage works), and operation and maintenance services on those schemes down to and including the tertiary turnout. RID has 12 regional offices, of which RID Region 5 is located at Ubon Ratchathani. The O&M Branch of Region 5 is responsible for the Lam Pao scheme, 220 km away. The project director (Project Engineer, O&M) has his headquarters near the city of Kalasin in the middle of the project area. The scheme is divided into eight Sections of approximately 6,000 ha each, with a Watermaster in charge of each Section. Typically, the Section is divided into four zones, with a Zoneman and his canal riders, gatemen and other staff in support. In total there are 466 approved staff positions for operating and maintaining the Lam Pao System. At the time of the OED team visit in March 1995, 377 staff were employed, leaving 89 vacant positions. This gives 128 ha/staff person compared to 112 ha/staff person at the time of the 1988/89 IER field study.

3.5 *Reservoir Operation.* The Water Operation Center staff monitor and manage the reservoir. In the late spring, any excess water is released from the reservoir to the river in preparation for rainy season flooding. Also during the rainy season, excess inflow, based on flood control requirements, is released. With the exception of the 1993/94 dry season, the reservoir supply has always exceeded the capacity of the canal infrastructure to deliver year-round water at full design level.

3.6 However, even with full supply, RID formerly closed the canals for the three months each year when water was not needed for the two principal cropping seasons. Periodic maintenance was concentrated in that interval. The present scheme management has abandoned that routine, and is gradually establishing a year-round supply. The intention is to guarantee water for all seasons and thus "take water out of the farmers' risk analysis." This objective is limited only by the canal capacity, which, as mentioned above, was not designed to permit double cropping throughout the system, even with upland crops. As a rule, WUGs are instructed to advise members to grow only up to 60 percent of their irrigable land in the dry season. Farmers make their cropping decisions within that limitation and submit plans through their WUGs to RID for inclusion in the dry season water allocation plan.

3.7 *Irrigation Scheduling/Water Allocation Plan.* In theory, irrigation allocation at Lam Pao is based on a central control system where irrigation is scheduled periodically by the system.
managers based on the anticipated water needs. Until very recently, RID has never tried to "impose" a cropping pattern. RID field agents do remind the farmers that water cannot supply the entire command area in the dry season, and they plant paddy only at their own risk. The warnings appear not to have interfered with most planting decisions (para 3.24). In the early years of operation, irrigation water was released to match the design discharge for the estimated crop area without field information. To improve the accuracy of irrigation allocation and improve the effectiveness of water use, thereby enabling increased cropping intensity, a program was introduced that depended on intensive field data collection to schedule water releases.

3.8 The Water Allocation Scheduling and Monitoring computized program (WASAM) was introduced in Lam Pao by consultants during the period of the Chi Basin Project and run by the Water Operation Center. At present, Zonemen collect the irrigation demand—crop type and cropped area—from WUG leaders at the tertiary level. This information is passed on to the Watermasters in each Section where it is aggregated and sent to the Chief of Operations at the Water Operation Center—where it is entered into the computer. Data from a number of rainfall stations located at strategic points in the command area are another important component of the input to the water allocation model. Recalculation of water allocation is done in time for a weekly meeting of operational staff that includes the eight sectional Watermasters. Based on the decisions made at the meeting, instructions are given to adjust releases from the reservoir and to modify gate settings throughout the main system: to route delivery according to the irrigation allocation decision. This process was observed in operation during the OED team visit, even during the waning period of dry season cropping when water demand was low.

3.9 During the wet season, the Zonemen are expected to inspect water adequacy at the farm level, ranking adequacy on a scale of 1 to 5. In the WASAM protocol, this factor is used to allocate irrigation to the most needy areas during periods when there is no rainfall and competition for irrigation is high.

3.10 However, the original WASAM program proved to be too complex for RID staff to follow. The requirements for data collection, and for control of water levels and flows through the distributary canals, were beyond RID's staff capacity. NEWMASIP has introduced major changes in the protocol. Its objective is to enhance the operational utility and relevance of WASAM at Lam Pao, and to use that experience to extend it to the other two large-scale schemes in the NEWMASIP project while simultaneously preparing it for use at other RID schemes in Thailand. The NEWMASIP technical team has converted WASAM to a user-friendly Windows environment and used this as the core of its training program for RID staff.

3.11 **Main Canal Operation.** The canal must be operated at or near capacity during most of the year to meet crop water requirements. Careful monitoring of water levels is necessary to make adjustments in time to avoid over-topping the canal banks. Readings at strategic check structures are made three times a day and reported to the Water Operation Center by radio or telephone. Together with daily rainfall data, this information is processed to provide appropriate canal regulation to avoid damage. All available evidence indicates that these procedures are being successfully followed.

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10. See the remarks in para 5.26 about the "grow-less-rice" campaign in the Chao Phraya and Maeklong schemes.

11. Below the tertiary turnout, RID does not attempt to adjust gates, for example to spread a deficit by lowering all watercourse targets proportionally.
3.12 However, the main canal control structures are also supposed to be adjusted according to the allocation plan. Though it appeared that information collection and processing was adequate, inspection of head regulators and main canal off-takes suggests that rather than quantified discharge rates suggested by the WASAM program, system operators can only adjust gates to control the main canal water level and have no way to measure the quantity being released into laterals from the main canal. There are only a few calibrated head regulators that enable discharge monitoring in the main canal. The WASAM program gives precise targets for each lateral, but operational settings are only relative with much opportunity for undetected deviation from the prescribed delivery.

3.13 Since the gates were inspected at the end of the dry season cropping season when water demand was low, none of the off-take gates were set to operate according to their design as constant head orifices. The lack of staff gauges for setting the gates raises questions about their proper use. It appears that gates are adjusted to deliver irrigation based on the water requirement as assessed by the Watermaster of the lateral, rather than on allocation instructions from the Water Operation Center. Except for periods when water demand upon the main canal is greater than can be supplied, this is the easiest and lowest-cost operation procedure. Since the OED team was unable to observe operation under stress conditions, it is not clear if they switch to calibrated off-take settings. Absence of gauges and lack of calibrated structures suggests this is highly unlikely.

3.14 But careful control and monitoring of the main and its outlets is one of the components of the original WASAM system that NEWMASIP intends to restore. To that end, its 1995/96 budget includes funds for providing measuring scales along the length of the mains, and staff training for discharge measurements from the main.

3.15 Lateral and Sub-Lateral Canal Operation. At the lateral level, irrigation delivery to the tertiaries is by rotation during periods of short supply. In the four sample laterals where the NEWMASIP and OFWM programs provided assistance, user groups have been formed at the lateral level. The other two sample "Bank" laterals do not have lateral groups, and have the largest number of missing and broken gates and by far the largest number of illegal off-takes from the canals. Rotational irrigation delivery has not been successful in these latter two sample laterals, while farmers reported few problems with rotational delivery in the four sample laterals with assisted organized groups.

3.16 If RID believes that sufficient water is not available to issue to all laterals, it has two options. It can advise farmers through the Village Headman and RID Zoneman not to cultivate land, as it did during the 1993/94 dry season. Or it can try to enforce a water rotation. Rotations at Lam Pao are practiced along the laterals and sublaterals at the tertiary canal level, though only where paddy is cultivated. The most common rotation is to issue water continuously for 6-7 days to a tertiary and then close its turnout gate for 3-4 days. The Zoneman organizes the rotation with the help of WUG leaders of the lateral and supervises its implementation. RID attempts to introduce water rotations in such a way as to guarantee water to the tailend tertiaries. But without reliable control structures and farmers who obey rules, those plans are often frustrated.
2. By the Irrigators

3.17 Operation of the Tertiary Canals. At the tertiary level, farmers have taken ownership of the canals and all have formed tertiary-level WUGs. Farmers from the NEWMASIP-assisted laterals reported they had few problems with water adequacy or distribution. Those in laterals assisted by the OFWM program reported moderate problems but indicated that they are able to manage them. One of the unassisted sample laterals reported difficulty in managing the conflicts over water delivery in the tertiary, and the other cited technical (a problematic cross drain) rather than management or institutional problems.

3.18 Operation at the Field Level. Farmers are responsible for all field-level irrigation activities, including maintenance. In areas where they only grow rice, there are fewer field ditches and farmers tend to irrigate their plots by field-to-field flow. However, for upland crops and fish ponds, they use ditches to give independent water control to each plot. One reason that farmers gave for not growing more non-rice crops in the lower part of the system was seepage from neighboring flooded paddy fields made it difficult to grow non-rice crops. They also had fewer field channels to give independent water control to individual fields and indicated that the cost of digging temporary drains to protect non-rice crops was prohibitive.

3.19 Conflict. Farmers from the two laterals that have not received outside assistance since the Bank projects did indicate a much higher level of conflict over water delivery among tertiaries, and one of them even within the tertiary. WUG were in place on both laterals, but weaker than at the assisted laterals and one of them seemed quite ineffective (see the criteria in para 3.2). They described classic head-to-tail problems in the laterals and inability to organize and operate rotational distribution during periods of shortage. Structures in these laterals were heavily damaged and many lateral off-take gates were completely removed. On the occasions when RID would try to provide water first to the tailend of laterals in the non-assisted areas, the effort often failed. Headenders were not prepared to see water they needed pass their holdings. RID's efforts to encourage the WUG to handle these problems have been insubstantial and ineffective.

3.20 One WUG leader talked of the "anarchy" that followed the onset of a period of particularly stressful water shortage during a wet season. This comment fits neatly to the thesis—advanced in the literature on irrigation in recent years—regarding the chaotic conditions of water sharing in the monsoon tropics during a mid-monsoon dry spell. The argument is that the monsoon farmers already have a standing crop in the field, planted in the expectation that supplemental water would be available during dry spells, and, when this does not happen, they fight to obtain water for their crops. Gates and other obstacles are broken or improvised depending on where the water has to be rerouted. This plausible scenario is said to characterize all irrigation behavior in these regions.12 This WUG leader was talking in particular about conditions along his tertiary, and of the turnouts to nearby tertiaries. He went on to say that the

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12. See in particular: (1) the PAR on the Maeklong Projects (see footnote 5 of this report); (2) "Skimming the Water: Rent-seeking and the Performance of Public Irrigation Systems," by Robert Repetto, Research Report #4, World Resources Institute, Washington, D.C., December 1986 (Repetto was the first to apply the phrase "populist anarchy" to monsoon irrigation systems); (3) "India Irrigation Sector Review: Irrigation Management on the Indo-Gangetic Plain," by D.J.W. Berkoff, Asia Technical Department, World Bank, June 7, 1990; (4) "Irrigation Rice Culture in Monsoon Asia: The Search for an Effective Water Control Technology," by Robert E. Burns, World Development. Vol. 21, pp. 771-789, 1993; and (5) A Review of World Bank Experience in Irrigation, OED, World Bank, Report No. 13676, (Chapter 7), November 3, 1994.
problems were much reduced in the dry season, when farmers plant far less rice and only when they have reasonable assurance they can harvest.

3.21 Care must be taken in interpreting the impact of activity that appears chaotic. Broken or removed tertiary gates do not necessarily mean that farmers are unable to control water distribution from the tertiary. Straw, earth, and stones were being used to control discharge and direct water delivery. Fixed gates make adjustment of discharge much easier, which is precisely why farmers frequently choose to remove or damage them. Although tertiaries at the end of the longest sub-laterals, and any canals that are not raised well above the surrounding fields, will continue to suffer shortage due to insufficient capacity or pressure, even with the mains running full, there is no pronounced "scarcity" problem at Lam Pao comparable to what the OED impact team saw, for example, at the Kinda and Kinmundaung sites in Myanmar.

3.22 The following quote from the field notes from one of the team's visits to the NEWMASIP area captures the spirit of abundance:

"I looked at parts of laterals #9 and #11 near the village. I was accompanied by the lateral group leader. They have lined about 900 m to stabilize the bank. There was leakage water in one field we inspected. We found an illegal buried pipe that crosses the road along the tertiary we were following. The wet field belongs to the command area of a tertiary located higher on the lateral, but this field is located on its tail. So the farmer steals water from the lower tertiary in the wet season when his legal supply from the upper tertiary does not meet his needs. However, it is difficult to completely close the illegal pipe and the leakage in the dry season makes it visible. The lateral group leader was amused but not upset that we found the pipe. Irrigation supply was no problem. There were no missing or broken gates. Except for spots where the canal has slumped slightly or eroded at a structure there were no visible problems with the distribution system. Now that they have worked out an agreed-to rotation there is minimum conflict even when everyone wants additional water. He and two other farmers I talked to on the field visit indicated that quantity and timing of water delivery was adequate and did not limit their cropping decisions."

3.23 Even though this lateral was in a favorable location, the relaxed answers about water supply were typical of conversations throughout the scheme. While recognizing the potential for chaos, OED's finding is that "rent-seeking" and "popular anarchy" are not apt descriptions of prevailing farmer behavior at Lam Pao. Informal social controls are in force that smooth the edges of hostile acts, and not even the headenders can get away with anything. Illegal pipes, farmer-made turnouts, and broken gates are visible everywhere: OED saw a few of them even in the NEWMASIP areas. But they do not mean the distribution system is out of control, in either season.

3.24 **Reliability and Timeliness of Water Delivery.** The main and lateral canals were designed for supplemental irrigation of rice in the rainy season. They were not designed to deliver 100 percent of the crop water requirement for paddy in the dry season, and the size of the canals limits flexible water delivery. Farmers visited with land in laterals that have been improved by the recent projects reported that water delivery was not a serious problem. They said their cropping decisions are more dependent on prices and labor availability than water considerations. Farmers in the improved areas gave numerous examples of delivery not being always reliable because of delays in emergency maintenance described below. But it appears
neither the frequency of nor damage done by these events significantly affects the planned cropping pattern.

3.25 In that sense there has been a clear improvement above the situation described at completion of the Stage II project. In the 1988/89 impact field review, OED's university enumerators compiled a quantitative basis establishing a "happiness index," which was a joint measure of reliability and timeliness of water delivery. Even then, only 1 of the 15 villages in the survey was rated "not satisfied" with wet season deliveries, and 5 of the 15 with dry season deliveries. All unsatisfied villages were in the area of Stage II, completed three years before. (Map 2 carries forward the happiness key.) By 1995, OED found few expressions anywhere of dissatisfaction with the scheme at a level that would call for a negative village rating, at the six sites selected for group interview or at any of the casual discussions elsewhere.

3.26 That does not mean there are no complaints. Farmers from the unassisted parts of the scheme, when consulted, have expressed more concern. They complained that rotations would be agreed and then fall apart. A delegation of 40 farmers from a tailend area made the 60 km journey to the RID office to request improved water delivery to complete their rice crop just a few days before the OED team visited the office. In this case, weeds in the right bank main canal were limiting the discharge reaching the tail area.

3.27 One Thai officer in the NEWMASIP program, in charge of preparatory work for on-farm system improvement, told the OED team that it was always more difficult to develop strong WUG if there was a lot of water, a condition he attributed to Lam Pao. The farmers felt less need for them.

3.28 Water-User and Lateral Groups. Until recent years, the Royal Thai Government did not encourage the formation of farmer groups. However in covenants of loan agreements with the Bank, the Government promised to introduce farmer organizations for irrigation O&M. In Lam Pao, WUGs were established with the construction of the tertiaries in Stages I and II. The Bank did not finance this institution-building component and the groups performed little until the OFWM program began to strengthen them by introducing rules and regulations of water delivery and maintenance. The NEWMASIP strategy has been to emphasize the formation of group control at both the WUG and lateral level. A cadre of field workers called Irrigation Coordination Organizers played a vital catalytic role in this regard.

3.29 WUGs take hydraulic boundaries as their boundaries, which can cut across village or hamlet boundaries. Often members of a WUG are not members of the same village. As a result, there is no natural social basis for them to cooperate. In this context, the formation of viable WUGs is a difficult process. Hence, NEWMASIP is promoting the two-tier structure, the first at the tertiary level and the second grouping WUGs on the laterals and sublaterals.

3.30 Only the landowners of a tertiary can become members of a WUG. Its main functions are to plan water distribution within the tertiary and to mobilize unpaid labor for maintenance. Each WUG has a group leader and sometimes an assistant leader. Each WUG meets at least once at the beginning of each season to plan tertiary maintenance. Where the lateral groups (LGs) have become strong, in the OFWM and NEWMASIP blocks, the functions and activities

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13. The land usually belongs to the women, but the men are recognized as legal landowners and usually represent the households in the WUGs.
of the primary groups, the WUG, appear to decline. This is to be expected, because the critical decisions on water sharing and scheduling for shut-down and cleaning are taken at the higher level, and the WUGs need not convene simply to confirm agreement for their particular watercourse. The frequency of WUG meetings falls off sharply, though not group work on maintenance.

3.31 An LG operates as an apex WUG. For example, one vigorous lateral group in an OFWM area has 484 farmers who cultivate about 1,000 ha. The main functions of an LG are to (1) check the water level at the lateral and inform the Zoneman of any emergency; (2) carry out damage surveillance of the lateral and its tertiaries; (3) check and assure that all tertiaries get adequate water; (4) decide the WUGs' maintenance schedules; and (5) decide how much the WUGs can fine shirkers. Although RID remains formally responsible for O&M of canals and structures through to and including the tertiary turnover, it has transferred to the LGs informal control over tertiary gate operation. Presumably maintenance will follow. The LG meets at least once a cultivation season to discuss the O&M and rotation schedules. An LG sometimes cultivates common lands to generate income for the LG fund. Sometimes also LGs organize hired labor gangs to help RID with its maintenance activities. In addition, LGs organize voluntary work by WUG members to assist RID in repairing and weeding canals. The LG Committee is composed of all WUG leaders of the lateral and the Watermaster and Zoneman of the area.

3.32 The need for group formation at the tertiary and sublateral/lateral levels is now well recognized by RID and the farmers. Those WUGs and LGs that function well have contributed significantly to O&M and crop diversification. In some instances, such groups have assisted members with input purchase, marketing and loans. Although the LG initiative by NEWMASIP appears to have had a successful start, there is as yet no definitive plan to create a further upper tier at the project level although that remains one of the NEWMASIP objectives.

C. Maintenance Performance

3.33 RID manages all maintenance of the main canals. Much of the lateral maintenance is done directly by RID, sometimes by hiring farmers as laborers. Farmers in all of the sample areas reported providing some assistance to lateral maintenance and some said they voluntarily made minor embankment repairs and cleaned weeds to safeguard their water supply and improve water delivery. Farmers in all the sample areas reported that they own, maintain, and operate the tertiary canals. In several cases they have received material assistance for improving structures in problem areas.

3.34 The 1988/89 OED impact team reviewed the status of the irrigation infrastructure and concluded it was unsatisfactory. The IER report rated each component of the system, including the dam, conveyance, distribution, turnouts, farm channels and drains. The ratings were mostly "poor," though the main canals were rated "fair to good." OED's judgment six years later is that those lower ratings must all be raised a notch, especially in the half of the scheme with subsequent assistance but even in much of the unassisted area. The following paragraphs review the outcome of measures taken to improve the situation.

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14. The current fine rate ranges from 50 to 200 baht a day, or US$2-8, for failing to participate in canal cleaning, and 50 baht for missing a meeting (the average daily agricultural wage is 90 baht, about US$3.75).
3.35 **Reservoir.** The spillway gates were replaced by inflatable rubber gates which successfully control the reservoir spillway. The wet layer in the dam reported in 1990 was excavated to investigate the source of water. It was determined that the source of wetness was not seepage from the reservoir. As an additional safety measure, piezometers were installed at intervals in the dam to enable monitoring of water pressures and seepage from the reservoir. As a result of these modifications, the reservoir is currently operating at full capacity without difficulty.

3.36 Heavy rains carry sediment into the main canal in the "cut" section just under the dam where the canal runs below ground level. Surface interceptor drains have not been adequate to overcome this problem. The solution so far has been to remove the sediment manually. An excavator was recently purchased to assist with sediment and weed removal. A long-term solution requires study and testing, including the possibility of protected revegetation of the eroding surroundings.

3.37 **Main Canals.** The present Lam Pao management is giving priority to maintenance of the main canals. Most parts of the system observed were in good repair. For example, all the gates on cross regulators were in operating condition. About 90 percent of the inspected CHO off-take gates from the main canal were also in working condition. Some had minor damage but were functional.

3.38 However, persistent weed and sediment problems exist in the main canals and continue to reduce their capacity. The weeds of the RMC have been particularly bothersome. The slope of the main is too gradual for effective self-cleaning. The standard plan is to de-water and clean the mains once just before each irrigation season. But, during the growing season it is difficult to keep ahead of weed regrowth, and de-watering is not an attractive option. Unlined segments have the greatest problem with weeds.

3.39 Since recently initiating a policy of supplying water during all months of the year, maintenance and repair requiring canal closure are even more difficult. Nevertheless, as part of RID's campaign to improve the reliability of the system and build farmer confidence in timely irrigation delivery during all seasons, maintenance is now carefully planned ahead of time, and crews work several shifts if necessary to complete work more quickly. The OED team was able to observe the staged approach to main canal lining necessary under this policy. Part of the lining for a segment of the main canal was constructed during one period of shutdown and completion was planned as soon as most dry season crops no longer require water. By preparing all materials ahead of time and organizing crews to work multiple shifts, it was possible to greatly reduce the canal closure time.

3.40 This arrangement, though logical, is uncommon among government-run irrigation departments and a strong signal that farmers' concerns rather than irrigation agency convenience were being taken seriously by the present Lam Pao scheme managers. While there was ample evidence that the plan for improving irrigation delivery reliability was in effect, it was still too early to determine the response.

3.41 **Lateral and Sub-lateral Canals.** Constant head orifice off-take structures were installed to control water delivery from the main canal to laterals and from laterals to tertiaries. Observation, confirmed by RID staff, was that CHO gates are not operated in the prescribed manner necessary to achieve accurately metered discharge rates intended to match the irrigation
allocation. Instead, one of the two gates is generally kept fully open and the other is operated to give relatively more or less water rather than setting a quantified discharge. Staff gauges essential for accurate double gate constant head settings are missing. There was no evidence that off-take structures have been calibrated so that a single gate could be adjusted for the prescribed discharge.

3.42 The state of repair of the structures along the laterals and sub-laterals examined varied widely. The OED team’s observation was that the repair status of the structures in the six sample laterals visited relates to their age. The NEWMASIP structures were in the best condition, with the OFWM programs next best. Even though they are seldom operated properly to achieve predetermined or measurable discharge, off-take structures are functional, except that they lack staff gauges for setting water levels. The lateral canals and off-takes to tertiaries were also in reasonably good repair, with considerable evidence of recent maintenance. There was some evidence of disrepair of relatively new structures, but that was not extensive. Farmer groups in areas where the OFWM and NEWMASIP activities took place said they assist with repairs when necessary.

3.43 Gates along the two laterals examined in areas where follow-on projects have not provided assistance were in poor to non-functional condition. The non-functional gates, both main canal and lateral off-takes, were primarily in the Stage I project area. This is sandier soil, so that the embankments themselves are more difficult to maintain. Structures everywhere do deteriorate with use and these were constructed over 15 years ago without major rehabilitation. Control of lateral to tertiary delivery is accomplished by farmers placing stone, earth, wood, and other materials to block and/or divert flows.

3.44 Institutional factors differ among these laterals. There was a notable positive correlation between the condition of lateral structures and level of farmer group organization. Stronger lateral-level farmer groups also practiced more extensive cultivation in the dry season, particularly concentrating on cash crops. Organized WUGs were able to influence the reliability and timeliness of irrigation delivery. While lateral-level groups improve coordination of water delivery among the tertiaries, reducing conflicts and damage to structures, their maintenance role is also important.

3.45 Overall, the perception by farmers seemed to be that RID does what is necessary to keep the lateral canals in working order, though sometimes there are long delays. Farmers indicated that they frequently help with routine weed and sediment removal from the lateral canals. In many cases they were hired by RID to provide maintenance labor. The laterals examined with organized lateral groups indicated they themselves sometimes initiate maintenance, such as weed removal, to improve canal discharge and preventive measures when they see water leaking from the canal. Most important was the impression that, where lateral groups have been formed, there was greater concern for the status of the lateral structures and less criticism was directed at neighboring farmers disrupting irrigation delivery. This may translate into fewer incidents of damage to lateral structures.

3.46 One of the striking lessons from Lam Pao, obvious in the comparison of the recently assisted watercourses and the “Bank” watercourses, is the effectiveness of strong group activity in both operation and maintenance. The TA activity by OFWM and NEWMASIP is paying off, and the institutions and improvements in performance would appear to be durable. The fact that in the OFWM blocks, where technical assistance was withdrawn three years ago, the WUG
retain this new vigor helps overcome doubts that the institution-building will last only as long as the donor-supported teams.

3.47 Emergency Maintenance. Farmers from the RMC lower lateral visited showed the OED team a problematic area mentioned above where leaks frequently develop and cause the raised canal embankment to breach. The canal embankment is raised several meters to cross a low area. The light soil available for constructing the embankment frequently develops leaks and fails. The farmers explained their understanding of the nature of emergency maintenance problems and how RID responds. They emphasized that when they see signs of seepage from the canal, the farmers immediately take action. If it is allowed to develop into a leak and breach, it may take weeks to repair and they will lose their crop. Even though maintenance of the sub-lateral is RID's responsibility, the farmers organized to make temporary repairs. The first step is to control the seepage by placing sand bags and tamping earth into the embankment. They report the problem to RID field staff and request that the discharge be reduced to decrease the pressure on the canal embankment. RID's technician visits the site, and also investigates the water requirements of the crops affected by the canal disruption. If crop damage is likely, he would recommend the RID send a "maintenance group" on priority basis. As RID has insufficient funds and manpower to respond to all requests, prompt action is uncertain. The farmers also lobby RID scheme headquarters for permanent repair that is beyond their ability.

3.48 RID generally responds immediately by sending someone to evaluate the situation and report to the maintenance department what action will be necessary and an estimate of the urgency. The maintenance department then establishes priorities for emergency response relative to all the requests in hand. The farmers reported that generally RID makes repairs within two weeks but sometimes not in time to prevent reduced yield or even total crop loss of an area. In 1994 they reportedly lost the entire crop in a 5 ha area influenced by a damaged canal. This may be an unusual area since they reported that RID makes two or three emergency repairs there per year.

3.49 One lesson from this account is that even on the older laterals, without technical assistance, the farmers are able to coalesce to deal with a major problem affecting all their fields. "Anarchy" is abandoned when mutually supporting action is warranted.

3.50 It should also be emphasized that RID has taken a much more proactive stance in the last three years, associated with the arrival in 1992 of the present Lam Pao project director. Improvements in the OFWM and NEWMASIP areas are being matched, as the budget allows, by better maintenance, WUG support, and operational procedure in the unassisted half of the scheme.

3.51 Field-Level Structures and Farmer Maintenance Input. There was evidence in all six sample laterals that tertiary groups were taking an active role in maintenance, though not all to design standards. Areas that have not received assistance from follow-on development projects had the highest portion of broken tertiary and field-level structures while, in most of the recently improved areas, field-level structures were in excellent condition. The level of maintenance activity also varied among the samples according to the problems they face. As mentioned above, one of the tertiaries that has not received outside assistance for improvement has a difficult situation with a cross drain that requires frequent and extensive repair which they have managed for many years. Other WUGs appear to have relatively little maintenance other than
routinely cleaning weeds, reshaping canal banks, and removing silt, which requires from one to five days of labor by each farmer each season.

3.52 One of the benefits resulting from organized WUGs is recognition and acceptance of water delivery rules. This appears to greatly reduce damage to structures found where ad-hoc group activity takes place.

3.53 The condition of the tertiary canals and smaller channels themselves, apart from gated structures, appeared everywhere acceptable. As in other country case studies included in OED's regional review, there was no evidence that the farmers were not contributing to and effectively maintaining the serviceability of the tertiaries and field channels. They were not all pretty, and likely to be full of weeds when water was not required. But when it was, they were cleaned as much as necessary to let the water pass, unless there was an obstruction the WUG could not correct without RID's assistance.

3.54 **Drainage.** The 1990 IER report describes conditions of flooding at harvest time in the tail reaches of the command area. In 1995, neither farmers interviewed nor system managers identified drainage as a problem.

3.55 **Irrigation Fees.** Government's official position is not to collect fees from farmers for irrigation works and services (or flood control) anywhere in Thailand. Government has agreed with the Bank from time to time to start collection for both capital costs and O&M, and on the OFD schemes such as at Maeklong (this does not include OFWM at Lam Pao) capital charges are made. Legislation exists backed up by a legal framework that would allow RID, CPD and other agencies also to collect O&M fees on all schemes. But parliament has thus far refused to approve the action, and government is reluctant to enforce the powers it already has until RID can guarantee reliable water delivery. Also, "water is from heaven" is still an appealing rallying slogan to keep the status quo. Thus, at Lam Pao reservoir water has always been free. Paddy farmers used to pay an indirect tax charged on paddy exports, which government argued was a suitable cost-recovery mechanism. But this tax was rescinded in 1987 following the decline in international rice prices.

3.56 WUGs generally do collect fees from members to cover costs of minor maintenance work, though the seasonal charge varies widely. One WUG may charge 40 baht (US$1.70) per rai (six rai = one ha) per season, while another charges 3 baht. If a member fails to provide one adult for each cleaning session, either family or hired labor, the household pays a fine to the WUG comparable to the actual wage.
4. Lam Pao Scheme: Agro-Economic Impacts

A. Agricultural Impact

4.1 Net Cultivated Area. Stages I and II brought the scheme to the full design size. The IER report (1990) uses 48,534 ha as the total area irrigated, but subsequent RID data suggests that that figure is a little low. The largest areas reported by RID for a wet season crop were in 1992 and 1993, both at about 49,500 ha. That is the figure used in this report.

4.2 Cropping Intensities. Table 2.1 (page 12) also shows the rainy and dry season cropping intensities for the period from 1986 through 1995, based on RID tables. The entire command area has been cropped during the rainy season. There are reports that some farmers have been reducing their wet season plantings, but this behavior is not so significant as to show up in the RID estimates. In the dry season there was an almost steady increase in the cropped area from 15 percent reported by the IER for 1987/88 and shown in the table, to 50 percent in 1992/93. This compares well with the 150 percent targeted for overall intensity at appraisal of Stage I, and 160 percent at appraisal of Stage II.\footnote{The 1990 IER report (page 19) states that from 1986 to 1988 the cropping intensity increased from 110 percent to 121 percent for Lam Pao I and from 104 percent to 127 percent for Lam Pao II. However, Tables 2.02 and 2.03, page 13 of the same report, show the same data and cropping intensity for 1987/88 that the 1995 OED team was given by the system managers, which computes to 114 percent cropping intensity using a service area of 49,500 ha.}

4.3 However, RID data on more recent years moves in the other direction. The 1993/94 figure in Table 2.1 is irrelevant, because cropping was disallowed. Above average rainfall in August and September of 1994 filled the reservoir for the 1994/95 dry season crop. But the actual figure for that year (28 percent for the dry season), and the planning target for the 1995/96 dry season (32 percent), suggests that the upward trend in dry season intensities may have leveled off if not reversed, and that RID is basing its near-term plans on that assumption.

4.4 Over the long run the RID project director is confident that with diversification from rice to high-value crops in the dry season, it will be possible to achieve 200 percent cropping intensity. Except for a brief period in the winter, and short periods at the end of the rainy and dry seasons that are coordinated with the farmers, his new policy is to keep the main canal filled to the design level all year. The director believes that if RID can convince farmers that water will be delivered reliably in all seasons, farmers will experiment with high-value crops which require less water than rice and progressively reduce the area fallowed.

4.5 For reasons discussed at greater length in the next section, OED considers the director's target admirable but ambitious. For one thing, the "under-dimensioning" of the Lam Pao canal system will forever constrain dry season plantings. Given the economics of new irrigation investments (para 4.29), the possibility that Government will approve enlarging the capacity of the scheme is remote. For OED's re-analysis of ERR (para 4.28), a maximum dry season intensity of 50 percent is assumed, a not-ungenerous projection. Paddy would comprise 80\% of the cropped area.

\footnote{The IER report noted that intensity was increasing, and, for its re-estimate of the economic rate of return, anticipated "some progress in cropping intensities". The IER report does not show the projected intensity used in its re-analysis, though the language suggests it was below 150 percent.}
percent of the dry season planted area. If the paddy were all substituted by cash crops, with only
two-thirds the water requirement of paddy, the dry season intensity would increase to 70
percent, or 35,000 ha. That is what the director is counting on. That is what other analysts
consider to be most improbable. NEWMASIP's agricultural economics unit, in a mid-term
evaluation of the whole of the NEWMASIP program, puts a ceiling of 25,000 ha (51 percent)
on dry season intensity and, within that, 8,000 ha on the cash crop (i.e. non-paddy) potential at
Lam Pao. Other NEWMASIP consultants consider even that too high.

4.6 Cropping Pattern. Lam Pao was and remains largely a double-cropped paddy scheme.
Almost 100 percent of the area is planted to paddy in the wet season, and about 80 percent of the
reduced area planted in the dry season, giving an overall paddy percentage of total planted area
in the five years 1989/90-92/93 and 94/95 of 94 percent. The percentage had been increasing,
due to improved farm gate prices for paddy in the years up through 1993. But it reversed in
1994/95. In terms of the types of paddy, in the 1994 wet season the proportions of glutinous rice
(GR) and non-glutinous rice (NGR) were about 9:1. Almost all the wet season paddy was
transplanted, and almost all was high yield (HYV) or improved local varieties. In the dry season,
nearly 70 percent of the paddy crop was both NGR and HYV. It was mostly broadcast, with pre-
germinated seed. The percentage of HYV has been increasing in both seasons. Typically, the
farmers keep just over half of the wet season's GR crop for home consumption. Before
irrigation, they had to keep almost all that they harvested. The NGR rice is sold.

4.7 The other crops cultivated are groundnuts (about 50 percent of the area planted to non-
paddy crops), followed by watermelon, sweet and baby corn, cucumbers, tomato, and other
vegetables that vary in importance depending on price changes. About 300 ha of fish ponds are
kept year-round by farmers as an additional source of household income. The ponds provide one
element of a vertically integrated cropping system, the prospects for which have excited some
recent visitors. It is diversification that will eventually determine whether the scheme remains
economically viable and financially acceptable for the young adults of the household.

4.8 High labor costs, lack of experience, unfamiliarity with options for diversification,
inadequate extension services, poor seeds, inappropriate and generally infertile soils, and
uncertain dry season water supplies are the main reasons usually cited for limited cultivation of
cash crops. However, only the first of them, high and rising labor costs, moves the debate to the
arena where Lam Pao's future cropping intensities and cropping systems will be decided. The
incentives to dry season cropping, and indeed to wet season paddy, are being determined not at
Lam Pao but in the cities and industries that are powering the emergence of Thailand as a
modern economy. Rural wage rates at Lam Pao are three to four times the levels in the two other
countries where OED visited irrigation systems in this regional review, Myanmar and Vietnam.
Opportunities for alternate employment in the booming economy are opening outside the farms
and outside the northeast. As these other jobs expand, the meager incomes available to farmers
and their families committed to paddy and traditional upland crops become increasingly non-
competitive.

17. That is the ratio RID uses to estimate crop water requirements at Lam Pao.
4.9 Two of the NEWMASIP consultants concluded, in another recent report on the prospects of the irrigation schemes, that either there has to be a decisive shift to irrigated cropping systems with high value added or the cropped areas will start to shrink and the farmers will abandon their fields. These consultants see good potential for one of the NEWMASIP activities, presently under implementation on all its scheme sites, referred to as the integrated/diversified farming component, where field crops, fish ponds, poultry and other livestock are organized in a symbiotic system where each reinforces the economy of the other. In such systems, *cropping intensity* gives way to *value intensity* as the defining index of performance. The consultants reckon that the farm incomes and returns to labor of such integrated systems will be high enough to compete as effectively for at least some of the young adults of Lam Pao as off-farm employment.

4.10 Interestingly, they also conclude that improved effectiveness of high profile components like WUGs and WASAM will have practically no influence on the emergence of these modern farm entrepreneurs.

4.11 Another approach to value-intensive farming is the "contract farming" model introduced by private sector companies to stimulate production of specialized cash crops for urban and international markets. This is being supported by NEWMASIP, and by RID management at the project site. It has not been as successful at Lam Pao as expected when it started in 1990, partly because neither the companies nor the farmers have learned to keep their commitments. Other reasons cited are inadequate extension and marketing facilities provided by the companies. Previous attempts to induce the irrigators to grow tomatoes for canning, and water melon for seed, were initially successful, but reversed later when the companies for one reason or another refused to buy part or all of the crop. One of the examples mentioned in OED's group sessions was about a number of farmers who had contracted to grow baby corn, but the company agents arrived later than the date agreed after the cobs had lost their quality. They declined to buy the crop. Possibilities for a turnaround and substantial growth of the contract farming business at Lam Pao are recognized, with past failures interpreted as inevitable growing pains. The project director insists that the missing element is simply to bring stability to the contracting process. But there are limits on how far this arrangement can expand, as explained next.

4.12 The project director was transferred to Lam Pao from the USAID-supported RID scheme at Lam Nam Oon, 100 km northeast of Lam Pao. There, with the help of an American technical assistance team during the mid-1980s, he induced several national and international agri-businesses to set up operations. This scheme is now considered the most successful in the northeast. He brought his optimism, experience and enlightened management to Lam Pao. That is why he was transferred: to improve water management, intensify farmer services, and make the largest RID scheme in the northeast also sparkle.

4.13 NEWMASIP's more conservative assumptions about the limits on dry season cropping are supported by the numbers of farms and farmers involved at the two schemes. Lam Nam Oon has 27,000 ha, compared with Lam Pao's 49,500 ha, and it too is well endowed with water for extensive dry season cropping. Nevertheless, after ten years of operation, dry season non-paddy farming occupies 3,000 ha, only a third of which is committed under contract. The contracted area peaked in 1991 at 1,320 ha, and leveled off at 1,050 ha over the next two years involving

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about 4,000 farmers. Those figures compare with 20,000 households at Lam Pao, and the 8,000 ha ceiling which NEWMASIP has put on projections for dry season, non-paddy cropping at that scheme. Even if contract farming "takes off" at Lam Pao, it cannot substantially improve upon the size of the operation in the success story at Lam Nam Oon. These projections depend of course on the demand for the specialty crops. USAID has described the contracted markets as "niches." It is difficult to imagine thousands of hectares of watermelons being planted for seed, at any site.

4.14 Continued, subsistence-oriented wet season paddy, a shrinking perimeter of dry season cropping, and vigorous and profitable ribbons of contract and integrated high value-adding producers along the principal canals, are not inconsistent or implausible images of Lam Pao's future.

4.15 Yields. Lam Pao paddy yield estimates for wet and dry seasons, GR and NGR, HYV and local improved varieties, vary too much for OED to make any safe statement. Reasons for this variance are unclear.

4.16 The Staff Appraisal Report (SAR) for Stage II projected wet season yields at full development of 3.0 and 3.8 tons/ha, depending on the variety, and 4.0 t/ha for HYV dry season. Subsequent estimates are shown in Table 4.1:

<table>
<thead>
<tr>
<th></th>
<th>Wet</th>
<th>Dry</th>
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</thead>
<tbody>
<tr>
<td>SAR 1978</td>
<td>3.0/3.8</td>
<td>4.0</td>
</tr>
<tr>
<td>IER 1988</td>
<td>2.7</td>
<td>3.6</td>
</tr>
<tr>
<td>NEW 1 1994</td>
<td>2.5</td>
<td>3.1</td>
</tr>
<tr>
<td>NEW 2 1994</td>
<td>2.9</td>
<td>2.7</td>
</tr>
<tr>
<td>OED 1 1995</td>
<td>3.2</td>
<td>4.1</td>
</tr>
<tr>
<td>OED 2 1996</td>
<td>3.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

4.17 "NEW 1" refers to NEWMASIP's economic report referred to in Footnote 18. "NEW 2" refers to a baseline study of the NEWMASIP areas of Lam Pao Stage I.20 "OED 1" refers to findings from the OED impact team's participatory rural appraisal group sessions, which were attended by higher-than-average performers. OED 2 are estimates used in this report.

4.18 The most scientific estimate is NEW 2, based on a formal survey of 50 headend and 50 tailend farms, interviewed before the NEWMASIP activities had impacted on farmer performance. But it was carried out in early 1994, and thus the low "dry" value reflects the nearly waterless dry season of 1993/94. Given the larger area planted to wet season paddy, OED has taken a figure 3.0 t/ha to represent actual Lam Pao yields in both seasons. A more recent estimate by NEWMASIP for the whole of the Lam Pao scheme shows even lower yields, about 2.5 t/ha for the two seasons taken together. This scheme-wise average is weighed down by

unimpressive performance outside the newly assisted blocks. NEWMASIP says there is a potential for improvement above that low figure. For this analysis the more generous 3.0 t/ha estimate is used.

4.19 It is important to note that in both the NEWMASIP baseline study and the OED group interviews, there was practically no difference reported between headend and tailend yields. In fact on some laterals the tailenders reported slightly higher yields. This is an important piece of information when assessing the efficiency of the distribution system, and actual losses attributable to poor O&M.

B. Financial Impact, Farmers' Level

4.20 The average irrigated farm size shown in NEWMASIP's 1994 baseline survey for Lam Pao (see footnote 20) is 14 rai, or 2.2 ha. The SAR for Stage II, prepared in 1978, projected family incomes from irrigated paddy farming at about US$2,600 per farm (converted to 1995 dollars). It assumed a dry season cropping intensity of 60 percent, with half of that in paddy. The total was about four times the without-project (without irrigation) income. Using NEWMASIP's analysis of its baseline survey, and a dry season paddy intensity of 50 percent as it hit its peak in 1993, OED reckons the 1995 annual paddy income of the same SAR farm for the two seasons is about US$600, less than a fourth of the SAR projection (and hence about equal to the SAR's pre-project income). The decline of the international rice price explains most of that difference. Lower yields, and substantially higher labor and other input costs in real terms, account for the rest. Of the US$600, about US$350 represents the value of paddy retained for family consumption. The family nets $250 in cash income. These figures do not include earnings from non-paddy crops, or from off-farm income. But they do demonstrate the substantial decline in incentives from paddy farming compared with appraisal estimates, and the meager rewards that this form of household employment now offers to the average Lam Pao family.

4.21 These estimates refer to a 2.2 ha irrigated farm, the size represented in NEWMASIP's baseline survey. Other farm-size estimates are higher: this report quoted 3 ha in a preceding section, and other sources point to averages between 2.2 to 3.0 ha. Using the upper boundary, farm incomes calculated in the last paragraph should be increased by 36 percent. Expanding farm size is one strategy to make farming more attractive, and there is good evidence that consolidation has been taking place. However, there is also evidence that farmer use of fertilizer and other cash inputs has been shrinking, in an effort to reduce costs. The two trends, concentration of ownership to expand the farm's potential earning capacity, and cost minimization as the family redimensions the farm enterprise to purely subsistence targets, appear to co-exist at Lam Pao. A few other farmers are selling land and leaving, and that trend is expected to accelerate.

4.22 Returns to family labor per day are somewhat more competitive with alternative incomes. Referring to the most recent NEWMASIP data on returns to labor, and assuming the

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21. The parameters are: Area=2.2 ha; Yield=3.0 t/ha; Intensity=150%; Paddy Price=3,500 B/t(US$146/t); Costs=US$260/ha/season.
22. OED's selected figure of 3.0 t/ha is about one ton short of the SAR projection. See Table 4.1.
23. Based on per capita annual rice consumption of 250 kg, or 2.5 tons of paddy for a family of six.
family is large enough to avoid hiring help, the returns per day are US$3.00 and US$3.80 for wet season and dry season paddy farming respectively. The latter figure is about the same as what the farmer would have to pay for recruiting an adult male.

4.23 But there is not enough work on the average 2.2 ha paddy farm to keep one adult busy for more than about 260 days (one rai requires 13 adult labor days; there are 6.25 rai per hectare). That sets a limit on total paddy income for the household. It is one of the main factors "pushing" the family members off the farm.

4.24 NEWMASIP provides estimates of returns to labor for other crops. The options for large-scale plantings of crops with markets that can absorb all the surplus without affecting the price—groundnuts and soybean are the best examples—face lower prices than paddy and even worse returns to labor. Low yields from the infertile soils are the main constraint. Returns to labor for those two crops are estimated at US$1.20 and US$1.80 respectively. Returns to specialty crops like baby corn and chilies are better, US$4.70 and US$4.30 respectively, but these are labor intensive enterprises and markets are limited.

4.25 For purposes of comparing the Lam Pao scheme with other Southeast Asian schemes included in the impact study, OED computed two paddy/input price ratios in relation to the daily wage and the cost of a ton of urea fertilizer. As discussed in the impact study Overview report, both those ratios are substantially lower than in the other two countries and indicative of the relatively poor returns to paddy in Thailand.

C. Economic Impact

4.26 The SAR, PCR and IER economic rates of return (ERR) for Lam Pao Stages I and II are shown in the following table:

**Table 4.2: Lam Pao: Previous Estimates of Economic Rates of Return**

<table>
<thead>
<tr>
<th></th>
<th>Stage I</th>
<th>Stage II</th>
<th>Consolidated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appraisal</td>
<td>25</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Completion</td>
<td>18</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Impact Evaluation</td>
<td>15</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

4.27 The progressive decline in these rates is largely driven by the decline in the economic rice price starting in 1982, accompanied by higher construction costs and lower yields. The Stage II rates as calculated for the PCRs and IER is lower than the Stage I rates because Stage I was mostly rehabilitation and took advantage of sunk costs of the existing dam and irrigation scheme, while Stage II was mostly new construction. The weighted average of the two IER ERRs is 10 percent.

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24. The financial farmgate paddy price per ton in Lam Pao is 39 times the price of daily labor for weeding (at B90 = US$3.75/day). It is 51 percent of the price of a ton of urea fertilizer (at B345/50 kg sack).

25. Weighting the two stages by actual costs. Costs of CR 461 were US$28.3 million, of which 38% (US$10.7 million) were invested in Lam Pao Stage I. Costs of LN 1630 were US$80.5 million, of which 77% were invested in Lam Pao Stage II. Stage I costs must be inflated from 1982 to 1988, or by 34%, to be comparable to Stage II costs. Stage II costs were 81% of total costs.
4.28 For the 1995 impact study OED did not repeat the economic analyses based on farm budgets carried out at appraisal, completion and for the first impact study. If one accepts that the basic structure of the earlier calculations remains valid, the IER overall figure of 10 percent can be evaluated roughly on the basis of the known changes in cost and benefit streams since 1988. The factors that have to be taken into account are: (1) higher real labor costs, by a factor of 2 for unskilled paddy labor; (2) yield estimates for paddy that are approximately the same for the two OED impact studies six years apart; (3) dry season cropping intensities that have increased above the levels projected in 1988, by an unknown factor but probably in the neighborhood of 10 percent; (4) the expanding share of paddy in the dry season cropping pattern, which has a lower economic price than the cash crops (a trend which the IER assumed would move in the opposite direction); and (5) economic paddy prices that have declined even more since the 1989 IER analysis, by about 6 percent. Given these trends of elements that comprise the ERR calculations, OED now makes a rough re-estimate of the overall ERR of 7 percent.

4.29 If anything, that 7 percent ERR estimate may be too generous. NEWMASIP's 1994 analysis is based on a completely new set of project costs and farm models for both seasons for all ten NEWMASIP-assisted schemes. The report gives for each scheme an economic return to the NEWMASIP investments. All Bank-supported Stage I and II project costs are treated as sunk costs. The report actually works on three options, depending upon whether the limited water supplies characteristic of all ten sites are targeted on maximizing wet season paddy, dry season crops, or dry season non-paddy crops. Lam Pao shows the highest returns, because it has the largest water surplus over wet season requirements. All three options for Lam Pao give 10 percent returns in NEWMASIP's analysis, an unusual outcome determined by the framework of the model. The other sites, most of which have negative returns to NEWMASIP costs, typically have different results for each option. Three of the schemes have positive ERs for all three options, but none of them get above 9 percent. The returns to the whole program, all ten sites weighted by area, range from 2 to 6 percent for the three options, averaging 4 percent.

4.30 Only when the calculations are rerun treating all NEWMASIP costs before 1994-95 also as sunk, do the ERs reach respectable levels for most projects. Lam Pao reaches 21 percent; five others are still below 10 percent. But by that time the economists are no longer looking at

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27. Assuming that the IER raised the overall intensity from an actual 115% to 130%, while the average for future years will in fact be 140%. That last assumption allows for some shrinkage from the present level of dry season intensity of 150 percent given in the text.


29. The procedure was as follows. The effects of the intensity increase (10%), and the paddy price decline (6%), almost offset each other (gross farm income increases by 3%). The effect of the shift to more paddy in the cropping pattern had an uncertain impact and was ignored (a generous assumption). The main impact on the ERR comes from the increase in variable farm costs (50%) due to the increase in labor costs (100%). Next, the implicit IER paddy farm model had to be recreated, since it is not presented in the report. NEWMASIP farm models for wet and dry season paddy show an average ratio of income to variable costs of 1.48. Adjusting that figure by the changes mentioned above gives a ratio of 2.14 at IER time. The analysis indicates that 38 percent of the IER net benefits must be removed. Hence, the IER "revised benefit" stream for the Stage II ERR (IER page 46) was reduced by one-third (a generous allowance, it should have been 38%), starting in 1992. The re-revised ERR for Stage II is 6.36%, about 70% of the IER ERR of 9.04%. Since Stage II comprised 81% of total costs of Stages I and II combined, OED reduced IER's combined ERR of 10% also by 70%.
the returns to past expenditure, but trying to concentrate the remaining three years of project investments on economically viable schemes and components.

4.31 This is a remarkably candid document, concluding that with hindsight the NEWMASIP program has proven to be a very questionable enterprise in economic terms and that project management must think about scaling back investments at many schemes and on many of the most fashionable components. Thus, for example, the report asks that all "overhead" activities—tests and demonstrations, institutional strengthening, marketing, M&E, etc.—be examined for cost efficiency and economic returns without taking any benefits of these "software" components for granted, just as the construction components are evaluated. Lam Pao survives the analysis as the only site offering consistently marginal, as compared with poor or negative, returns. But it too is embraced in the sweeping recommendation that all NEWMASIP components have to be cut to the essentials.

4.32 One other feature of the model is that NEWMASIP's "without" situation treats most of the presently irrigated wet season croplands as farmed under rainfed conditions. Thus the models capture most of the benefits of the schemes, while suppressing most of their historical costs. The point that complements OED's analysis is obvious: that even after stacking the cards so much in favor of these follow-up investments, the economics of irrigated paddy are such as to make most of these TA/rehabilitation schemes nonviable. The fact that Lam Pao does not rise above 10 percent in the new, detailed calculations, where all Bank-related investments are written off, reinforces the suspicion of a previous paragraph that claiming 7 percent for those earlier investments may indeed be too generous. It would take a substantial increase in the rice price, well above the 17 percent increase projected in late 1995 for the next two years, to overturn that conclusion.

4.33 Since the returns to fishing from the ponds have not been included in the above analysis, keeping the 7 percent figure seems appropriate.

4.34 It is too late to "rescue" the ERR of the Bank's projects. Even with a rapid conversion to integrated/diversified farming, and substituting risk-takers for risk-averters in the households, the ERR will top off below 12 percent. That would be, nevertheless, a respectable outcome given the infertile conditions of northeast agriculture, and one that fully justifies continuing work, by a leaner NEWMASIP, to encourage such a transformation. The upper limit will be determined to a large extent by the capacity of national and foreign markets to absorb the surplus of cash crop production over local requirements.

30. This allows for a tripling of the adjusted Revised Benefits (in the IER Stage II ERR analysis, see footnote 29) in all years after 1997.
5. Maeklong Right Bank Scheme

A. Structure of the Scheme

5.1 The Vajiralongkorn Diversion Dam on the Maeklong River about 14 km downstream from Kanchanaburi was completed in 1970 with assistance from Loan 394. RID began construction with its own funds of a main irrigation and drainage system on the right bank, and simultaneously, with Bank support, on the lower half of the left bank. In this phase, two main canals totaling 157 km were built on the right bank, together with laterals and drains. About 860 km of farm irrigation ditches (tertiaries) were constructed, under RID's "ditches and dikes" program, covering about 33,000 ha. The "ditches and dikes" program was another Bank supported activity that had its origin on the Chao Phraya. It provided a grid of relatively straight and parallel tertiary distributaries, with turnouts to adjacent fields. At the time Irrigation Project XI was appraised in 1979, about 20-30 percent of the area remained uncommanded, the ditches were in a poor state of repair, and thus afforded very little water control.

5.2 The new project provided for rehabilitation and enlargement of the existing 157 km of main canal; completion of 33 km of new main canal; improvement, enlargement and new construction of laterals; and intensive development of a tertiary network for 61,000 ha of paddy and 5,000 ha of sugar. The tertiary program for paddyland, labeled On-Farm Development (OFD), was the dominant component. Again, it was similar to that which RID had recently begun to implement in other parts of the country, and a definitive departure from the low-technology, low density "ditches and dike" model. Tertiary canals would be provided to serve units of about 60 ha. The maximum area served from one farm turnout would be 4 ha and all farmers would have direct access not only to irrigation water and drains but to motorable roads. The Dutch designed romijn gates—moveable, overshot, broadcrested weirs, an innovation for Thailand—were installed at all but a few tertiary turnouts. In one small experimental area undershot CHO gates were used at the tertiary level, but they were standard for all turnouts higher in the system.

5.3 Elsewhere in Thailand, OFD was preceded by intensive land consolidation. Since there is little fragmentation of holdings on the Maeklong right bank, RID decided a rational layout of canals, drains and roads could be achieved following cadastral boundaries, with only a minimum of realignment. Hence this was classified as "B" category consolidation, at substantial cost-savings. Rough leveling was provided in the vicinity of the new facilities and boundaries; final leveling was the responsibility of the farmers.

5.4 The farmers had to formally agree to OFD before their areas were incorporated in the project. Each of the Water User Groups, formed on the prospective tertiaries with support from RID and the Cooperative Promotion Department (CPD), had to secure a majority vote of members. When over 50 percent had approved, the detail design works went ahead. Eventually, 100 percent agreement was expected. For a number of reasons, farmers occupying about 30 percent of the command area voted "no," including a large contiguous block of previously irrigated area just south of the city of Ratchaburi half way down the project (including the depression mentioned in para 1.19, see Map 3). Disqualification from the OFD program meant that the laterals into those areas were also left out of the project rehabilitation program. Thus, the PCR and PAR reduce the total project area from the targeted 66,000 ha to 46,000 ha. The
Bank later canceled US$19 million from the Loan to reflect the reduction in project scope. RID refers to the areas that voted "no," and were excluded from OFD, variously as the "canceled" or "unconsolidated" areas. In fact those laterals have been maintained at minimal standards of serviceability by RID. Provided there is adequate water in the mains, the turnoffs to these old laterals are left open and farmers along them can and do irrigate, either from field-to-field flooding or by low-lift pumps from canals and drains. Some of these farmers have large holdings (as well as off-farm assets) and close relations with local politicians and senior RID staff, and are able to exploit their advantaged position near the ditches without concern for the lack of OFD. Nevertheless, none of these canceled area irrigators are considered beneficiaries of the project (though their access to water was improved marginally from the remodeling of the first section of the RMC).

5.5 The "no" vote is best explained by the costs to the farmers of a "yes" vote. First, they had to give up to 7 percent of their land to project infrastructure—the canals, drains and roads (they were compensated for expropriations over 7 percent). Second, they had to repay part of the capital costs of OFD, originally they were told 50 percent (but now only 20 percent). Third, and most important, they had to agree never to convert their irrigable land to non-farm enterprise, or to sell it to parties that did not intend to farm. With the rapid industrial and commercial development along the highway running south from Ratchaburi through the project area, the loss of flexibility in the use of land was unacceptable to many. Usually, a few larger farmers at the headend of an old or proposed tertiary would agree to vote against the program, and other farmers would follow suit. Also, in the small percentage (about 10 percent) of the project where sugar predominated there was a higher propensity to reject OFD. Some of those "no" groups—in both paddy and sugar areas—are now appealing to RID for inclusion in OFD.

5.6 The sugar story is best examined on the left bank of the Maeklong, under Irrigation Project XII. The great majority of land in both the southern part (Stage I - the target of Ln 394) and northern part (Stage II - the target of Project XII) of the left bank developments are higher, better drained, and committed to sugar. Stage I had been developed by RID following the "ditches and dikes" model and has never been converted. The Stage II area was separated into sugar and paddyland, and Project XII financed rehabilitation and extension of the mains and laterals for the whole region, but offered OFD only to the paddyland.

5.7 The behavior of the sugar-growers in adapting to irrigation supplies from the low-technology "ditches and dikes" program, in contrast to the paddy farmers, attracted the attention of the author of OED's PAR on Projects XI and XII. The PAR argued that the low cost alternative to OFD was a viable and preferred option to the high-technology introduced on the Maeklong under OFD by Irrigation XI and XII. However, in the interval since the PAR was issued, RID, with the active collaboration of the sugar farmers, is converting to a more intensive tertiary system, partly blunting the PAR criticism. The rising cost of fuel for their diesel pumps is part of the explanation why many sugar growers now want to have gravity supply. That issue is raised again in the last chapter.

31. The PCR and PAR use the phrase "lack of farmer cooperation" to explain the "no" vote.
B. Water Availability

5.8 For the foreseeable future, until the Maeklong schemes have to compete with Chao Phraya basin users for Maeklong River waters, the great majority of the right bank farmers will be in a water abundant position. The fact that tailenders on tertiary schemes—that were at the tail end of laterals at the end of the right main canal—reported no serious shortages interfering with cropping decisions, confirms that conclusion. The more that these farmers can be attracted to higher value cash crops in the dry season, the better that situation will be. OED did not compute any efficiency estimates, which have limited value in conditions of abundance.

C. Operation and Maintenance

5.9 Since rehabilitation and extension of the right bank scheme during the 1980s, under the Bank-supported Irrigation Project XI, there have been no further assistance programs comparable to OFWM and NEWMASIP at Lam Pao. Nor have there been any socio-economic follow-up studies comparable to London University's 1970-76 survey and OED's 1988/89 impact survey at Lam Pao. When the Dutch consulting team left the scene at completion of Project XII in 1988, an institutional capacity had been created at RID to continue to make semi-annual, socio-economic sample surveys on both the right and left bank schemes to follow farmer progress. Surveys of small, non-substitutable samples have indeed continued, but the data is simply tabled without verification or analysis at RID headquarters. Thus there is no reliable body of ex-post information available comparable to NEWMASIP's library.

5.10 OED's team visits to the right bank in 1995 were planned without any other organizing principle than to assess impact and O&M experience at selected points representative of the head, middle and tail of this long and narrow scheme. The Maeklong irrigators as a whole so far enjoy abundant water supplies exceeding those at Lam Pao, so that severe tail-end-headend problems or even the conflict level found at Lam Pao were neither anticipated nor encountered. The following paragraphs set out the major differences in operation and maintenance performance between Maeklong right bank and Lam Pao.

5.11 WASAM. This sophisticated computerized water scheduling and monitoring system was introduced by a Dutch consultant firm under contract with RID at the beginning of the project—in the early 1980s and therefore at least five years before it was brought to Lam Pao by the same firm under the Chi Basin TA program. The Maeklong scheme was the first testing ground for WASAM in Thailand. When the consultants left RID's regional headquarters near Kanchanaburi following the completion of their contracts for Projects XI and XII, they reported that the training program for RID personnel to carry on the system was successful, and a basis had been laid for RID to extend WASAM to other schemes in Thailand. In fact, a pilot WASAM had succeeded under the TA team's management, and there was reason to believe RID had accepted the routine and was prepared to expand its reach.

5.12 That assessment, reported faithfully in the Bank's PCR, was too optimistic. WASAM's progress was intimately tied to the consultant's presence. OED's audit, conducted in early 1990, found the WASAM program as designed was inoperative, and most of the data-gathering routines had been abandoned. The situation resembled that at Lam Pao before the arrival of the

32. Another project innovation on the Maeklong schemes, the Automated Maintenance Planning Process, was also closely tied to the consultants and did not survive their departure.
NEWMASIP team: calibrated devices—situated at main and lateral turnoffs to measure flows and permit their adjustment—were mostly missing or unreadable and obviously unused.

5.13 NEWMASIP has learned from the lesson of the Maeklong and substantially downgraded the scheduling routine. It would appear that at Maeklong by experience and at Lam Pao by intent, the residual WASAM protocols have converged to a model that does not aim to adjust flows to and through the tertiaries to computerized commands based on system analysis, but rather to measure flows through and out of the main canals and laterals to ensure supply from the headworks is reasonably consistent with anticipated requirements in the laterals and tertiaries. This measurement function is a vital one to large irrigation schemes, and fully justifies the remodeling and retention of WASAM. However, the intensive, field level data requirements of the original model were insupportable. NEWMASIP foresees a day when a better trained and paid RID staff can run the sophisticated system; it also anticipates that sometime in the future RID will have to modernize its operational system to something like the original WASAM if not WASAM itself. NEWMASIP has therefore oriented its training program around a flexible WASAM model that can be upgraded on demand.

5.14 Romijn Gates. The Maeklong right bank was also the pilot for another Dutch innovation in Thailand irrigation. Adopted from original models in Indonesia, the romijn gate was installed on practically all tertiary turnouts in the right bank scheme. The constant head orifice gates which had been used widely elsewhere by RID in Thailand, and are associated with the early American aid programs in the country, were installed mostly on the mains and laterals. The romijn gates are overshoot gates, which means the water released into a tertiary flows over an adjustable metal crest sealed below by a metal plate that slides vertically up a wall set in the base of the channel. The CHO gate, by contrast, is an elaboration of the popular single undershot orifice gate, which means the water is released under the base of the adjustable vertical metal plate. Actually, to improve accuracy in setting the discharge two gates are used for the CHO, an improvement over the traditional undershot gate. In practice, and since the main purpose of all these gates is to regulate and/or limit the water passing through the outlet, farmers at Maeklong and Lam Pao who irrigate behind the tertiary outlet do not like either—or indeed any—gate, unless it is one they can improvise when they want to. They break or remove them, or let them stand wide-open indefinitely, if they can. The extra trouble for farmers with the romijn gate is that to the uninformed it appears never to be wide open. The nature of the design requires a wall—below the adjustable crest—which can be broken by farmers who wish to secure more water. And that they have done with unexpected frequency at Maeklong. The romijn gate was not installed anywhere else in Thailand.

5.15 Weekend Shortages. The Lam Pao reservoir supports flood control and irrigation. The dams on the Kwae rivers also provide hydroelectric power. The national power authority, the Electricity Generating Authority of Thailand, reduces the flows through the power generation stations on weekends in response to lowered industrial demand, thereby limiting releases to the river flow for two days. The diminished flow reaches the irrigation scheme eight hours later, and RID has to adjust irrigation supplies to the laterals throughout the year to that variation in system supply. RID claims that most of the damage to gates and structures is timed to those intervals of low flow. The romijn gates were particularly vulnerable, since as overshoot gates they depend on full supply to function properly.

5.16 Condition of Canals and other Structures. The headworks, main canals, laterals, and cross regulators appear to be in acceptable condition. RID's O&M budget has been expanding in
recent years, and, though still lower than desirable, priority is given to maintaining these primary structures. The condition of the smaller gates is, as suggested above, a different story. The PAR estimated that 10 percent of the tertiary gates were non-functional. Five years later, O&M officials on the right bank estimate the percentage of gates damaged in one way or another, or missing altogether, to be much higher. OED’s field visits confirm a very mixed profile. In fact one of the more remarkable features at Maeklong is that some lateral systems present almost all gates in functional order, with evidence of recent greasing, while others show a majority of gates either gone or irreparable, and these different profiles can be on neighboring laterals. In three consecutive field visits, the team saw one terrible example of tertiary gate maintenance, and two of fully functional systems. The poor case was near the head of the right main canal, the two good examples were in the middle and tail regions. OED was unable in the time available to discern any factor that could reliably predict the condition of a tertiary system, other than, as at Lam Pao, the internal cohesiveness and political strength of the WUG.

5.17 "Functionable" gates does not mean functioning gates. There was no evidence that the well-greased gates were being used to ration water among farmers who demanded more. As at Lam Pao, the main and lateral turnoffs remained open during most of the monsoon and dry seasons to provide water on demand. The grease implied the gates were being adjusted. But on tertiaries where in the aggregate half the gates were inoperable, rationing water only for those systems which maintained the structures would be unfair and unsustainable.

5.18 Another observation is that the tertiaries which did maintain their systems in working order did so without any prompting from technical assistance agencies funded by external funds. The recent institutional progress at the WUG and Lateral Group levels in Lam Pao has attracted attention. But the WUGs at Maeklong are almost as old as at Lam Pao, their development was a top priority of the consultants for Project XI and XII, and they seemed to the OED team to be functioning reasonably well throughout the length of the right bank scheme. Moreover, associations of WUGs not limited to neighboring tertiaries have been developed, called Cooperative Associations, and these perform economic functions for their member groups that can go beyond the LG activity at Lam Pao.

5.19 Upstream Water Shortage. On the Maeklong right bank, water shortages are reported more by upstream than downstream farmers. This is due to several factors. First, the topography of the upstream area is undulating. This requires water flowing at its peak level to reach tailend areas. At the same time, the overshot design of the romijn gate requires full supply levels in the main and laterals to function as planned in diverting water to tertiaries. Wrong elevation of tertiary gates can obstruct the flow of water, and the romijn design exacerbates the problem. Second, the soil of the northern area is better drained and therefore needs more water than the paddy lowlands. These problems lead to higher breakage rates in the north. This fraction shrinks in downstream areas, particularly in the tailend of the project.

5.20 Political Influence. Another difference between Maeklong and Lam Pao is the larger fraction of politically powerful land-owners on both banks of the Maeklong scheme. The typical household economy at Lam Pao is based on farming, supplemented by some off-farm wage earnings. That model represents almost the entire universe of households at Lam Pao. At Maeklong, there is a larger number of business-oriented farmers with substantial assets and a primary source of income from off the farm. That is a common character of the sugar growers. It is also representative of a significant fraction of the paddy landholdings, especially in the canceled areas. Political patronage implies favorable and inequitable treatment. The PAR
reported that influential and powerful farmers within the scheme perimeter could modify water delivery schedules and install permanent pipes in canal banks. They regularly pump water from the main canals not only to their holdings within the commands, but also to their holdings outside the command where they usually cultivate high-valued crops. They do not pay any fees for this facility. Such farmer actions clearly require the active cooperation of the canal bureaucracy. A senior RID officer lamented that RID gets "orders from heaven, i.e. the gods" to help these people. But he hastened to add that such free pumping of water does not affect the supplies to other users as, in calculating water requirements of the project area, such illegal pumpings are taken into account and there is enough water to accommodate all these claims.

5.21 Conflict Resolution. Water distribution problems created by damaged structures, long laterals, illegal pumping and water stealing by upstream farmers are reported to WUG leaders and Zoneman daily. But the level of conflict is relatively subdued, no doubt a reflection of the overall level of water abundance. If a farmer is caught damaging a structure or stealing water from others, he is usually fined by the WUG leader and just as usually pays. Interpersonal clashes never go beyond the heated arguments. In Maeklong as in all of Thailand farmers are quick to assert their water rights. If they feel that the main system does not give them their due share of water they say so, individually and through their group. The only major exception to the relatively benign conditions at Maeklong is the strife between sugar growers and paddy farmers. This is predictable, since they have different water requirements and paddyland flooding prejudices neighboring stands of sugar. RID officials have colorful stories of this warfare: paddy farmer tractors pulling out illegal regulators placed by sugar growers to prevent water movement down the channels. etc.

5.22 Cost Recovery. Unlike Lam Pao, the farmers entering the OFD program at Maeklong (or anywhere in the country) were required to repay part of its capital costs. The share was reduced from 50 percent to 20 percent, which they are to pay back over 10 years. RID also recommends a fee level to be paid to the WUG—substantially larger than at Lam Pao and supposedly related to expected WUG O&M expenditures. The norm is 40 baht per rai per season (para 3.56). It is collected by CPD and deposited in the WUG accounts (at Maeklong the WUG have legal recognition and can act as economic entities). The WUG pays its members, or other workers, for labor inputs on the tertiary.

5.23 RID's O&M Budget. For reasons OED could not clarify, the Regional RID administration for the Maeklong schemes has a much more serious staffing problem than at Lam Pao. The number of filled positions is a small fraction of either planned capacity or posted positions. For the left bank, the rough numbers as estimated by the project director for the Stage II area was 400 required, 150 approved and 30 permanent persons in place. The quality of the canal staffing complement is compromised by the need for individual Zonemen to cover much larger canal sections than intended, and for RID to promote workers and gatemen to superior positions for which they are unprepared. At the office level, RID has difficulty in competing with the private sector for the engineers and other professionals it needs. The result has been a decline in the RID team's capacity to operate the schemes as intended. The cut back in civil service positions is part of a national movement by government to substantially reduce the size of the civil service cadre. RID's prominence as a public employer makes it a likely target, and the quality of agency-level O&M can be expected to deteriorate. This threat was not so apparent at Lam Pao.
D. Agro-Economic Impacts

5.24 Net Cultivated Area and Cropping Intensity. The appraisal target was to irrigate 66,000 ha from the two main canals on the right bank. That target was cut back, when some groups of farmers declined to commit themselves to the On Farm Development Program. Their blocks were dropped and the project funds canceled. When the PAR and PCR were issued under one cover in 1990, the PCR claimed that the area irrigated as of 1988 had reached 37,700 ha, and that RID intended to continue OFD works to a total of 44,500 ha. In 1995 RID reports a total of 39,500 ha irrigated, with no further expansion underway or planned. RID also reports that it supplies another, approximately 2,000 ha within the "canceled" zone, a figure that is higher in the dry season than the wet season. Other information suggests the size of the area, within the canceled zone, that has access to water in the canals and drains is much larger. In any case, most of the rest of the canceled area is also cropped, under rainfed conditions, in the monsoon season. (2 shows the canceled area.)

5.25 Cropping intensity within the scheme perimeter (i.e. excluding the canceled area) until recently was very high: the common assertion is that all of it is cropped in the wet season and about 90 percent in the dry season. The SAR had aimed at 200 percent intensity on 66,000 ha, including about 5,000 ha of irrigated sugar land. Most of the sugar growers were among those who voted against OFD. The PCR also anticipated 200 percent at full development (of 44,500 ha). The pre-project cropping intensity had been calculated at appraisal at 105 percent, so all these ex-post re-estimates reflect excellent progress to double cropping targets, albeit within the reduced perimeter.

5.26 Nevertheless, the fraction of irrigable land planted in the dry season appears to have begun to decline. Starting in 1993/94, the plantings have fallen from 90 to 60 percent in the dry season. RID attributes this to the increasing labor shortage. That is part of the explanation for the "push" factor mentioned in the discussion of Lam Pao. Another part is the early effect of the government's recently initiated "grow less rice" campaign. RID management on both banks of the Maeklong is intent on prompting farmers to start getting out of paddy and into other crops, both to economize on water and diversify away from rice. The campaign is less successful here than in the Chao Phraya basin, because the quantity of excess water flowing down the Maeklong makes RID's exhortations less convincing. However, while the campaign has been effective in persuading some farmers to plant less paddy, it has been less successful in persuading them to plant the same fields with other crops. They leave them fallow.

5.27 Cropping Patterns. The project was designed for paddy, with a small area dedicated to sugar. No other crops were considered in project design, although of course farmers were expected to devote small plots to vegetables and other subsistence requirements. With the removal of most of the sugar farms from the project perimeter, the project has become almost exclusively committed to paddy. That shift has been reinforced by a tendency among sugar farmers remaining within the perimeter to convert sugar to paddy, in response to better farm-gate paddy prices and waterlogging in sugar fields surrounded by double-cropped paddy. RID data shows 2,200 ha in cane in 1994, and calculates that half of the sugar land has converted to paddy in the last five years. Unlike Lam Pao, farmers in the Maeklong area prefer non-glutinous varieties: about 80 percent of all paddy grown in the two seasons is NGR and HYV.

5.28 Yields. Overall performance with yields has also been close to target. The SAR projected increases of the following magnitudes: for rainfed local varieties from 2.5 to 3.5 t/h
and for dry season HYV from 3.0 to 4.2 t/h. PCR re-estimates showed a 10 percent shortfall in rainy season yield performance, and a small improvement over SAR projections in the dry season. RID and OED group discussions confirm those PCR estimates, with an average yield over both seasons of about 3.9 t/h per crop. This is almost a ton higher than current yields reported at Lam Pao.

5.29 **Financial Impact, Farmers' Level.** The SAR presented models for 2 ha and 4 ha paddy farms. In 1995, OED’s group interviews suggested the average irrigated cropped area per farmer has risen somewhat, to about 3.5 ha including land rented in. This reflects a process of farm consolidation under fewer management units. Using the yield and area estimates given above, and an intensity of 160 percent, total paddy production per operating unit is about 22 tons. At present farmgate prices of about US$146/ton, that production yields about US$3,200, gross of production costs. With production costs of about US$260/ha average (over both seasons) for HYV paddy per crop, total farm costs are about US$1,450 and gross margins per farm unit US$1,750. That compares with US$600 at Lam Pao. The paddy prices and production costs per hectare are nearly the same on the two schemes.

5.30 The large margin on earnings per paddy farm that Maeklong farmers enjoy over Lam Pao farmers is fully explained by the factors already described: higher yields (by 0.9 ton), higher intensity (160 vs 150), and larger farms (3.5 ha vs 2.2 ha). The average farmer at Maeklong harvests 22 tons, the average farmer at Lam Pao 10 tons. Returns to household labor are also substantially higher than at Lam Pao: the larger yields more than offsetting slightly lower crop prices and higher wages paid to labor in this region bordering Bangkok.

5.31 These remarkable advantages are not reflected in a more stable farming population on the Maeklong schemes. Even more than at Lam Pao, the households have choices for employment and lose family members to the attractions of cities and nearby factories. More so than at Lam Pao, an increasing number of farmers who used to plant dry season crops are giving it up. The modernization of the Maeklong farmers was well illustrated by the scheduling of group interviews for OED’s impact team. The meetings had to break in mid-afternoon in time for the farmers to get on their motorcycles and go pick up their children from school. One memorable group discussion about alternative life-styles yielded comments about how the parents wanted their children to get their education and leave the farms. They did not want the next generations to remain paddy farmers. When asked what the farming population, and their situation in particular, would be like ten years hence they said they had no idea. This is the reality of small-scale, part-time farming throughout those regions of Thailand undergoing rapid industrialization. Lam Pao may be heading in the same direction, but so far the urgency of change is less embracing.

5.32 **Economic Impact.** The ERR for the Maeklong right bank subproject was appraised as 35% based on a command area of 66,000 ha and the 1979 commodity price forecasts. The PCR, prepared in 1988, revised that estimate sharply downward to 8.2 percent, reflecting updated price forecasts and a perimeter of 44,500 ha. It maintained the appraisal yield estimates for full development, averaging 4.1 t/ha for the two seasons.

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33 The ERR calculation in the 1979 SAR is in error. The economic rice export price used for 1980 was US$320, as provided in the Bank's commodity price projections. The price used for 1990 was US$480, but it should have been US$380 according to the same projections.
5.33 As with Lam Pao, the structure of the ERR analysis at appraisal and completion is accepted to be correct. The ERR must be lowered again, responding to a further decline in the rice price by about 6 percent, the failure of RID to expand beyond 39,500 ha (10 percent below the 1988 estimate), average yields of 3.9 t/ha (7 percent below the SAR and 1988 estimates), and the decline in cropping intensity from 190 to 160 percent. Each of the four factors depresses the ERR. Since the SAR and PCR do not provide the structure of the ERR analysis, a simple model had to be created to simulate the PCR results. The recomputed value is 3.6 percent (Annex 1 shows the procedure).

5.34 The re-estimated 3.6 percent ERR for Maeklong is only half the 7 percent ERR re-estimated for Lam Pao, despite the better on-farm physical and financial performance at the first site. The reason is the large reduction in project scope at Maeklong—the "no" vote removed 30 percent of the design command and another 10 percent was planned but never completed—with a simultaneous increase in investment costs. Actual total costs for the Maeklong right bank subproject were re-estimated at completion at the same level (US$137 million) as at appraisal, even with the reduction in scope. There was no increase in costs for Lam Pao Stage II, under implementation at about the same time. Thus, the Maeklong costs per hectare irrigated were US$3,470, which compares with US$1,550 at Lam Pao (Stages I and II, both figures in 1988 dollars). Both schemes suffered from the decline in rice prices, which explains the greatest part of the shortfall in actual ERR from SAR estimates (35 percent for Maeklong right bank). Removing another 40 percent from the residual benefit stream leaves Maeklong with only a small margin above total costs and a 4 percent ERR.

E. Social Influences and Impacts

5.35 OED's impact study emphasizes agro-economic impacts, mentioning social factors where they seem to have a substantial influence on the outcome. The intention was to concentrate on the relation between O&M and scheme performance. Here and in the other country impact reports (Myanmar and Vietnam), there is no section devoted to the social dimension. Because of the special effects of industrialization on the rural economy in Thailand, with "push and pull" incentives far exceeding those in the other two countries, an expansion of this Thailand review adequate to cover the social dimensions of irrigation impacts would have been especially worthwhile (i.e., changes in family labor; the uses of the fish ponds; the equality of the partnership between farm husbands and wives; the discouragement of some of the early experiences with contract farming at Lam Pao; the replacement of women in the paddy fields as the "iron buffalo" (the two wheel tiller) took over all preparation and cultivation operations at Maeklong; the increases in employment for landless labor at Maeklong, which seems to have assured them of year-round incomes they never enjoyed before; etc.).

34. Including the error: see footnote 33.
6. Conclusions: Influence of O&M Performance on Agro-Economic Impacts

6.1 There is no significant O&M constraint on irrigation system performance, at Lam Pao or Maeklong. The abundance of water on both schemes overrides any production-depressing effects that broken and missing gates, and disrupted rotation schedules, otherwise might have had. This seems to be the case even on the "Bank" laterals at Lam Pao, the older parts of the works constructed 10 to 15 years ago and showing many signs of disrepair.

6.2 The evidence in the field of poor maintenance, supported by farmer complaints of inequitable treatment and official reports of sub-optimal yields, recall a familiar scene described in the international literature of O&M inefficiency and scheme decay. If the Lam Pao and Maeklong schemes were water short, and the demand for water from enterprising farmers was growing, then the O&M failures could indeed translate to production losses. On these schemes however abundant water and a migration to off-farm jobs needs another paradigm.

6.3 One could argue that with water rationing on the Chao Phraya, O&M failures are necessarily depressing production in that part of Thailand and OED's case studies drawn from two other river basins are exceptional. But even on the grand river the case is not solid. The Director General of the Royal Irrigation Department told the OED mission the remarkable story of the 1993 drought, which forced the most severe rationing on the Chao Phraya schemes RID had ever administered. The monsoon drought, here as in Lam Pao, left too little water in the reservoirs to supply a dry season crop at normal levels. What water there was had to be concentrated on blocking the advancing salinity from reaching the city's pumping station above Bangkok. Rains on March 14, 1994 finally brought relief, but not before the paddy and orchard farmers on the Chao Phraya had organized voluntarily with RID's encouragement and developed a rationing plan that saved most of both crops, an outcome that exceeded all expectations. The Director General pointed to his lesson from that experience, which was that there was a lot of slack in the present distribution system. But there is another lesson for OED in the experience, which is the ability of irrigators to defend themselves collectively when they have to. The OED mission found similar evidence of farmers coalescing under pressure either formally or informally. A few of those cases have been mentioned in this report. The strengthening of the WUGs reinforces this natural capacity wonderfully.

6.4 The one potential threat to the scenario of abundance is from the "under-dimensioned" canal system at Lam Pao, which would prevent the dry season cropping intensity from expanding much beyond the level it reached in the early 1990s—around 50 percent split between paddy and other crops. But economic forces in the northeast are creating powerful disincentives to farmers to expand dry season cropping. The returns to paddy are so small as to discourage any substantial expansion of that crop, and the limited markets for other crops offer farmers no good alternatives. If paddy prices were to recover to the levels contemplated when the two Lam Pao projects were appraised, then one would have to assume farmers would respond by each trying to expand his/her paddy crop, putting pressure on the constrained water supply. In that circumstance, any margin of inefficiency in use of gates and rotations would be translated into losses of production. But that scenario is no longer realistic.
6.5 With respect to the wet season at Lam Pao, and both seasons at Maeklong, there is enough water in the mains and laterals to guarantee good crops to efficient farmers who are willing to work to keep the local watercourses open. And that is what is happening. Individual farmers with their own field channels, and the WUG activity on the tertiaries (and in support of RID on the laterals), keep the water moving when they need to. Of course there are small areas, usually identified with the tailend of tertiaries, where local geographic features and poor canal design prevent all farmers from getting full supply. Those complaints are amplified in group and individual interviews. But, in general, the incidence of water short situations in a regime of abundance is low. The fact that on both schemes OED found a majority of tailenders unemotional and unconcerned with water shortages, and reporting yields almost as good and sometimes better than the headenders, is strong evidence that water is reaching the ends of the systems.

6.6 In the other countries in the regional impact study an operational efficiency issue arises from the preference of farmers to plant paddy instead of other cash crops whose economic as well as financial returns would be better. That issue does not arise at the two Thailand sites under review. The soils at Lam Pao are marginally adequate for paddy, and poor for most non-rice crops. The returns to labor are low in paddy and even lower in the other field crops, at least under traditional husbandry practices and at present prices. The soils at Maeklong are ideal for paddy, and sugar is reckoned to be the only competitive crop though even that contest is shifting in favor of rice despite government's "grow less rice" campaign. The economist cannot fault the prevailing cropping pattern at either scheme. Of course a shift toward integrated, diversified, value-intensive enterprise at Lam Pao (and presumably part of Maeklong as well) should be encouraged. But that is unlikely ever to replace paddy over the majority of the scheme where it is now grown.

6.7 Water-use efficiency calculations for Lam Pao are not disturbing. For the dry season, OED had determined an efficiency ratio of 43 percent, which is adequate. For the wet season, efficiency ratios usually have been much lower. However, as pointed out earlier, better efficiency performance would only have the effect of forcing RID to release more water into the river and on to the end of the scheme.

6.8 In the light of these considerations, the failure of the fully developed WASAM control and monitoring system to be sustained is unimportant and, in retrospect, predictable. What NEWMASIP is trying to do with WASAM at Lam Pao seems just about right, to abandon intensive data gathering for the purpose of control below the mains, while strengthening the measurement capability of RID staff to ensure that water in the reservoir and the mains is managed efficiently. In the long run, perseverance may pay off with an extension of sophisticated controls below the mains, as staff and farmer training and competence mature. That point is not expected to be reached in the near future. And again, a fully effective WASAM would mean even more water running down the rivers and mains to the end of the schemes.
7. Other Conclusions

7.1 RID Leadership at Lam Pao. While it appears that the follow-on OFWM and NEWMASIP project activities have had major impact on the performance of the Lam Pao scheme, credit must also be given to RID management. RID has been responsive to the technical assistance inputs it has received and made them operational. Most notable is the agricultural production orientation of scheme operation and maintenance. While it is recognized that irrigation is not the only determinant in farmer cropping decisions, RID management is trying to remove concern for water from the equation altogether. The decision to keep water in the main canals year-round instead of the long maintenance closure practiced in the past is evidence of an attitude seldom found among irrigation department system managers.

7.2 Planning maintenance for short periods of canal closure is much more difficult than past practices. It requires advance planning and stockpiling of materials. Organizing a work force that can be split into several shifts, additional supervision, and lighting to work at night are all problems management has dealt with.

7.3 RID management has also taken an active part in encouraging the private sector to introduce contracts for non-rice crops. While RID has no capacity to provide extension services to farmers, it has encouraged agricultural enterprises to provide inputs and services and encourage production contracts with farmers.

7.4 The European Initiative at Lam Pao. Working together with enlightened RID scheme management, two technical assistance programs, supported by partial rehabilitation of tertiary (and a few primary) structures, have substantially improved on the performance of selected tertiary systems and groups of tertiary systems for about half the total area under command. The emphasis has been on institution building, and NEWMASIP, the program now under implementation, has raised its sights to lateral water user groups as well as tertiary groups. These improved LGs and WUGs have upgraded O&M performance in ways that are easily detected by field observations and discussions. One of the clearest lessons from Lam Pao is that getting the farmers to work together, and paying attention to their organizations, pays off.

7.5 Transfer. Irrigation management experts throughout the world have become increasingly interested in the potential for improved O&M opened up by transferring higher and higher levels of responsibility to the user groups. Since in all schemes in this regional study the groups already are responsible for operation as well as maintenance below the tertiary turnout, transfer in the context of the study refers as a first step to turning over to the irrigators responsibility for managing water supplies within the lateral canals and maintaining the laterals, the regulators in the laterals and the gated tertiary turnouts from the laterals. NEWMASIP's work with lateral groups is the only example of official "transfer" in the regional study. In this case, responsibility for operation of the laterals has been formally turned over. Responsibility for maintenance of the canals, regulators and turnouts remains with RID, although the WUGs support RID with cleaning and some have taken over the gates as well. As mentioned several times in this report, the experience thus far has been very encouraging. The fact that the Water User Groups have seen their authority and functions diminish as the Lateral Groups mature is not surprising, since decisions at the higher level of association preempt discussion by WUGs.
7.6 Faulty Construction. At both sites the conditions of these primary structures under RID's control are satisfactory. The laterals at Lam Pao which have not been incorporated in one of the follow-up programs show signs of wear that suggest inadequate maintenance. But their condition is better than it was when OED visited the site in 1988/89. The team was unable to detect widespread evidence of faulty construction of original works on the main canals, whereas the earlier OED impact team, in its 1990 report, speculated that the Bank had deliberately sacrificed quality in order to lower costs and raise rates of return—and to give the Bank a chance to re-enter later with a rehabilitation project. Whatever evidence there was at Lam Pao in 1989 seems to have been corrected. The biggest engineering "mistakes" were to under-dimension the main canal and then not provide enough slope in its initial section. The first was done deliberately, reflecting projections of likely dry season cropping intensities, and will never be corrected. The second has been eliminated by NEWMASIP. Neither problem is attributable to cost-cutting at the design stage.

7.7 Modernization. The NEWMASIP rehabilitation program followed completion of the Bank-supported Stage II at Lam Pao by only seven years. That is a short cycle for construction and reconstruction, and recalls the criticism that the Bank deliberately built to low standards with rehabilitation in mind. Nevertheless, at both Lam Pao and Maeklong, right and left banks, these so-called rehabilitation works invariably have included elements of modernization—re-engineering of physical and human design to incorporate lessons of experience, advances in the technology of water controls, changes in command area, changes in relative crop prices and incentives, and shifts in irrigator interests. This is not to applaud a seven-year construction cycle. But there are advantages that have to be recognized. Moreover, regardless of whether donors favor repeater projects, the government also seems to respond better to scheme degradation by approving periodic rebuilding rather than annual budgeting for effective preventative maintenance.

7.8 High-Tech Controls. Modernization does not mean greater technical complexity. The Lam Pao Water Operation Center was created in the late 1980s to implement the WASAM program. While the irrigation distribution control capacity is not sufficient to accurately implement the planned allocation, the exercise of collecting field information and processing it for discussion in a weekly meeting that includes the RID Lam Pao System manager, head works operator, operations engineer, watermasters from each zone and other staff has a positive influence on irrigation distribution. All system operation topics are discussed at these weekly meetings. Initiating these meetings was one of the ways the system manager has emphasized and activated his policy of being responsive to agricultural production needs. These weekly meetings keep the officers focused on problems in the field.

7.9 Nevertheless, the introduction of this sophisticated control system to the Maeklong projects in the early 1980s, and subsequently to Lam Pao, appears in hindsight to have been ill-advised. One of Thailand's best-known irrigation engineers told the OED mission that the Bank, in this case with international technical support, imported a Mercedes when a Toyota was needed. Staff skills were simply not ready for the intensive data collection and analytical demands of the system. NEWMASIP has downgraded the complexity of the original system to make it workable.

7.10 The WASAM experience, coupled with the failure of the romijn gates and the CHO gates that preceded them to function as intended, lends an uncomfortable sense of donor excess to this case study. It is as if USAID and the Bank had financed American and Dutch technical
irrigation teams to compete in RID's backyard and at RID's expense. One would have hoped for more realism in their technical agenda. Whether this view has clarified only in hindsight is unclear. Inevitably there are those who will assert that the degradation of the WASAM, romijn and CHO technologies on Thai schemes was predictable. In fact, that was one of the main conclusions of an earlier Bank report discussing the lessons of experience of all irrigation projects in Thailand, up to the early 1980s. That report, challenging two decades of conventional engineering in the Asia region, began a long debate among irrigation engineers in the Bank and outside about irrigation design and management.

7.11 The 1990 IER Report. Field research in 1994 and 1995 shows that many of the O&M problems identified in the previous field work, carried out in 1988/89, have been corrected, and overall performance by the Royal Irrigation Department as well as by the farmers has improved. Progress is also attributable to the inputs of European technical assistance and funding, which started almost as soon as OED's earlier work was concluded. If the improvements are sustainable, the experience provides a nice case study of the difficulty of assessing with any certainty the evolution over time of these projects.

7.12 Low Product Prices. The projected international price of rice has fallen by 70 percent since the three projects were appraised in the period 1974-79. No rice irrigation project in the world had an economic base that could have survived a collapse of that order. This is the primary factor behind the "push" of paddy farmers out of, especially, dry season cropping and ultimately off the land. Under these conditions, efficient but demanding O&M protocols face a most uncertain future, and fine tuning of water delivery systems has no utility. The majority of the lowland under command in both schemes is formed by the heavy clays that are uniquely suited to paddy, so there is no real escape for these farmers other than to exit.

7.13 Final Comment. The booming Thailand economy offers alternatives to "pull" the farmers away and further reduce the pressure on available irrigation supplies. Maeklong is more exposed to these incentives, but they threaten the stability of farming systems at Lam Pao as well. In a sense, the Lam Pao scheme is trapped. Just as the RID/NEWMASIP reforms are starting to take hold, promising substantially improved O&M performance, the collapse of the paddy economy and surge of the modern economy have undermined the incentives to irrigate. There is no reason not to anticipate a similar fate for any canal-intensive scheme dedicated to paddy in the Bank's completed portfolio.

35. This criticism of course does not extend to other areas of the consultant's technical contributions. One remarkable legacy of the consultant's tenure is the exceptional collection, and display, of scheme maps.


37. In October 1978 the Bank's commodity price projection for "Thai 5% broken f.o.b. Bangkok, for full development (1990), was US$398 in constant 1977 dollars, or US$787 in constant 1990 dollars. In May 1995 the commodity price projection for 1995 was US$237, in 1990 dollars, exactly 30 percent of the 1978 projection.
Maeklong Right Bank: Reestimates of Economic Rate of Return

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<td>177.6</td>
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<td>931.8</td>
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<td>10</td>
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<td>11-30</td>
<td>177.6</td>
<td>25.3</td>
<td>1,122.6</td>
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<tr>
<td>ERR</td>
<td>35</td>
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<td>8.2</td>
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1. Annex 4, Table 4, page 70.
2. Same Total (US$ 1,644) stretched over eight years.
3. Two-thirds of SAR values, reflecting decrease in project command area.
4. A possible income stream, to arrive at PCR's 8.2 ERR.
5. The possible PCR stream, reduced by one-third.
IRRIGATION O&M AND SYSTEM PERFORMANCE IN SOUTHEAST ASIA:
AN OED IMPACT STUDY

REVIEW OF THE KINDA AND TANK IRRIGATION PROJECT SCHEMES
MYANMAR

June 27, 1996

Operations Evaluation Department
### Abbreviations and Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ASC</td>
<td>Agriculture Supervisory Committee</td>
</tr>
<tr>
<td>Bank</td>
<td>World Bank</td>
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<tr>
<td>DY</td>
<td>Distributary</td>
</tr>
<tr>
<td>ERR</td>
<td>Economic Rate of Return</td>
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<tr>
<td>GOM</td>
<td>Government of Myanmar</td>
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<tr>
<td>ID</td>
<td>Irrigation Department</td>
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<tr>
<td>LMC</td>
<td>Left Main Canal</td>
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<tr>
<td>LORC</td>
<td>Law and Order Restoration Council</td>
</tr>
<tr>
<td>MAS</td>
<td>Myanma Agricultural Service</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Operation and Maintenance</td>
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<tr>
<td>OED</td>
<td>Operations Evaluation Department</td>
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<tr>
<td>PAR</td>
<td>Performance Audit Report</td>
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<tr>
<td>PCR</td>
<td>Project Completion Report</td>
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<tr>
<td>RMC</td>
<td>Right Main Canal</td>
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<tr>
<td>SAR</td>
<td>Staff Appraisal Report</td>
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<tr>
<td>SLORC</td>
<td>State Law and Order Restoration Council</td>
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<tr>
<td>VTLORC</td>
<td>Village Tract Law and Order Restoration Council</td>
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<tr>
<td>WASAM</td>
<td>Water Allocation Scheduling and Monitoring Program</td>
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<td>WUG</td>
<td>Water User Group</td>
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This report was prepared by Edward B. Rice (Task Manager), with support from Robert Yoder, Jayantha Perera, Annemarie Brolsma, Sinee Chuangcham, U Hla Myint (Consultants) and U Tun Naing (UNDP), who visited these projects in November 1994 and April and June 1995. Afis Zormelo and Megan Kimball provided administrative support.
1. Introduction

A. Background

1.1 The Kinda and Tank irrigation projects in Myanmar were selected as part of OED's impact study of gravity-fed irrigation projects in the humid tropics of Southeast Asia. Other gravity-fed schemes, also with storage, were selected in Thailand and Vietnam. A flood control and drainage project in Bangladesh was added to the regional study, to widen the thematic perspective on problems of operation and maintenance (O&M).

1.2 Credit 1031-BA for the Kinda Dam Multipurpose Project was approved for US$90 million in May 1980, made effective in November 1980, and closed in March 1991 with a cancellation of US$3.04 million. A Project Completion Report (PCR) was issued in June 1992, covering both the power and irrigation components. OED has not audited the project, and this impact analysis refers only to the irrigation component. Credit 1315-BA for the Tank Irrigation Project—supporting the Kinmundaung and Azin schemes—was approved for US$19 million equivalent in December 1982, made effective in April 1983 and closed in June 1990 with cancellation of US$3.00 million equivalent. A PCR was issued in October 1991. A Project Performance Audit Report (PAR) has been prepared in parallel with this impact study.

1.3 The primary subject of the impact study was the Kinda irrigation scheme. The report focuses first on O&M performance, second on agro-economic impacts, and third on the influence of O&M on those impacts. The discussion of O&M and impacts of the two tank subprojects, at Kinmundaung and Azin, are shorter and concerned mostly with similarities and differences compared to Kinda.

B. Preparation

1.4 In the mid-1970s the Government of Myanmar (GOM) initiated a program for extending irrigation through storage of wet season stream flows. Its objectives were twofold: to protect paddy production from the vagaries of monsoon rainfall in the central dry zone, and to develop a second paddy crop and promote nonpaddy crops there and in the southern high-rainfall coastal region. In the same period, and under the aegis of the Second and Third Four Year Plans (1975-78, 1978-82), a series of agricultural reforms were implemented which included increased investment in agriculture, an intensified agricultural extension program, improved availability of inputs, and increased rice procurement prices.

1.5 The Kinda and Tank Projects were the Bank's fourth and fifth irrigation operations in Myanmar. The first three had concentrated on flood control, drainage and small-scale pumping

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1. The project was appraised as the Nyaunggyat Dam Irrigation Project. Government requested the name be changed in 1981, a year after the credit was approved.


in the paddyfields and uplands of the delta of "Lower Burma." In the mid-1970s Bank and FAO/CP missions began to assess the potential for: 1) rehabilitation of existing run-of-the-river diversion schemes, 2) large-scale storage and infrastructure improvements on other older schemes, and 3) medium-scale storage ("tanks") at both old and new sites—all three options in the central dry zone of "Upper Burma." The Kinda project was identified in 1974, and preparation was financed by funds from the Bank's first irrigation project. Preparation of the Tank project started four years later at several proposed sites in the central dry zone. Another cluster of sites on the southern coast of "Lower Burma" were incorporated in the analysis in 1980. The Tank Project as finally approved included one tank each from the dry zone (Kinmundaung) and coast (Azin). It was intended to be the first in a series of multiple-tank projects supported by the Bank in a time-slice progression. Tank II was appraised in 1988. But changes in political conditions in Myanmar later that year brought the processing of all further Bank projects to a halt, and no other irrigation projects have been or are currently being considered. GOM, meanwhile, has in the last several years accelerated the construction of new tanks using domestic funds, and is currently completing another major dam on the Zawgyi River adjacent to the Kinda scheme. End-Maps 5-7 cover the three individual schemes.

C. Implementation

1.6 The Kinda Project was implemented by the Irrigation Department (ID) of the Ministry of Agriculture and Forest. ID was specifically responsible for construction of the dam, rehabilitation of the old "Panlaung" run-of-the-river diversion system serving 88,000 acres (36,000 ha), and construction of a new irrigation scheme serving 113,500 ac (46,000 ha) adjacent to the existing system on higher ground. The Myanma Electric Power Enterprise was responsible for construction of the powerhouse at the dam and a 50 km transmission line to the national grid. The Myanma Agriculture Service (MAS) was responsible for strengthening the extension service, constructing training facilities for irrigators, and establishing a cotton research farm.

1.7 Works were started at Kinda in 1980. Excellent progress was made in the implementation of the dams, appurtenances and power generation facilities. The first release of water from storage was made in August 1985, and power reached the national grid on schedule in January 1986. The irrigation component of the project was delayed and completed only in 1991, over four years behind schedule. The principal factors explaining the delay were shortages of diesel fuel, reinforced steel and cement. Although irrigation water reached the first pilot activities in 1985, full supply up to the reservoir's capacity for the right and left main canals was not available until 1992. The PCR, issued that year, echoes the concern of the latest supervision reports that MAS' extension services had also fallen behind schedule, and the irrigators and their associations were not yet prepared to manage water efficiently.

1.8 The Tank Project was also implemented by ID. A small water supply component in the Azin subproject for a local town, Mudon, was implemented by the Construction Corporation. Works started simultaneously at Kinmundaung and Azin in 1984. As the shortage of diesel and

4. The first of the three, the Irrigation Project (Cr 483-BA), financed about 13,000 pumps, of which 2,760 were installed in the central dry zone and the rest in Lower Burma.

5. Acres, rather than hectares, are used in this text when referring to scheme size and scheme-wise cropping patterns. This allows direct comparisons with GOM and Bank estimates of these key variables in the analysis. However, most references to farm size are metric, and all other measures, e.g. distances, are also metric.
construction material worsened, ID concentrated on Kinnmundaung and was able to make the first release, from an unfinished dam, on schedule in 1986. The first release from the Azin dam was made in 1989, three years later than planned. In this case, MAS was better prepared to assist the farmers.

1.9 For more complete discussions of implementation experience, the reader is referred to the two PCRs and the new PAR on the Tank Project.

D. Characteristics of the Command Areas

1.10 Kinda. The old Panlaung scheme and its eastern neighbor, the Zawgyi River scheme, both in Mandalay Division, together constitute the ancient Kyauske system, the largest of the run-of-the-river irrigation-based granaries of the kingdoms of Upper Burma for over a thousand years. Both rivers originate in the Shan hills to the east, and provide a perennial source of water to farms along the rivers and diversion canals before they empty into the Irrawaddy River near Mandalay. There were five old weirs along the Panlaung River, diverting water mostly to low lying paddylands on either side. About 20 percent of the irrigable 88,000 ac in the Panlaung scheme is higher land ("ya-land"), better drained and suitable for a mixture of crops.

1.11 The British rehabilitated these and other systems in Upper Burma, but generally left the canal alignments and basic structures intact in recognition of their high technical and engineering standards. The Bank-supported Kinda project also did not modify in any significant way the basic conveyance and distribution structures of the existing system.

1.12 In olden times the irrigated farmlands belonged to the kings, and the farmers were serfs who followed cropping systems under instruction of the kings' agents. In more recent times the farmers were freeholders, until, in 1964, a new socialist regime assumed ownership of all agricultural land. The farmers were converted to tenants. But they consider their rights inalienable and an active, informal, and officially illegal land market exists.

1.13 The new system established a parallel canal alignment to the west that would command a strip of 107,000 ha of mostly ya-land. Only 15 percent of the land under the new command consisted of the heavy soils of fine texture, with imperfect drainage, that is suited to paddy but not other crops. None of this ya-land—light soils of coarse texture—had previously been irrigated. Except for about 4,000 ac of bush, the new area was cultivated with paddy and other rainfed crops during the monsoon season. The northern half of the strip was the driest and much of it abandoned in years of poor-to-modest rainfall.

1.14 The project area is about 80 km from north to south and 30 km east to west. It has a tropical monsoon climate with three distinct seasons: a rainy season from mid-May to mid-October, a cool dry season from mid-October to mid-February, and a hot dry season from mid-February to mid-May. There is practically no rain from December through March. The rainfall gradient is sharp, with much more rain in the hills behind the dam site than in the command area out on the plain. This is the edge of the central dry zone. Average rainfall in the command area is only about 800 mm; at the dam site it is just over 1,000 mm. Farms without access to the canals can only harvest a monsoon crop with reasonable, but far from absolute, security. Non-

6. At appraisal, the project's total net command area on both banks was estimated to comprise 85,400 ac of paddyland and 116,100 ac of ya-land. About 7,000 ac were unavailable for irrigation.
paddy off-season rainfed cropping—based on early pre-monsoon rains and on the post-monsoon residual moisture—is a precarious practice. The old Panlaung diversion system helped secure the monsoon crop, and substantially improved the safety of a second crop in about 30 percent of the existing canal network. Pre-project annual cropping intensity in the old system was estimated at appraisal at 125 percent.

### 1.15 Kinmundaung

This site of 5,000 ac was selected for the first Tank project from a cluster of four sites in near proximity in the Yin basin of Magwe Division. The site is in the middle of the central dry zone, where, as in Kinda, low and unreliable rainfall confines unirrigated agriculture primarily to one monsoon crop, plus precarious efforts to bring crops to harvest during the pre- and post-monsoon periods. Without supplementary irrigation a paddy crop during the monsoon is even more risky than at Kinda, because of frequent failure of the late rains. Sesame, groundnuts, and other oil-seeds (Magwe Division is the center of oilseed production in the country), and other crops with lower moisture requirements than paddy, perform well in the monsoon season, and reasonably well in the pre-monsoon and post-monsoon seasons in about half the years. Without irrigation, cropping is impossible in the four, dry months December through March.

### 1.16 The area of the Yin basin is favored with good soils and a topography that provides occasional sites for storage on rivers—of relatively limited catchment area—running westward to the Yin River and on to the Irrawaddy. However in the mid-1970s there was no storage capacity in the Yin Basin and few run-of-the-river schemes of any significance. Kinmundaung was one of them. British engineers had rebuilt the earlier irrigation works on that river in 1911. But in the intervening years the canal had silted up, the infrastructure had deteriorated, and by 1980 only about 1,000 ac were still receiving supplementary wet season irrigation with any regularity. Thus, a large majority of the farmers to be incorporated in the 5,000 ac scheme had no previous experience with gravity flow irrigation, apart from watering their gardens from shallow dug wells.

### 1.17 Azin

The Azin site of 2,850 ac was one of a cluster of ten potential tank sites strung out in a 20 km line north and south of the town of Mudon in Mon State. The area comprises a corridor of land bounded by the Taungnyo hills to the east and the Salween River estuary to the west. The area is divided into two principal land forms: the piedmont fan, and the esturine flood plain. The area grows mostly rainfed paddy on the flood plain, while the piedmont fan is cultivated with rubber (mostly government estates), and private orchards in small gardens irrigated from shallow dug wells. Stored water can be used to support either or both the perennial tree crops or the paddy on the plains. This was the first tank built by ID on the southern coast.

### 1.18 The rainfall regime is radically different from the central dry zone. Monsoon rainfall was adequate to sustain paddy without supplementary irrigation. Yet the Azin River was ephemeral like the rest of these streams—dry in the dry season. The storage was intended to support a second paddy crop in this "summer" season. Initial plans did not include irrigation for orchards in the piedmont. Later, 850 ac of orchards were added to 2,000 ac of paddy to enhance the economic returns.

2. Kinda Scheme: Structure and Efficiency

A. Structure of the Irrigation Scheme

2.1 The Kinda Reservoir is formed by a 236 ft high rockfill dam on the Panlaung River and three smaller rockfill dams straddling saddles in hills ringing the reservoir. It is fed from a catchment of about 2,240 km². Water is released from the reservoir through the hydroelectric plant. From the dam, water travels about 12 km down the Panlaung River bed to the old Kinda Weir site. The Kinda Weir was rebuilt as a regulating dam with 1,800 ac-ft of storage. The regulating dam releases water directly to the old right bank Kinda Canal, now called Right Bank Main Canal (RMC) and the new Left Bank Main Canal (LMC). It also controls releases down the riverbed to be picked up by the other 3 functioning weirs on the river. Map 5 identifies the main structures.

2.2 The canal network terminology used in the rest of this report conforms to local usage. It starts with the "main" canals. The distributaries off the mains are called just that, "distributaries" (DY), and these either feed a "tertiary" distribution line that feeds "watercourses," or, as in much of the old system, feed the watercourses directly. The watercourses feed the "ditches" that lead to individual fields. On the Kinda LMC, as at the other new sites in this study (Kinnmundaung and Azin), the ditches were supposed to reach every field. But they were the responsibility of the farmers, and have not been completed on many tailend watercourses. The farms on the fringe depend on field-to-field flooding. In Kinda RMC field-to-field flooding had been more common and the project authorities did not intervene except in a pilot area (para 3.11).

2.3 The 125 km long LMC canal terminates in the Pyugan Tank. This tank is reported to have been built about the same time as the original Kinda Weir in the eleventh century. The tank serves 200 to 500 ac of paddy land reaching to the banks of the Irrawaddy River. The LMC follows the contour from the regulating weir to the tank. To reach it, which appears to have been one of the objectives of the design engineers, ID had to accept a lower gradient than it would otherwise have chosen. The low gradient made the conveyance capacity of the LMC sensitive to excess water use and weed growth in its upper reaches, among the factors that explain the shortage of water for distributaries close to the tank. Including the Pyugan Tank, the LMC feeds 35 distributary canals. The tank feeds another three distributaries.

2.4 The distributary canals run down the slope approximately perpendicular to the LMC. Many tertiary canal offtakes are incorporated into head regulator/drop structures. The tertiary canals run on the contour perpendicular to the distributary canals. They are equipped with

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8. Storage at the maximum operating level is 786,000 ac-ft. The active storage area is 619,000 ac-ft. The surface area of the reservoir is 36 km² at maximum and about 16 km² at minimum operating elevations. The main spillway has four gates which, together with an emergency open cut spillway 180 m long on the left rim of the reservoir, are designed for safe passage of the maximum probable flood occurring under full reservoir conditions.

9. And, in the case of the RMC, one "minor."

10. In Kinnmundaung two old distributaries are called "minors." In Azin there are "minors" in between the distributaries and the teritiaries.

11. About 80 km of the LMC is constructed of compacted earth and the remainder is lined with bricks to reduce seepage.
concrete structures designed for proportional delivery of water to watercourses, which run down the slope perpendicular to the tertiaries. The grid is adjusted to irregularities in ground level. It is more reticulated than in the old system, partly because of the higher elevation of the main canal. The turnouts from the mains to the distributaries and from them to the tertiaries are all fitted with undershot gates, at least on the LMC. The turnouts to the watercourses are made from concrete with grooves for stop logs, though most of these are missing. On the Panlaung system, there are many instances where the older openings are ungated.

2.5 Few changes in main canal infrastructure were made by the project in the Panlaung system, including the RMC. None of the canals in this system are lined. The RMC has a steeper gradient than the LMC. Continuous operation for hundreds of years has proven the sustainability of these canals. The Kinda weir remains the upper-most diversion. Until the Kinda Project it only diverted water into the right bank Kinda Canal. But now, about eight km from the weir the RMC bifurcates into the Pyaungbya and Ngalaingzin (ex-Kinda) canals. (Map 5 shows details.) Drainage from the last three distributaries from the Ngalaingzin Canal as well as water from the Zawgyi River irrigation system to the east is picked up by a common drain. The Panlaung River portion of the Kyaukse system was fully incorporated into the new Kinda Project. There are three more weirs. The last, the Kyime Weir, is a major structure and diverts water to the left bank of the Panlaung River into the Sama Canal. The Sama Canal irrigates a strip of land about 38 km long.

2.6 The Panlaung system irrigates 88,000 ac. The LMC was planned to supply 107,000 ac. The combined irrigable area as designed was 195,000 ac. As explained below, the inflow to the reservoir has been 80 percent of the projected supply in the nine years since the dam was completed. The last sections of the LMC are rarely supplied. Thus the actual command is closer to 175,000 ac. At appraisal there were about 14,400 farms in the RMC/Panlaung system, and 9,000 farms in the LMC system (as designed).

B. Water Availability and Efficiency

2.7 During the period of project preparation, water availability was estimated using all available hydrologic and meteorologic records. It was concluded that the average annual inflow to the reservoir would be about 1.1 million acre-feet (ac-ft). From 1986 through 1994 the average inflow was about 0.9 million ac-ft, or 79 percent of the expected average. In this nine year period the expected average annual inflow was reached only in 1992. The average release for the nine year period was about 850,000 ac-ft, roughly 78 percent of the planned average irrigation. It is still too early to conclude to what degree the expected inflow was overestimated, since rainfall was below average in the reservoir watershed during this period. However, ID officials believe that it was overestimated, though not by the full margin suggested by the first nine years of records. Inflows in the last four years averaged about 89 percent of the expected, long run average.

2.8 The annual inflow and release figures mask an evident problem of timing of releases for optimum water use for irrigation. ID indicated that hydropower production was given priority in the winter months, when the demand for irrigation was less than the water released. This contributed to water shortage during periods of higher irrigation demand. ID staff are skeptical that that priority will ever be reversed, especially in the face of electricity shortage.
2.9 OED has computed seasonal and annual irrigation system efficiency for the period 1990-1994 (Annex 1). Average efficiency over the whole period was 52 percent, which combines a rate of 69 percent for the pre-monsoon, 51 percent for the monsoon, and 10 percent for the winter seasons (weighted by water releases). While efficiency for the winter crops was low due to hydropower releases, the monsoon season efficiency was good and the pre-monsoon efficiency very high.

2.10 High efficiency levels might indicate that reservoir water is being used not only in the fields of first release but also lower down. In fact the rate of recapture of water is itself low, reflecting on the one hand the substantial depth of the water table in this dryland region of Myanmar, and on the other hand the lack of experience of farmers with conjunctive use of groundwater. There are some shallow wells near the rivers, but the OED team saw no evidence that farmers were pumping water for agricultural purposes.

12 While indicative of the real efficiency level, this analysis has some flaws. Complete meteorological data for each day was not available for the entire period. The crop water requirement was computed using ID's values for Mandalay Division, prepared from long-term monthly average evapotranspiration and rainfall records, and does not reflect the influence of seasonal evapotranspiration and rainfall differences or conditions specific to the Panlaung plain.
3. Kinda Scheme: Operation and Maintenance

A. Institutional Arrangements for O&M

(i) Agency Level

3.1 The Cropping Plan. Irrigation systems in Myanmar are unique for the study area in the level of crop planning and control over crops planted. Targets reflecting national priorities are set by the Central Government and distributed according to agricultural potential among the State (or Division\textsuperscript{13}) Agriculture Supervisory Committees (ASC). The State ASC use production statistics available at the State level to distribute production targets among District ASC for implementation. A similar process takes place at the District to provide targets for each Township.

3.2 At the Township level the ASC must deal directly with the farmers and decides for each irrigator how many acres of each crop he or she is to cultivate. In addition to distributing acreage to fulfill national targets, this decision is based on the ability of the irrigation officials to deliver water. To facilitate the process of meeting with farmers, Townships are divided into approximately four regions called Circles, each encompassing several Village Tracts (a rural area with one or more villages). An interim Circle ASC committee meets with farmers in the region to discuss and provisionally allocate the targets to each individual farm.

3.3 The present government of Myanmar is the State Law and Order Restoration Council (SLORC). It is represented at the Township and Village Tract levels by subordinate councils, which exercise authority within those jurisdictions. This structure is parallel to but fully coordinated with the ASC structure, and helps plan, approve, supervise and enforce the ASC decisions on water rights and planting obligations. The chairman of the Village Tract Council (VTLORC) chairman is a key figure in implementing the cropping plan.

3.4 Currently, depending on the location of fields relative to the irrigation supply, farmers in the Kinda Project are assigned to grow either paddy, cotton, and/or sesame on most of the land they farm. They are free to select and declare the crop of their choice on the one or two acres that are not assigned under the targets. Generally the ASC tries to accommodate the mix of crops requested by farmers but flexibility is constrained by target crops. Planning at the Circle level allows some adjustment of crop assignments to match soil characteristics.

3.5 Farmers must cooperate with the State Plan. If farmers disagree with their assignments, the ASC can transfer the assignment to other farmers and proportionally reduce the irrigation allocated for those who do not agree to fulfill the plan. Recalcitrant farmers may be penalized by the Township or VTLORCs.

3.6 Management of Allocations and Deficits. Water allocation initially is directly tied to crop assignments and the water is distributed solely on the basis of estimated irrigation requirements of the different crops. As the season unfolds, one of the important tasks of the ID

\textsuperscript{13} The administrative units below the nation-state are called Divisions and States, the former occupying the Burmese heartland, the States representing mostly minority groups. The word State in this text can mean either.
representatives on the ASC committees is to match crop water demand to progressive changes in reservoir supply. The reservoir level and average annual inflow information for the months of the cropping season are the basis for recomputing expected supply. The field level staff of ID, MAS, VTLORC and other institutions continuously supervise agricultural work at the farm-level on behalf of the ASC. They check whether the farmers cultivate their prescribed crops and are getting adequate irrigation supplies. When shortages are anticipated they help decide which farms, watercourses or entire tertiaries will be cut off.

3.7 The State has full authority to modify the allocation. Farmer rights in irrigation systems in many parts of the world mandate that even a dwindling irrigation supply be shared equitably, even to the point that inefficiencies increase and most crops are lost. In Myanmar the State or District MAS can reduce the area irrigated, even after crops have been planted, to make efficient use of the available irrigation resource. While this enables production to be maximized, some farmers may lose all their irrigated crops.

3.8 **Penalties.** The penalties as prescribed by law for farmers not meeting their production target are severe and include possible loss of land-use rights or even imprisonment for willfully disregarding the crop plan. However, if production fails because ID could not deliver the allocated quantity of irrigation at the right time, farmers can appeal for exemption from payment of the designated tax on production (the procurement quota, see para 3.23). They cannot appeal for compensation for crops lost. Extreme sanctions are usually avoided in the absence of a legitimate appeal, unless the recalcitrant is a repeater. Nevertheless the frequency of punishments and even jailings obviously reduce the incidence of abuse and conflict.

3.9 **Operational Procedures Introduced by the Project.** Project design documents show that the expected annual irrigation supply under normal rainfall conditions would generally not be sufficient for crops of rice and cotton over the entire cultivable area. The targeted annual cropping intensity for the whole of the Kinda scheme was 160 percent. To make best use of the available water the Kinda authorities, through international technical assistance, introduced a modern water management system for use by ID.

3.10 A computer program called Water Allocation, Scheduling and Monitoring (WASAM) was installed and calibrated, and staff trained in its use by the end of 1987. The objective of the WASAM program was to: 1) allocate the irrigation supply by calculating the weekly required discharge in each canal section of the irrigation system—through the tertiary turnout; 2) prepare a report of expected weekly total water requirements of each part of the Kinda system for operators to follow in adjusting release of water from the reservoir and distribution among the canals; and 3) monitor the actual water distribution and compare it with planned distribution. Since the appraisal and technical assistance teams had not anticipated a shortfall of water, WASAM was not designed as a mechanism to reallocate supplies in times of scarcity. The information it provided could be used to facilitate those decisions.

3.11 WASAM was introduced throughout the LMC, but the consultants also sponsored an intensive pilot operation in 20,000 ac below the RMC. New tertiary canals with gated control offtakes were introduced, running along the distributary canal, to which three or four watercourses were connected. These watercourses had no controlled offtakes before rehabilitation and had taken off directly from the distributary.
3.12 In the consultants' final report (1987) at the end of 13 months of assistance they concluded that the foundation had been laid for "modern water management" at the scheme. Work accomplished included establishment of a Water Operation Center and installation of a computer and WASAM software. The necessary calibration of structures for discharge measurement was well underway with several teams trained in calibration procedures. However, the report concluded that further development and training was necessary to realize the full benefit of the program and achieve "equitable" distribution of the limited irrigation supply as efficiently as possible, and to achieve the cropping intensity of 160 percent as planned.

3.13 **Main, Distributary and Tertiary Operation.** The responsibility for system operation and infrastructure maintenance down to the tertiary level rests with ID. GOM through budget allocations to ID's Mandalay Division provides funds for O&M. The Executive Engineer of the Kinda System is in overall charge. Assistant Engineers in each township supervise the irrigation distribution from the main canal to distributary and tertiary canals. Under each Assistant Engineer are from one to three Canal Inspectors who with their staff of assistant inspectors and Zonemen are resident in the command area. Each Zoneman is assisted by up to 5 assistants. At Kinda, most of the positions are occupied, and by experienced personnel. There are few vacancies.

3.14 **Rotations.** Prior to construction of the Kinda Dam there was generally simultaneous delivery of water in the principal Kinda (RMC) and Panlaung canals. Only during periods of drought did they rotate delivery between these canals. Without a reservoir for storage, water was lost to the scheme if not used, so whenever possible during the rainy season these canals were operated at maximum discharge. This allowed much of the command area of the canals to receive water continuously. As supply diminished between rainfall events, rotation was first practiced within these canals and then among them only if necessary.

3.15 The Kinda Irrigation Project system, including the LMC command, was also designed for continuous water supply to the main canals and distributaries. It was planned that tertiary canals should always be operated close to full discharge to enable equitable distribution among the watercourses within the tertiary. To achieve full discharge in the tertiary, rotation was planned among tertiary outlets of the distributary. For the RMC/Panlaung system, where there were few tertiaries apart from the pilot area, continuous water delivery was to be maintained. The pilot area was to experiment with finely calibrated releases at all offtakes.

3.16 **Maintenance.** Except for a small number of dump trucks and a backhoe, there is virtually no mechanical equipment used in system maintenance. The work is labor intensive. ID has a pool of permanent laborers and their supervisors. They generally live near their area of assignment. They are assigned to patrol a segment of canal and remove debris, silt, and weed from the canal and banks. In some segments of the various canals this labor is sufficient to maintain the canal in good condition. In other segments it is impossible for such a small labor force to keep up with problems and periodically larger labor gangs of farmers are hired to assist. Until the early 1990s ID carried out all the maintenance by labor gangs on daily wages, which resulted in very high costs.

3.17 Faced with budget cuts in 1992, GOM required farmers to provide mandatory labor for all earth work and routine maintenance including cleaning. The cut in funding resulted in little money to pay labor gangs, and the need to increase mass mobilization of labor to carry out O&M above the watercourses.
3.18 While ID determines the number of laborers and organizes and supervises the work on site, it is primarily the staff of the Township LORC members that organize villagers to work on the main canal. These mass mobilizations generally require all adult males from specified villages to attend work at a site determined by the ID staff. The length of canal or amount of cleaning is frequently assigned to villages in proportion to the number of adult males in the village. Landless laborers and villages without access to land irrigated by the canals are included in the mobilization of labor. The rationale is that they get some benefit from irrigation.

3.19 The Village Tract LORC organizes cleaning and repairs of the distributary canals. Again, all farmers who live in the Village Tracts which are served by these canals are expected to take part whether they operate irrigated land or not.

3.20 In short, whereas ID is technically responsible for canal maintenance down to the watercourse level, farmers are now asked to assist in most parts of the system. Corvee labor has a long tradition in Myanmar and, at least on these irrigation schemes where community benefits are visible, does not raise objection.

(2) Irrigator Level

3.21 Responsibility. Farmers are responsible for construction of all channels below the tertiary canal, and maintenance of the tertiaries as well as the watercourses and ditches. In much of the previously irrigated area, where the watercourses connect directly to the main or distributary canals, farmers do all maintenance up to the main canal. Tertiary and watercourse maintenance is a collective activity. Villagers who do not irrigate are not obliged to participate at these levels. Segments of watercourses are generally assigned to individual farmers for cleaning in proportion to the farmer's landholding in the watercourse command area. Though the "proportionality" standard for water sharing often collapses under stress of water scarcity (para 3.36), for maintenance it is preserved. A typical irrigator may spend 9 days a year cleaning canals as a member of a group (apart from his ditches): two days each on watercourses and tertiaries and five days on the distributaries and main canal.

3.22 If a farmer cannot attend to watercourse maintenance work he is responsible for sending a replacement. Any man over 18 years is acceptable. A woman is not acceptable as a substitute as "women cannot do heavy work like maintenance of canals." Failure to contribute labor makes farmers in most areas of the system liable to a fine. The current rate is 100 kyat\textsuperscript{14} a day, about twice the daily wage. Irrigators typically do not pay cash to their watercourse group for O&M, apart from a contribution for food and festivities on corvee days. There are exceptions to the system. One group of LMC farmers explained to OED that their watercourse leader collects money from each irrigator and hires labor to clean the watercourse.

3.23 Cost Recovery. Irrigators pay a flat annual fee of 10 kyat (US$0.10) per acre. This is in addition to a land tax of 2.5 kyat per acre that all farmers pay. These fees have not been adjusted for years and obviously cover practically none of government's O&M expenses. However, government raises substantially more than the O&M outlay from the irrigators through Myanmar's compulsory crop purchase program, and the Bank has considered that mechanism an acceptable though imperfect alternative. Quotas are established for each crop—irrigated and

\textsuperscript{14} About US$ 1 at current (street) rates.
rainfed—based on area cultivated. The quotas have been reduced since 1988 as part of the liberalization program. Currently, irrigators must sell 12 "baskets" per acre of paddy to government at the compulsory price, while rainfed paddy growers must sell 5 baskets (a basket of paddy weighs about 21 kg). For the average Kinda irrigator, the formula means he/she currently sells about 17 percent of his crop to government at a controlled price that now amounts to about 25 percent of the free market price. He/she can sell the rest of his surplus above subsistence in the marketplace. In the past the quota was much more onerous. Of course, the low, flat annual water fee also encourages planting paddy over other crops.

3.24 Leadership. Irrigation management at the watercourse level is done by leaders selected by the farmers. The nominee must be approved by the Township LORC. ID has a rule—and usually farmers try—to select a person with land in the tail-end of the watercourse, to encourage fair water distribution among farmers. The leader's main duty is to interact with ID staff to ensure sufficient water for farmers of the watercourse to cultivate crops according to the crop plan and to oversee fair distribution of water to each cultivated holding. If there is conflict the leader contacts the Assistant Canal Inspector of the area for assistance. In parts of the old system, watercourses are longer and divided into one or more areas with separate leaders for each. In the LMC the watercourses are uniformly small by design.

3.25 The leader generally manages watercourse cleaning, though there are cases where Village Tract officers organize and supervise maintenance. In general leaders are exempt from physical work on irrigation canals. They plan and direct the work and attend to food and drinks.

3.26 In many watercourses there are few if any meetings where farmers contribute to group management of O&M activities. Since maintenance primarily involves labor, no financial accounts are kept and there is no need for a secretary/accountant. Again there are exceptions, and several farmers described meetings where planning was carried out as a group and decisions were made by consensus of the watercourse members. But, as a rule, the "group" concept is poorly developed.

3.27 While there is some degree of self-governance at the watercourse level and in a few cases even at the tertiary canal level, organizing specifically for irrigation management has not been encouraged until very recently. The Village Tract authorities, who may or may not be irrigators, are often responsible for helping to mobilize resources for maintenance and to manage conflicts. From the sample of farmers interviewed it was clear, as one would expect from the long history of sustained irrigation, that the previously irrigated areas have considerably more local organization and governance capability than in the new areas of the LMC.

3.28 In the LMC the tertiary canals have a leader selected by the watercourse leaders and ratified by the Township LORC. His responsibilities are similar to the watercourse leader except at one higher level of association. He organizes with the watercourse leaders the tertiary's

15. In principle, the quota applies only to the monsoon crop. Marketing of the new pre-monsoon irrigated paddy crop is not controlled (although planting is!). However, Government can apply quotas to the off-season crops if it needs to do so to meet national production targets. Actual practice may differ from state to state.

16. D. Vermillion of the International Irrigation Management Institute (IIMI) comments: "In many ways state intervention in irrigated agriculture in Myanmar resembles that in China. China also uses mass mobilization of compulsory labor for irrigation maintenance and until recently still required a percentage of the crop to be sold to government purchasing boards." (Personal correspondence, January 19, 1996).
maintenance and mobilizes the farmers on the tertiary to clean it each season. In the Sama and RMC there are also cases where leaders are selected to represent more than one watercourse to direct maintenance and oversee irrigation distribution for the entire area.

**B. Operational Performance**

3.29 *The Pilot.* The pilot project for improving irrigation access by constructing tertiary canals in the RMC met considerable farmer resistance. The pilot activity was to demonstrate improved irrigation distribution efficiency and equity by allowing better control over the water. Many farmers, however, were not open to the changes. Farmers who lost precious land to new canals that crossed their farms resisted the move. More important, the new canal configuration required changes in distribution practices that conflicted with the established traditions, however inequitable, and caused sufficient conflict that the pilot arrangement was not repeated.

3.30 *WASAM.* Subsequent to the consultants' work in installing the computerized WASAM program, civil unrest made it necessary to move the computer to a safer location for a period of time. This disrupted operation of the WASAM program. However, there is little evidence that subsequent recalibration has taken place or that any systematic measurements below the main turnouts are made. Discharge measurements are made at only a few key structures. Other factors also contributed to abandonment of the WASAM program. As mentioned above, the pilot project, where WASAM had been controlled by the technical assistance team, was discontinued. Further, implementation of the program proposed for Kinda is data-intensive, requiring extensive field reports that include: on a weekly basis field wetness and actual area irrigated by each crop, and continual monitoring of actual discharge at many locations. This level of data collection overtaxed the capacity of ID staff and duplicated long-established procedures for recording cropped area.

3.31 Most important, WASAM's emphasis on equitable water sharing did not support the policy of top-down, target-driven, goals for maximizing production. Since the state owns all land, giving farmers only the right of use, it attempts to operate the agriculture system as a single integrated farm where decisions are made to maximize the returns to water and land. Equity in the distribution of irrigation and agricultural benefits is of secondary importance. GOM is interested in achieving its production targets, and places less importance on individual farmers' fate with regard to production. ASC will not hesitate to stop water to the tail end areas if water is not sufficient, despite the fact it had assigned targets and crops to those lands at the beginning of the season. Government does not take any responsibility for uncultivated land and crop failures due to water shortage. Farmers who planted according to targets and lost some or all of their crops can expect a reduction in their procurement quota but no compensation for costs incurred or income foregone. Township and Village authorities are sympathetic with farmers who suffer from these harsh conditions, and do not take decisions to cut off tailenders lightly. For their part, the deprived farmers appear to accept these decisions as appropriate to the circumstances. The WASAM program below the distributaries is largely irrelevant in this scenario and has been replaced by less data-intensive manual procedures.

3.32 *Reservoir and Main Canal Operation.* As noted above, the reservoir status and reservoir inflow expectation based on historic averages are used to establish the cropping plan and water allocation each season. Rainfall recorded in the command area and at the dam site may be significantly different from the rainfall distribution in the catchment area, so reservoir status is independent of the conditions in the farmer's field. ID staff monitor the reservoir, and township
level MAS and ID staff monitor soil moisture and crop conditions. But, rather than weekly as proposed by the WASAM program, the irrigation status is reviewed on a monthly basis. Once the crop plan is fixed the irrigation allocation is adjusted only to accommodate deviation from the expected water supply. Farmers cannot request changes in the allocation based on subsequent decisions to modify their crop plan.

3.33 Release of the irrigation supply through the hydroelectric plant is working smoothly. The only problem reported regarding reservoir operation relates to a policy for determining release of water for power generation at rates of discharge and at times that make it impossible to fully use the water for irrigation. In 1994 government accepted that ID requirements should take precedence over power requirements in decisions on water release. These priorities have yet to be fully respected. Water released for power generation in the months December to January, when ID has only limited needs for supplying farmers growing onions, wheat and other winter crops, largely escapes down the Panlaung to the Irrawaddy.

3.34 Rotations. The shortage of reservoir water, and problems in enforcing effective rotation at the tertiary level, have prompted a change in plans. Both the RMC and Panlaung canals are currently operated using a rotation which gives the RMC all the water for nine days and the rest of the Panlaung system all the water for the next nine days. In each system, the upper regions get water for five days and then the lower regions for four days. During the "on" portion of the rotation for the lower region of the main canals all of the upper distributaries are closed, a relatively easy situation to monitor.

3.35 For the LMC, ID now divides the 125 km LMC into three "sections" and, when there is sufficient water to supply all three, rotates water between them, closing all distributaries along the stretches of the two out of turn. In the past five years, since the distributaries of the lower reaches of the LMC were completed, that has generally not been possible. Section III has often not been provided any water at all, especially during the pre-monsoon season. Section II begins at distributary 18 (DY18); Section III begins at DY26 (see Map 5). ID admits that only farmers in Section I can expect secure water supplies in the pre-monsoon. Section II farmers are at varying degrees of risk, and the situation of Section III farmers is considered precarious. During the monsoon, many Section III farmers are still out of reach and effectively outside the command (para 4.2).

3.36 Rotations below the distributaries are operated with varying effectiveness depending on the location. The variability of this arrangement makes it difficult to describe a common practice. The impression from OED's group interviews is that rotations are generally effective along the distributaries with secured supplies of water, where the rotation is amongst tertiaries. Rotations amongst and within watercourses were not part of the original design, but have been adopted on occasion by the watercourse groups when they made sense to the group as a whole, either during the pre-monsoon season or when supplementary water was required during the monsoon. But these arrangements appear to break down in periods of water stress. Then, headenders take what they need before passing the water downstream and the tailend farmers invariably suffer. By contrast, rotations at the watercourse level is practiced mainly in the old system.

3.37 That the deprived farmers acquiesce in this situation, rather than press their claims, is one of the remarkable features of the Myanmar experience. It is a result of several factors, including an acceptance of the headend farmer's advantage, a mutual understanding that the
headend advantage will not be exploited excessively, a tradition of social discipline supporting 
the status quo, LORC's effective control over retaliatory action, and the absence of any sense of 
shared concern for consistently equitable treatment in distributing irrigation water. On the LMC, 
the lack of durable rules for proportional sharing of available water contrasts with the very real 
communal commitment to proportional contributions to watercourse maintenance based on the 
size of holdings.

3.38 However, at and below the tertiary level, under conditions of scarcity, rotation gives way 
to another form of rationing. In this case, as mentioned above, ID, ASC and LORC authorities 
anticipating a shortage simply block all tertiaries and watercourses below a certain point. These 
administrative actions can cut off entire watercourses, or farms at the tail of watercourses.

3.39 Although prolonged drought periods spelled disaster for large segments of the command 
areas roughly one year in ten prior to dam construction, farmers in the tail end of the RMC 
declared that was better than with the dam and the rotation system currently practiced, where 
water is to be delivered to them only 4 out of 18 days. Farmers in the lower parts of the last few 
distributaries of the RMC no longer have access to even supplemental irrigation for rainy season 
paddy. They blame this on LMC which, because of the size of the command area, they say 
receives continuous water release from the reservoir.

3.40 Irrigation Department staff disagree with the farmers' interpretation. They agree that 
less water is being delivered to the RMC and other Panlaung canals in the rainy season, but claim 
that sufficient water is released to those canals to provide supplemental irrigation to their entire 
command areas if all farmers use water efficiently. They see the problem as one of overuse in 
the upper parts of the canal depriving the lower portions of water. The fact that LMC farmers 
also complain—that their shortage is explained by excessive allocations to the RMC and other 
Panlaung canals—indicates a high degree of ignorance about the rationale for the present 
operational plan.

3.41 Department staff did agree, however, that the development of government farms which 
extract water from the RMC and LMC for over 7,000 ac—for cotton, mangoes and other upland 
crops—have diminished the amount of water that can be delivered to the tail areas. This 
condition is being rectified in part on the RMC by constructing a connection to the Zawgyi 
system for the tail distributaries of the RMC. This is possible because a major dam on the 
Zawgyi River is now nearing completion.

3.42 Delivery Problems. One constraint on problem rotations along the main canals is that 
the distributary, tertiary, and watercourse canals should have been designed for larger discharge 
in order to deliver the design volume to designated areas in a shorter period than would be 
required during continuous flow. The consultants installing the WASAM program reported that 
the canals were being destroyed by not operating them in continuous flow "as designed." 
However, inspection in 1995 only identified minor problems that can be attributed to larger than 
design discharge.

3.43 The LMC design discharge is 950 cubic feet per second (cfs). ID staff indicated that 
when the LMC canal is clean they can safely deliver up to 1,000 cfs. They also said that at 1,000 
cfs the system would perform satisfactorily with continuous delivery up to about DY26 but that 
even with slightly more than the design flow and a clean canal adequate irrigation delivery past 
DY29 was not possible. The low gradient of the LMC cannot explain all of this apparent design
error. It would appear as well that more irrigation than allocated in the original design is being delivered to upper distributaries. Since this land has only recently been developed for irrigation and is not yet fully leveled, some additional irrigation may be necessary until the fields are appropriately developed. The substitution of paddy for cotton and other field crops is another factor. OED suspects that yet another explanation is that the rate of infiltration in the ya land is higher than expected at design, and water is lost from the system that should have reached the lower distributaries. Since this water moves eastwards perpendicular to the LMC, it cannot be recaptured by farmers on the distributaries further north—the farmers who are now bearing the largest shortfall from design discharge.

C. Maintenance Performance

(1) Maintenance by the Agency

3.44 Dam. The reservoir and dam infrastructure is well maintained. Mechanical gates in the spillway which have never been used to release water because of less than planned inflow are in good working order.

3.45 Newly Irrigated Area. Physical control structures are in place in the LMC. At the main canal level they are operated by ID with little interference from farmers. Minimum routine maintenance of this recently completed system is keeping the infrastructure in good operating condition. All LMC structures observed—ooffline gates, cross regulators, siphons, and escapes—were in good operating condition. Structures below the main canal are also in good working condition. The outlet side of the drop structures show some erosion that could be corrected with routine maintenance. Access roads along the distributaries are heavily used and in poor condition. Lack of maintenance of the roads does not threaten the canal system.

3.46 OED did see evidence of unauthorized pumping and siphoning over and even through the LMC embankments. In several spots deep trenches had been cut under the roadway through the embankment to allow farmers to install a private hose connected to a pump either inside or outside the canal. Elsewhere there was a proliferation of loose hoses draped over the roadway, siphoning or pumping to adjacent fields. These encounters were at the upper reaches of the LMC, in Section I where water supply was most secure, during a rotation to a section downstream. ID officials accompanying the OED mission demanded immediate removal of the illegal equipment. But it was convincing evidence not only of selfish behavior by advantaged irrigators, but of some laxness in ID's patrol schedule (the deepest cuts must have been there several days) and of the difficulty of maintaining complete control even with the formidable administrative apparatus of ID and LORC.

3.47 Apart from illegal abstraction, the only serious problem with the LMC is rapid weed growth in the canal. It is a major concern for ID. The weed growth chokes the canal and reduces delivery capacity. Though, according to ID, the clean canal delivers the design discharge of 950 cfs, it only takes twenty days of full sunshine in the pre-monsoon season for weed growth to reduce the discharge by 15 percent. Within fifty days of cleaning the canal the maximum possible discharge is about 600 cfs, a 36 percent reduction from design values.

3.48 ID tries to clean these weeds from the LMC, a new species not previously seen on the RMC system, but has not yet been able to control the problem. Because of the persistence of the weeds, mass mobilization has become routine. Before the pre-monsoon season starts and in
principle every 50 days thereafter the canal is closed. About 3 days are required to drain the water from the canal. Then villagers have two or three days to remove the weeds and silt. Nearly 75,000 persons worked to clean over 140 km of LMC and RMC in December of 1994. Parts of the LMC were cleaned four times that year, generally with a much small number of persons. Mass labor mobilization for removing weeds has been effective, but it is difficult to schedule the necessary canal shutdown for 5 to 6 days every 50-54 days during the pre-monsoon season to enable cleaning.

3.49 While responsibility for maintenance of distributary and tertiary level canals technically lies with ID, lack of budget requires periodic assistance for maintenance from the farmers at these canal levels too. Even in situations where responsibility is not always clearly spelled out, the response by farmers has been supportive.

3.50 Previously Irrigated Area. The new and repaired structures of the main canals are in operating condition. All the head regulator/drop structures inspected on the RMC were functional. Some have had only minor repairs for many decades and others were improved by the project. In a number of cases erosion downstream of the structure is threatening to collapse the stilling basin walls. However, given the long life of these structures it is clear that timely maintenance has been done in the past or they would have collapsed decades if not centuries ago. Extending the downstream lining beyond the turbulent flow region would solve the problem in most cases.

3.51 A few distributary canals have been fitted with new gated control and measurement structures by the project, but in most cases existing structures have been repaired or improved. The ungated pipe outlets from the main canal in these systems have not been modified. However, numerous gates that were not renovated are missing spindles or linkage between the spindle and wooden gate. In many cases the gate could be operated manually but this requires more than one person to lift and prop the gate open. There are also many ungated offtakes from the main canals of the previously irrigated area. Because of their numbers, these cannot be controlled by ID. Even the gated distributary and watercourse outlets in these systems are mostly operated by the farmers.

3.52 The main and minor canals on the right bank have steeper gradients than the LMC and there was little evidence of weed growth and few complaints that weeds hampered irrigation delivery. For the RMC and Sama canal, villagers near the canals generally spend only one or two days helping clean them.

3.53 Drainage System. The project included construction of 180 km of new drains. No evidence was found of drainage problems in either the new LMC or the old RMC and Panlaung system despite a dramatic increase in irrigation application. In some of the lowest areas of the old system the water table is within a few meters of the surface but farmers do not report water logging.

(2) Maintenance by the Irrigators

3.54 At the watercourse and field channel level maintenance is adequate in that no connection could be established during field visits between maintenance performance and lower than expected cropping intensity and production. The condition of watercourses varies from those that are virtually nonexistent in the lower reaches of the LMC and lowest parts of the middle
distributaries, to those that are well-developed and maintained in the areas where the water supply is reliable. Watercourses not receiving pre-monsoon water are maintained just prior to the start of the rainy season. Farmers reported that working as a group they can reshape and clean their watercourses in one or two days.

3.55 It was observed that individual farmers built field ditches to their plots growing non-paddy crops in the pre-monsoon season. These ditches were cleaned regularly. Farmers reported that they close field ditches running through their fields during the monsoon season to expand the paddy area and because they prefer field-to-field irrigation.

3.56 The only visible maintenance problem at the farmer level is the poor condition or absence of most project-supplied gates at tertiary as well as watercourse turnouts. Farmers rebuild the gates with banana stalks, earth and cloth when necessary. But the damage is evidence of the suspicions that most farmers behind the gates harbor about the utility of rotations.
4. Kinda Scheme: Agro-Economic Impacts

A. Agricultural Impact

4.1 *Net Cultivated Area.* The PCR assumed that the design in the Staff Appraisal Report (SAR) was still valid and assumed that by the year 2000 the entire programmed area of 195,000 ac would have access to irrigation, despite the delays in expanding the network in the early years. That assumption must now be abandoned. Not only are releases from the dam likely to be less than expected over the long run. The application of water to paddy planted on the high land of the LMC command implies that much more water than planned is being lost through infiltration through these better drained soils. The rate of infiltration through these soils also appears to be higher than expected. Added to these losses, the low-gradient architecture of the left main canal, and the weed growth it has stimulated, reduce the velocity and discharge to the lower reaches. Taken together, these factors indicate water supplies to the LMC will never provide full coverage up to appraisal design even if the dam were full. The roads through the lower reaches of the LMC—apart from in the vicinity of the Pyugan Tank—pass through a virtual desert, much of which is unlikely ever to benefit from the project.

4.2 Perhaps 20,000 ac will remain forever rainfed, though that will not be confirmed for many years. If the estimate is correct, it means that the project will have added about 87,000 ac of newly irrigated land to the 88,000 ac irrigated in the old scheme, for a total of 175,000 ac net irrigable and cultivated area. That is less than the 195,000 ac planned, but not an unimpressive result.

4.3 *Cropping Intensities.* The more important shortfall is not in the net cultivated area—the acreage under actual command—but in the gross cultivated area—reflected by the cropping intensity. That is where the real problems of the Kinda scheme are found.

4.4 In the areas on both the right and left banks where water has been secured throughout the year, the project's objectives have been fully reached. The Kinda reservoir has dramatically improved reliability of irrigation delivery to these parts of the command area. The effects of reliable water supply on the cropping intensity of a large number of farmers was forcefully revealed during group interviews. Increases in land prices (in the "illegal" land market) in areas with a secure water supply support that point.

4.5 Almost all of the farmers interviewed in several sessions in these favored areas had individual cropping intensities above 140 percent, with the average for groups of farmers from the different areas ranging from 180 to 200 percent. Those figures compare well with pre-project intensities for the old scheme alone, reported at appraisal to be 125 percent. The situation of these farmers does not represent the command area as a whole. However, the consistency of their cropping intensity suggests that, *with adequate and reliable irrigation,* the project design goal of 160 percent could easily have been achieved in all parts of the command area.

17. Para 3.43.
4.6 Many farmers in these groups said they frequently face water shortages that affect yields and in some cases the crop selected, but few of them said that water was the main constraint in selecting more intensive cropping. Rather, unattractive market prices, cropping patterns imposed by the state, lack of labor, and the high cost of other inputs were more important factors. However, farmers with land in the lower reaches of the same distributaries, with infrequent and unreliable irrigation, were unanimous in saying it was the lack of irrigation that was the main limitation.

4.7 There is no routine reporting of agricultural data related exclusively to the scheme. The Irrigation Department assembles MAS data based on Village Tract reports of actual planted area and yields for all crops. These data come from four townships, but before they can be used, the Tracts inside and outside the scheme must be separated. These data purport to distinguish between irrigated and non-irrigated fields and are considered reliable. The PCR used the same source.

4.8 Table 4.1 presents the area cropped by season, for the 175,000 ac net irrigable and cultivated area under actual command, for the period from 1990/91 through 1994/95, the five years since the LMC distributaries were completed. Average cropping intensity for the period is 105 percent. For the last three years, the average is better, 117 percent. Comparing these figures with the average of the PCR estimates for these three years, 112 percent, actual scheme performance looks rather good, although several years behind appraisal schedule. But the PCR assumes that intensities would continue to improve steadily from 75 percent prior to the project (including the rainfed left bank) to the SAR target level of 160 percent at full development. This projection can no longer be justified. In fact the trend of annual cropping intensities may have already leveled off. The PCR projections are undermined by the expected shortfall of water in storage, and by the preference for planting paddy over cotton and other upland crops. If the latter practice cannot be reversed, overall cropping intensities are unlikely to close much of the gap between the recent level of 117 percent and the level targeted level in the SAR of 160 percent.

4.9 Cropping Pattern. The choice of crops has a large impact on water requirements. In the pre-monsoon season, for example, ID estimates that it will need to deliver about 58 ac/inches of water for a crop of rice at Kinda compared to 30 ac/inches for cotton or sesame. Thus, any shift from paddy to these upland crops—where soil conditions permit—will double the effective area irrigated and raise the cropping intensity. In the monsoon season, the ratio is even higher—closer to three to one—though less irrigation water is needed for any crop in that season.

4.10 The area actually planted to each crop can be compared to the area planned during design. Table 4.1 shows the actual and planned annual cropped area for the major crops. The area planted to paddy was close to the design area, and even exceeded it in 1994. The area planted to chilies, sesame, and especially cotton averaged considerably less. As a percentage of total cropped area, the paddy/non-paddy difference is even more pronounced.

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18. The PCR's year-wise estimates have been read from a trend line. Annual figures are not provided. The PCR data refer to the full 195,000 ac design command.
## Table 4.1: Seasonal Cropping Pattern and Intensity

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<td>6,400</td>
<td>1,770</td>
<td>1,529</td>
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<td></td>
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<td>1991/92</td>
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<td>175,000</td>
<td>362</td>
<td>8,863</td>
<td>14,147</td>
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<td>Premonsoon</td>
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<td>13,021</td>
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<td>11,799</td>
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<td>86,187</td>
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<td>Monsoon</td>
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<td>1,950</td>
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<td>8,314</td>
<td></td>
<td>26,541</td>
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</table>

Source: MAS data using Village Tract information on actual planted area.
Information assembled by the Irrigation Department.
4.11 The most noticeable difference is the failure to establish cotton as the dominate crop on the LMC. There is less cotton acreage now than there was before the project. If farmers can be persuaded to replace paddy with cotton where soil conditions permit on existing irrigated fields, the shortfall in cropping intensities from SAR targets would be substantially, though far from fully, closed.

4.12 The average area planted annually during the period from 1993 to 1995 was 196,000 ac, a little less than two-thirds of the 317,000 ac planned. As discussed above, reservoir inflow remains below design by a factor of about 11 percent (para 2.7). If 11 percent more water were available and if all of it was applied to non-paddy crops, the total area cropped would increase to 228,000 ac or a little less than three-quarters of the 317,000 ac planned, a significant improvement though still well below the level expected at design. The deficit in irrigation supply thus joins the paddy preference to provide the main causes for the gap between expected and actual area cropped and the low cropping intensity.

4.13 The dominance of paddy is the result not only of the farmers' preferences but also of pressure from government. The gap between projected and actual cropping patterns is thus an indication of the failure of project designers and officials to adequately understand farmers needs, as well as anticipate the overriding force of government's long-term policy objectives. By allowing rice prices to rise in the last several years, government has been able to satisfy farmers and its own policies simultaneously.

4.14 Yields. OED's estimates of paddy yields in the pre-monsoon (3.1 tons/hectare) and monsoon (3.6 t/ha) seasons are about 80 percent of SAR projections for full development. The PCR gave a single estimate of 3.7 t/ha for both seasons. These figures compare with estimates of pre-project paddy yields of 2.8 t/ha for irrigated fields in the old system, and 1.5 t/ha on rainfed farms of the LMC. OED's estimates of sesame yields are also about 80 percent of the SAR projection: 320 kg/ha vs 400 kg/ha (the PCR accepted the SAR projection for sesame). Those irrigated sesame yields can be compared with the SAR and PCR estimates of pre-project sesame yields—both about 200 kg/ha.

4.15 A much larger shortfall from projected yields emerges with the cotton crop. OED's estimate is 650 kg/ha, only 40 percent of the SAR projection for full development (1.7 t/ha) and no different than the SAR and PCR estimates of pre-project irrigated cotton yields. Thus, for cotton, not only has there been no growth in irrigated area, but the yields have remained static.

19. Cotton was incorporated in the planned crop rotation to raise the ERR and justify the project, against the objections of some Bank staff who felt that the assumption it would be taken up by farmers at the scale projected was too optimistic. At appraisal, non-paddy crops, led by cotton and sesame, were expected to occupy 66 percent of the total cropped area, mostly on the LMC. Cotton was expected to take a third of that (about 23 percent). But for the three crop years 1992/3-94/5 non-paddy crops actually took only 46 percent. Cotton took 7 percent, and most of that was planted in traditional zones in the old scheme. In short, paddy has crowded out upland crops in the farmers' rotations—compared with appraisal projections.

20. That refers to the 175,000 ac assumed in this report to be under command.

21. Yields are reported per hectare in this report. See Footnote 5.

22. OED's yield estimates are based on interviews with MAS and ID staff, as well as individual and groups of farmers.

23. These are PCR estimates. The SAR used lower pre-project estimates: 1.5 t/ha and 1.0 t/ha for the pre-monsoon and monsoon seasons.
This deals a further blow to the SAR rate of return estimates, since almost one-half of all incremental benefits were attributed to cotton.

4.16 Production. Annual total production in tons of paddy, cotton, sesame and several other crops is shown in Table 4.2, supported by Annex 2. It compares projections at appraisal for full development, which was to be reached in 1993/94, and as calculated by OED in 1995 for the average of the last three years, i.e. the same time frame. Area and yield figures for the three main crops are as quoted above. The production total for each crop includes yield increases attributable to better water supply on fields in the old areas that were already irrigated. The table shows the remarkable concentration of incremental production on paddy. The anticipated expansion of cotton, sesame and the other crops failed to occur. The paddy crop grew by 100,000 tons, two-thirds of the expected 149,000 tons recomputed by OED based on appraisal area and yield estimates. By contrast, an incremental cotton crop of 67,000 tons projected at appraisal never materialized, and cotton production actually declined by 6,000 tons.

Table 4.2: Kinda—Incremental Crop Production Estimates

<table>
<thead>
<tr>
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<th>SAR</th>
<th>OED Impact</th>
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</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>148.7</td>
<td>99.6</td>
</tr>
<tr>
<td>Cotton</td>
<td>66.9</td>
<td>(6.3)</td>
</tr>
<tr>
<td>Sesame</td>
<td>7.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Chillies</td>
<td>20.4</td>
<td>8.3</td>
</tr>
<tr>
<td>Onion</td>
<td>20.2</td>
<td>4.4</td>
</tr>
</tbody>
</table>

4.17 Since the basic canal infrastructure is now in place, and all available water is used and used rather efficiently (para 2.9), no substantial further expansion of total production can be anticipated. The exception would be if inflows into the reservoir return to appraisal expectations, which would provide an additional eleven percent to the water supply. The PCR acknowledged the shortfall in area planted and production at the time of writing in 1991, but assumed that ultimately the scheme would catch up with appraisal targets. That assumption is no longer defensible.

B. Financial Impact, Farmers' Level

4.18 The average family holding of irrigated land is larger on the previously rainfed left canal than on the already irrigated right canal. Nevertheless, current information suggests that a rough average of about three hectares is acceptable for both. Crop budgets per hectare calculated by OED at 1995 financial prices and free market exchange rates (K100=US$1) indicate a net incremental income of about US$1,815 per year for a fully-irrigated three hectare upland farm on the LMC with two crops of paddy (Annex 3). Each crop returns about US$300 per hectare, after subtracting the value of a rainfed sesame crop that would have been grown during the monsoon season in the absence of irrigation. If the LMC farmer were growing irrigated sesame and cotton as had been planned for the pre-monsoon and monsoon seasons respectively, the total incremental return would be much less. In this case it would be only US$670 for the two crops (3 ha), reflecting the substantial difference between the present price incentives for paddy and
other field crops. Presumably, this is the factor mainly responsible for the LMC farmer ignoring the appraisal cropping rotations and planting paddy on the ya-land.\(^{24}\)

4.19 The paddyland farmer on the RMC enjoys a smaller incremental income attributable to the project, because he was already profiting from the older scheme. Assuming he used to grow one secure monsoon crop per year, and a pre-monsoon crop every second year, his incremental income would be about US$1,005. Total net income for the farmers on the LMC and RMC from paddy is the same, however, about US$2,010 from the three hectares. The equivalent of about 13 percent of that in paddy would be retained by the family for home consumption.\(^{25}\)

C. Economic Impact

4.20 The SAR economic rate of return (ERR) for the whole of the Kinda scheme was estimated at 21.3 percent, including the power component. The PCR re-estimated the ERR at 14 percent, a decline attributed to higher investment costs (15 percent above projections), a lag in crop production benefits, and a fall in the price of rice. As mentioned above, PCR maintained that the SAR's full development production targets would eventually be met.

4.21 The ERR again must be revised sharply downward. For the impact study OED did not repeat the complete economic analysis based on farm budgets carried out at appraisal and completion. Rather, the SAR analytical framework was preserved, and adjustments were made to the cost and benefit streams to reflect the 15 percent increase in construction costs and, of far greater significance, the actual and projected shortfall in the incremental value of agricultural production. Production of the different crops was aggregated after adjusting each crop other than paddy by a crop/paddy price ratio to convert them to paddy equivalents.\(^{26}\) This allows the SAR and OED tonnage estimates to be compared.

4.22 Actual total production benefits are only about 40 percent of the appraisal projections.\(^{27}\) When the SAR crop production benefit streams are reduced by these amounts, with comparable reductions to the costs of crop production, and the higher investment costs are also incorporated, the ERR falls from 21.3 to 9.7 percent.

4.23 A final adjustment has to be made to reflect the decline in the traded price of rice since the appraisal report was prepared. The SAR used a 1990 rice price, based on 1980 constant

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\(^{24}\) As discussed in the Overview to this irrigation impact study, a comparison of input/output price ratios from all three countries included in the study shows that Myanmar's paddy farmers have a distinct advantage and enjoy the most favorable ratios.

\(^{25}\) That corresponds to 2.5 tons of paddy, or 1.5 tons of rice. These parameters are based on per capita annual rice consumption of 250 kg, for a six member family. See Mitchell, Donald O., and Merlinda D. Ingco. November 1993. The World Food Outlook. International Economics Department, World Bank, p. 160.

\(^{26}\) The prices were taken from the PCR (economic prices, PCR p. 55). OED did not update the PCR prices, and to the extent there have been changes in relative prices the comparison should also be adjusted. That adjustment is immaterial, however, because of the vast difference between SAR production projections and OED's updated projections.

\(^{27}\) Appraised projections for groundnuts and pulses were ignored. These crops are grown in the LMC extension, but mostly without irrigation

\(^{28}\) See Footnote e, Annex 4.
dollars, of US$504/t. That converts to exactly US$700/t in 1990 dollars. The actual price in mid-1995, again in 1990 dollars, was US$237/t, or 34 percent of appraisal expectations. Adjusting only the appraisal paddy price in the ERR calculations by this factor,²⁹ leaving the other economic crop prices intact, would bring the ERR to 7.4 percent. This analysis was not pursued³⁰ because it was obvious the project is only marginally viable in economic terms. Details of the calculations are provided in Annex 4. The benefit stream for the power component was left intact. Flood control and the fish catch from the reservoir³¹ are additional economic benefits which are not reflected in the analysis.

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²⁹ The adjustment should be by less than the difference in fob Bangkok rice prices, but the impact of that distortion has little effect on the outcome.

³⁰ For example to adjust all the re-calculation to reflect the very recent increase in the Bank's rice price estimates for 1995-1996 by 17 percent.

³¹ About 70 full-time fishing families live on the margin of the reservoir, and deliver their catches to one of their own, a women licensed by the Central Government Commander in Mandalay. During the monsoon she is contracted to deliver to collecting army personnel of Central Command about 130 kg a day. Any surplus is retained by the fishermen.
5. Tank Schemes

A. Structure of the Irrigation Schemes

5.1 Kinmundaung. The Kinmundaung subproject included a 25 meter-high earth dam, a reservoir fed from about 74 km\(^2\) of catchment, construction of a six km main canal, rehabilitation of an existing diversion weir, extension and remodeling of the right and left distributaries (each about six km long), and construction of the subsidiary irrigation network (Map 6). The system as finally approved would command about 5,000 irrigable acres, although original plans called for 4,000 ac. The storage capacity was expected to provide supplementary irrigation for the monsoon crop for all 5,000 ac, including 3,000 ac of paddy and 2,000 ac of other field crops (cotton and sunflower were proposed in the SAR). It was also expected to support 1,500 ac of pre-monsoon sesame and "up to" 1,000 ac of post-monsoon groundnuts. The average farm holdings of irrigable land was a little under 5 acres, and 1,100 farmers would participate.

5.2 The annual inflow to the reservoir was overestimated. Streams with highly variable discharge are extremely difficult to gauge reliably. Bank files during preparation attest to the concern of the hydrologists to get reliable estimates. Preparation had perforce to rely on flow measurements taken at the weir, not at the reservoir site. The SAR states that estimated runoff from the reservoir catchment based on records for the period from 1959-81 was 22,800 ac-ft. The expected water availability ("yield") from the reservoir was estimated to be 16,800 ac-ft. The actual average inflow for the 1986-94 period was only 8,700 ac-ft, about 50 percent of the expected irrigation supply, and the average release for the same period was 5,900 ac-ft, about 35 percent of the expected supply. The maximum inflow in one year was 72 percent of the expected supply. The spillway has never been topped. The scheme is clearly overdimensioned in relation to the catchment. When water is needed, the irrigation infrastructure in the lower reaches of the system remains dry and nonfunctional. The water shortfall is significantly more severe at Kinmundaung than at Kinda. It appears to be attributable to the miscalculation of reservoir inflow rather than the period of reduced rainfall, though that has aggravated the problem.

5.3 Azin. The Azin subproject includes a 28 meter-high earth dam, a reservoir fed from about 6 km\(^2\) of catchment, and construction of a main canal, two major distributaries and the subsidiary irrigation network (Map 7). The distance from dam site to the end of the longest distributary is about ten km. The system as designed was to command about 2,000 irrigable acres of paddy land and 850 ac of orchard. It was expected that the 2,000 ac would be farmed by about 450 families, averaging four-five irrigable acres each. The irrigated orchard land was to be divided between a state farm of 250 acres and 160 individual holdings averaging nearly four acres each (totaling 600 ac). Unlike Kinda and Kinmundaung, the catchment and reservoir at Azin have proven to be more than adequate to irrigate the design area, and the spillway is topped every year.

B. Operation and Maintenance

(1) Kinmundaung

5.4 Water Allocation. The planning process is the same as described for Kinda. The crops specified by the targets in Kinmundaung are paddy and sesame. There is little if any farmer
input to the crop plan. Farmers must plant the specified crops or face penalties that could include loss of cultivation rights or imprisonment.

5.5 **Punishment.** In 1994 twenty persons were arrested and fined. All were fined K500 (US$5), five for breaking the article of the water code which prohibits damaging the canal, the others for failing to attend to maintenance as requested. Some of the persons were reported by the watercourse leaders. Some were reported by ID staff. Several were arrested by the chairman of the Village Tract LORC and taken directly to the police without consulting ID.

5.6 **Rotations.** An important difference between Kinda and Kinmundaung is that the water shortage in the Kinmundaung tank limits distribution of supplementary monsoon supplies as well as pre-monsoon applications. As indicated in para 5.17, only 2,500 ac of the planned 5,000 ac receives monsoon irrigation regularly, and only about 500 ac receives pre-monsoon irrigation. Rotations in the monsoon season at Kinmundaung are administered on an ad hoc basis, depending upon the rainfall. Nevertheless, it appears that at Kinmundaung as at Kinda these rotations at the tertiary and watercourse levels are respected by the farmers as long as supplies are sufficient—over the area approved by ASC and ID—but break down when water is short. Then, as at Kinda, headend farmers use as much water as they reasonably believe they need while tailend farmers go short. Their group structure is not cohesive enough to guarantee proportional distribution, and neither is it enforced by ID or the Village Tract LORC. The farmers who are to get nothing are usually told that in advance of the season.

5.7 There is no "rotation" in the pre-monsoon season at Kinmundaung. ID and the Village authorities decide which small block(s) of farmers will receive the privileged supplies and when the releases will be made. Because the 50 ha project research farm is located in the command area of the RMC at Kinmundaung, the RMC is favored for water release in the pre-monsoon season and farmers adjacent to the station can count on being selected.

5.8 **Leadership.** The process of election of watercourse leaders, and ratification by the Village and Township LORCs, is comparable to the Kinda model. An informal system was already in place covering the approximately 20 percent of the project farmers who benefited from irrigation supplied from the old diversion weir. However, in the OED interviews there were few references to rules, roles or other indicators of farmers playing an active part of management. "Participation" in scheme decision making is limited to the leaders and those other irrigators who are members of the Village Tract authorities.

5.9 **Maintenance.** It appears that the agencies and irrigators handle most if not all maintenance tasks without difficulty. Before the dam there was considerable silt carried into the system which farmers say enhanced fertility, even though they had to desilt the canals. After the dam there is very little silt deposited in the canals. The main maintenance activities therefore are cleaning weeds and making minor repairs to embankments where crabs, rats and other animals have caused damage. Many of the lower reaches of canals have never been used. But even there, because of low rainfall there has been little deterioration in the canal and its structures though the channels are overgrown and often hidden by weeds.

5.10 Overall the canals inspected by the OED team below the distributary level including watercourses and field ditches were not as well cleaned as in Kinda. There appeared to be more than two months of weed growth and siltation. Nevertheless, the water was moving well enough to serve the fields still requiring supply. It is when the flow drops below that point that the
farmers clean the canals. The incentives for concerted action well in anticipation of pre-
monsoon supplies are stronger than for monsoon supplements—because the pre-monsoon crop
depends on the canals—but that affects at most ten percent of the design command area.
Officials as well as farmers claimed the irrigators maintained the canals when necessary. How
the canals look does not matter to farmers as long as they get their water.

5.11 Much of the work on the larger canals is done by labor hired by ID, although, as at
Kinda, farmers respond without objection to instructions from the Village Tract LORC to clean
the mains, minors and distributaries. One farmer interviewed with fields 3,000 m from the main
canal on LMC Minor 1 is 1,000 m beyond the limits of supply through that channel and has only
received water in his fields once since the canal was built. However, in 1994 he had to spend
three days on two occasions cleaning the minor. There is sufficient labor living in the design
command area to clean all canals in a few days if necessary. The weed species that proliferates
in the Kinda LMC has not appeared at Kinmundaung, where the major canals have a steeper
gradient and the water a greater velocity. There was adequate demonstration that the VT LORC
can accomplish such mobilization to conclude that canal cleaning does not limit system
performance.

5.12 The dam and its control structures are in good condition. Nothing was seen by the
mission or reported that would indicate any problem with operation of the reservoir. The
diversion weir, RMC and LMC structures are also in good working condition. Where Minor 1
from the RMC had breached an embankment several years ago because the embankment had not
been properly compacted, and although ID intends to repair and line the minor, farmers simply
bypassed the break using an existing watercourse. Most gate emplacements and other masonry
control structures below the distributaries were functional, although the wood gates (stoplogs)
were everywhere missing. The few gates in the system operated by ID's Assistant Canal
Inspector were operational. Accepting farmer-installed banana stalks and earth as gates, then all
structures are functional.

(2) Azin

5.13 Crop allocations, watercourse groups and rotations are organized as at the other sites in
Myanmar. No O&M problems of any sort were reported or observed. The overall rotation
provides the orchards water two days a week, and the paddylands five days a week. Each paddy
farmer gets water twice a week. Tailend farmers are served first, and there are few complaints
about headender abuse. No water is released into the main canal during the four monsoon
months: the rains are sufficient. Orchard farmers receive irrigation the other eight months;
paddyland farmers only during the pre-monsoon growing period. Complaints of water shortages
by the orchard and paddy farmers are rare. However, MAS is currently piloting a third crop in
500 ac out of the 2,000 ac paddyland total. MAS foresees the day when the present abundance
of water will end, and competition for irrigation will emerge. It is trying to persuade orchard
farmers to shift to sprinklers and other water saving technologies in anticipation of that event.

5.14 The dam, main and two principal distributaries were all in good condition. The
distributaries are lined to the boundary between the villages and the paddyfields. At the time of
OED's visit the main had just been cleaned and was immaculate. Watercourses in the paddy area
are structurally sound but often choked with weeds, when, for example, the summer crop is being
harvested. The OED visit coincided with the start of the monsoon season, and the farmers were
unconcerned with the appearance of the channels. In anticipation of each summer season ID
organizes one substantial cleaning of the larger structures, and farmers help with three other
cleanings during that season. They provide this labor when instructed to do so. They also patrol
the canals, including the distributaries, and call for ID's intervention only when they cannot make
the repairs themselves.

5.15 According to ID and MAS the ditches initially constructed by these paddy farmers—who
had never worked with irrigation before—were poorly made. The agencies had to step in to
instruct and assist the farmers in remodeling the channels. In the last three years the paddy canal
network has been extended to the full 2,000 ac. Those farmers that had opted not to construct the
ditches but relied on field-to-field flooding have now almost all made private connections. The
last 85 acres to be connected, in four separate pockets on the fringe of the scheme, were to be
completed in 1995.

5.16 For the first time at the three project sites visited in Myanmar, OED found a large
collection of wooden gates that were in good condition and said to be used as intended. Since
they were not needed at the time of the visit, they had been pulled out of the masonry gate
structures and stored in the yard of a member of the water user group at the edge of the village
and close to the scheme. This is further evidence of the Azin scheme operating as planned.

C. Agro-Economic Impacts

(1) Kinmundaung

5.17 Over the last four years ID has provided, on average, supplementary monsoon irrigation
for about 2,500 ac, all of it dedicated to paddy. The SAR indicative plan called for 3,000 ac of
paddy and 2,000 ac of cotton and sunflower. Thus, only half of the area commanded by the
project infrastructure has actually received irrigation during the rainy season. In the pre-
monsoon season the fraction is much smaller. In 1994 ID supplied 500 ac of paddy; in 1995 it
supplied 310 ac of paddy and 250 ac of sesame. Had all the pre-monsoon water been applied to
field crops other than paddy, the 1995 total would have been about 900 ac, up from 560 ac. The
SAR estimate for the off-season was 1,500 ac of sesame plus up to 1,000 more acres of
groundnut. The SAR did not anticipate using water for paddy in the second season.

5.18 The SAR indicative plan for developing a monsoon cropping system that included
irrigated cotton was also frustrated. The only cotton planted in the scheme is at the research
farm. The sunflower and groundnut components of the SAR rotation were also not taken up by
the farmers. As long as paddy dominates the cropping pattern, the intensity of land use will be
commensurately lower than the potential.

5.19 For 1995, the intensity of irrigated farming was 61 percent for the design command area
(5,000 ac), or 122 percent for the actual command area (2,500 ac), figures that can be compared
with the appraisal target of 150 percent for 5,000 ac.32

32. The SAR cropping pattern tables show a minimum 130 percent intensity, ranging up to 150 percent depending on
annual water availability for a 1,000 ac post-monsoon groundnut crop. In the SAR ERR calculations, the full groundnut
component was included without qualification.
5.20  Most of the crops irrigated during the off-season, whether it be paddy, sesame or other, can be counted as incremental. But that refers only to about 500 ac. The monsoon benefits, enjoyed by about half the farmers within the scheme perimeter, are more substantial. During interviews, farmers within reach of the irrigation supply claimed that their monsoon paddy yields had doubled, an increment of about 0.8 tons per acre (2 t/ha).

5.21  A reestimated rate of return was worked out for the Kinmundaung subproject, based on the SAR ERR framework. The sharp reduction of 60 percent in cropping intensity substantially decreases the ERR. This loss is compounded by the decline in the price of rice, as described in the Kinda analysis. The recomputed ERR for Kinmundaung is negative. The SAR estimate was 13.6 percent. The PCR reestimate, issued in 1991, is 12.3 percent, based on the assumption that the appraisal cropping pattern and intensity would be achieved.

5.22  Paddy yields for the farmers who have reliable water for the monsoon season are about the same as at Kinda, and incremental net income per hectare per crop is also estimated at about US$300. The average irrigated farm size is 2 hectares; thus for those privileged farmers enjoying full water supply for the two seasons, the net incremental farm income from irrigated fields is about US$890. Total net income from those two-hectare farms is US$1,340, two-thirds the earnings of the Kinda farmers (see Annex 3). A little under 20 percent of the paddy would be retained for home consumption (Footnote 25).

(2)  Azin

5.23  Average annual releases from the Azin reservoir during 1992-94 were 99 percent of projections. Against the SAR target of 850 ac of orchard, an estimated 838 ac are presently under irrigation, including all 250 ac on the state farm. The acreage of paddy benefiting from irrigation has grown steadily since the first release to the lowlands was made in 1991. In the 1994/95 dry season, 1,914 ac of paddy were irrigated. The total was expected to reach the scheme potential of 2,000 ac in 1995, as the last farmers dug their ditches and entered the network.

5.24  Summer season paddy yields have been about as high as expected, ranging between 3 and 5 tons/ha (60-100 baskets/acre). MAS uses an average of 1.7 tons/acre (80 baskets/acre, or 4 t/ha) in its reports, which compares with the SAR projection of 1.8 tons/acre. That is consistent with the OED interviews, and is 20 percent higher than actual yields at Kinda and Kinmundaung. This is all incremental production attributable to the project. Nothing was planted on these fields in the dry season before the project. Conversely, no supplementary irrigation is needed or released for the monsoon crop, and no benefits from that season are attributable to the project.

5.25  The private orchards, comprising varying mixtures of mango, durian, pomelo and other fruit, appear to be maturing on schedule. Planted in 1989, the first fruit were harvested in 1994. Full maturity will not be reached for all trees until 2009. The plantations have many vacancies, but these supposedly are being or will be filled by replacement seedlings. MAS reckons that the farmers will have no trouble reaching the SAR yield projections for durian and pomelo, but that the mango estimates were exaggerated to begin with and the potential is about half the SAR figure. None of the 187 farmers presently in place (up from 160 at appraisal) have had prior experience with orchards of this size (4 acres), and the Azin project was seen as a pilot for subsequent irrigation schemes in this part of the country. MAS is satisfied that the experiment has succeeded.
5.26 These projections of fruit production, although reasonable and consistent with MAS expectations, may prove to be overly optimistic. The orchard program got off to a bad start because the parastatal bank which the government had agreed would provide term credit to support the plantings,\(^{33}\) never set up the necessary lending line. All of the private plantations were self-financed, apart from a subsidy on the seedlings, with some risk to the quality of the plantings due to inadequate application of fertilizer and other inputs. MAS believes the damage was small. Fruit prices have been rising rapidly in domestic markets in the last five years, giving MAS confidence that fears at appraisal that the market would be quickly saturated were unwarranted. Nevertheless, the harvest has just begun, and the real test of marketability on domestic markets has yet to come.

5.27 Rates of return have been re-estimated for the Azin subproject, again based on the SAR ERR framework. There is no reduction necessary for cropping intensity, where performance meets the SAR target. If MAS succeeds with its pilot project, and a third crop is added throughout the paddylands, the intensity will increase above the target. However the ERR is affected by the decline in the international price of rice. OED re-calculates the ERR for the Azin investments, including the Mudon town water supply component, at 6 percent.\(^{34}\) The SAR estimate was 12.3 percent. The PCR reestimate was 7.3 percent, reflecting the first, dramatic phase of the rice-price collapse and higher orchard investment and operating costs. If the dam had been completed and the water released on schedule three years earlier, OED's reestimated ERR would have been only marginally higher, about 8 percent. If the rice price had not declined, the ERR would have been 11 percent.

5.28 Net incremental earnings from the second irrigated paddy crop, for the typical two hectare (four-five acre) Azin farmer are US$840. Incremental earnings for the orchard farmers have not been recalculated, pending progress of the plantation and the success of pest control and infilling.

\(^{33}\) And to support as well the households during the trees' immature period, to the extent the intercrops did not meet all their needs.

\(^{34}\) The Mudon water supply benefit stream was adjusted to reflect the very slow buildup in demand for household and standpipe supplies. See the PAR. The PCR was prepared before the shortfall in demand appeared.
6. Conclusions: Influence of O&M Performance on Agro-Economic Impacts

6.1 Kinda. As demonstrated by Chapter 3, O&M performance by ID as well as the irrigators is satisfactory. The primary problems were the overwhelming dominance of paddy and the uncontrollable weed proliferation in the LMC. Nevertheless, the OED team considered, and ID and MAS officers were asked to assess, the relative importance of five O&M practices at Kinda where sub-optimal behavior could be depressing total irrigated crop production. Three are operational deficiencies; two are maintenance deficiencies:

- supporting inefficient cropping patterns, especially by supplying water to paddy in seasons and fields where larger areas of ya-land crops could otherwise be cultivated and where more water would escape by infiltration;

- inappropriate and erratic rotation practices at all levels of turnout to subsidiary channels. This includes a concern about ID's failure to continue the sophisticated control system WASAM;

- overusing water on the fields, particularly but not exclusively on paddy;

- inadequate maintenance of the irrigation structures—the canals, gates and other controls—resulting in excessive losses in conveyance; and

- insufficient cleaning of canals and watercourses, also resulting in losses in conveyance to the fields.

6.2 The tendency of established water rotations at Kinda to break down under stress, when headenders take more water than an equitable rotation would otherwise have allowed, encourages the preference of headenders for paddy. At present, that leads to an inefficient outcome: apart from the inherent desirability of diversification scheme-wise, the headenders occupy higher, better-drained fields with a comparative advantage for crops requiring less water. If the rotation worked as planned, more water would pass to tailend farmers with fields that can only grow paddy. But that outcome is attributable to crop preferences and relative crop prices, not a failure of rotations. It is easy to imagine a situation where headender crop preferences and comparative advantage are aligned, and overindulgence of headenders because of ineffective rotation would be economically justified. Rotation at Kinda is an instrument of equity, not maximization of value added. Thus there is no predictable relation between the failure of rotations and production impact. In any case government overrides all conventional rotation practices—precisely in order to maximize production—by simply cutting off sections of canal altogether. WASAM does not enter this picture. It was too data-intensive and sophisticated to survive without the consultants.

6.3 Oversupply of water to paddy fields—above the crop's evapotranspirational requirements—is a factor, but appears to be less important than in other countries in OED's regional impact study. The village-level presence of MAS and other public agencies is impressive in Myanmar. Given the government's preoccupation with crop production targets, and given the recognized shortage of water in the reservoir, excessive waste of water is not
accepted behavior in the Panlaung system and never has been. Headenders will have more opportunity to overuse water, but the level of abuse seems to be tolerable.

6.4 With reference to the maintenance of structures, the masonry works everywhere, and the undershot gates leading off the main canals and most distributaries, are kept in good condition by ID. However, at the levels operated by the farmers—the turnouts to the watercourses and from them to the field ditches—project supported metal and/or wood gates have been removed. The OED team was especially alert to the high visibility of damaged and missing gates. This problem has the same effect as the breakdown of rotations, in encouraging headenders to grow paddy. But, as with rotations, the direct impact of missing gates on production is unpredictable.

6.5 The farmers behind the gates do not want them. Farmers downstream from the gates do. When the agency replaces the gates, the intent is usually to shift water from the first group to the second. At Kinda, ID feels it is futile to try, because it is so easy for the first group to remove them again. Meanwhile the farmers behind the gates have time-proven methods for replacing the gates when they want to block the water. Most of the masonry gate housings are intact, and narrow enough to allow the farmers to substitute stalks, earth, cloth and other local materials. So, what appears to an outsider to be a wasteland of degenerate gated controls, is in fact a substitute system that works well enough to carry out normal rotations when the canals are full and the only rotations that are acceptable when they are not.

6.6 Cleaning of canals and watercourses seems to be timely and sufficient to achieve the objective of keeping the water moving, with the single and substantial exception of the LMC.

6.7 It is not possible to measure the impact of the LMC weed problem on production. One would have to separate four factors that are all contributing to reduce supply to the tailend watercourses on tertiaries in the upper reaches of this canal system, and to the distributaries on the lower reaches: (1) the water shortage itself; (2) the inherited design feature, which gave the LMC such a low slope; (3) the weeds that have come up as a consequence of low velocity flows, and ID's inability to control them; and (4) losses of water from the LMC system altogether due to infiltration down (percolation) from the better drained fields that receive it. Efficiency rates are higher on the RMC system, because it is mostly low paddyland and infiltration losses are smaller. ID reckons it could push twice as much water through the LMC were it not for the weeds. To do so, however, it would have to divert water from the RMC system. If this were a water abundant situation, where the requirements on both the RMC and LMC could be met, the weeds on the latter might depress overall production. With water scarcity, the lower discharges through weed-clogged canals are mostly compensated by increased production on farms which the water does reach.

6.8 In the face of these considerations, government's insistence on the paddy priority is inconsistent with its other behavior. Paddy is not the best use of water resources in the pre-monsoon season at Kinda, nor of the higher land on both main canals in the monsoon. But government is now enforcing paddy production through its crop targeting program, and encouraging farmers to plant paddy in non-scheduled fields as well. It could have, but chose not to, enforce the expansion of the cotton crop—as dictated by project design. That might have been equally undesirable. This issue is listed in para 6.1 as an "operational" issue, presumably amenable to improved O&M performance. In fact changes in crop preferences and pricing policies are required, not exhortation to better O&M.
6.9 **Kinmundaung.** The tank subproject is a repeat of the Kinda LMC experience. The water shortfall is more severe, and nearly one half of the farmers who expected to benefit do not get supplied, even in the monsoon season. The preference for paddy in fields that could support crops with lower moisture requirements, and government's current policy of concentrating the small amount of water available for pre-monsoon cropping also on paddy, combine to lower net economic benefits.

6.10 The other familiar operational and maintenance problems listed in para 6.1 all appear to be under control. There is no unusual weed growth, so in that sense the O&M deficit is even less alarming than at Kinda. However, water scarcity so completely overshadows all other problems that it is difficult to say much about the current level of performance with operation and maintenance practices.

6.11 **Azin.** Poor O&M performance is not at issue in Azin. The paddy lands receiving water have no better option than paddy in both the monsoon and summer seasons, so the crop allocation is optimal. MAS is promoting a third season, but paddy is left out of that rotation. Structures, gates and canals are in satisfactory condition. The rotation between orchards and paddy functions well, and rotations within the 2,000 ac paddy zone also are handled routinely.

6.12 The Azin experience supports the claim that under conditions of water abundance, O&M problems recede. Persons familiar with farmer behavior on the south coast as well as the central dry zone add another explanation, that the residents of Mon State are better farmers than the others, even if they have never irrigated before.
7. Other Conclusions

7.1 Water Scarcity, Abundance and O&M. The Myanmar case studies provide two dramatic illustrations of over dimensioned systems and inadequate water supplies. Exceptional low rainfall explains part of the water shortfall. But miscalculations of potential inflows to the reservoirs appear to have been made, especially at the tank. ID claims this is exceptional, and that other irrigation systems even in the central-dry zone are not suffering water shortages to the same extent. The inclusion of the counter-example of Azin is a reminder that O&M issues that present themselves forcefully in situations of scarcity tend to recede in importance in situations of abundance.

7.2 The Economics of Paddy Irrigation. The decline in the traded price of rice since appraisal rates of return were calculated—by a factor of about 65 percent—is enough to drive any paddy irrigation project well below the opportunity cost of capital. Azin is reaching its production targets, but even there the projected net incremental production is too low to overcome the low rice-price. OED now re-estimates the Azin and Kinda ERRs to be about 6-7 percent, and Kinmundaung's ERR to be negative. Diversification away from paddy into the specified field crops of cotton and sesame, and into higher quality crops, would have improved the results at Kinda and Kinmundaung. But the shortfall in cropping intensity and net cultivated area at both schemes would still have kept these results marginal at best.

7.3 This impact study does not follow the lead of the two PCRs. They argued that the cropping patterns as planned at appraisal, with a sharply diminished role for paddy, would eventually prevail, not because relative prices had changed but because improved extension services, and fertilizer and chemical availabilities, would lift farmers onto a higher plane of technical farming. In 1992 the Kinda PCR said that "no better assessment can be made under the current uncertain prevailing conditions in the country." Three years later conditions have improved, the farming systems seem to have stabilized, and the prospects of a radical shift in the cropping pattern without some major change in government policy has receded. To OED it seems more realistic to extend the present trend.

7.4 Water Control. There are many ungated offtakes from the main canals of the previously irrigated area at Kinda. Because of their numbers, these cannot be controlled by ID. Even the gated distributary and watercourse outlets are largely operated by the farmers. Especially in periods of water scarcity, this situation requires local institutions to control water delivery. Rules, roles, and practices protected by traditional rights have developed over the centuries and still provide the underlying governance even though a modern irrigation department and formal government structure dictates cropping patterns from the top. As a result, relative to the newly irrigated area of the LMC, farmers in the previously irrigated area make more efficient use of the irrigation system, according to ID.

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35. The increase in the rice price recently projected by the Bank for 1995-1997—17 percent in 1995 falling to 5 percent in 1991 and 2 percent thereafter—is not reflected in this figure. It would not have a significant effect on the conclusion.

36. PCR, p. 15.
However, as in irrigation systems in other parts of the world, it was observed that local organizations are more successful in managing equitable water delivery if collective action is necessary to accomplish operation or maintenance tasks of mutual benefit to all members. In the Sama Canal, for example, farmer watercourse groups are successful in using communally recruited water guards to move water to the tail region of the main canal, but are not similarly successful in sharing the water equitably within tertiaries and watercourses once it reaches the tail. Head to tail differences were higher within the watercourses than head to tail differences between watercourses or between distributaries in main canal operation. Collective action is required from all watercourses to hire enough water guards for the main canal. However, within the watercourse, farmers at the head of the watercourse do not depend on farmers in the tail for most operation and maintenance activities and can take a greater share of the water. A strong organization is not necessary to carry out cleaning, and groups come together smoothly for this activity. By contrast, organizing to distribute irrigation is disadvantageous for the headend farmers, and they neither want nor have been forced to cooperate.

Missing: the Impact of Maintenance on Group Cohesion. At some schemes in other countries, particularly farmer-owned schemes with long conveyance canals demanding collective action on clearing and repair for any members to benefit, maintenance requirements have the effects of encouraging members to associate at all levels of scheme O&M. That is not the case at Kinda and Kinmundaung. Construction of the dams has nearly eliminated silt deposits in the canals. Maintenance consists of weed removal and channel-bank repair. With the support of ID and the group leaders, Village Tract officials are usually expected to manage maintenance of the main and distributary canals—cleaning and repair. This works in favor of the irrigators. Not only does it reduce the burden on them of policing compliance and enforcing sanctions against free riders, it increases the labor force and lightens their load by including landless and ncn-irrigators in the work force.

The LMC control structures at Kinda are of high quality, in good repair, and receiving adequate routine maintenance. Since ID does not impose strict regulation of irrigation distribution below the main canal outlet, it has not been necessary for farmers in an advantaged headend position to break structures to assure access to water on demand, with reduced benefits as one moves down the distributary and tertiary canals. In many distributaries no irrigation can be delivered to lower tertiaries in the pre-monsoon season, and even in the monsoon season the timing of deliveries to tailenders is much later than to farmers in the headend. With low maintenance responsibility and no need to monitor and control water delivery from the main canal, there are even fewer incentives than in the previously irrigated area for farmers to cooperate in equitable water distribution among tertiaries and watercourses.

Mass Mobilization. There is one maintenance activity in these irrigation systems that is unique in the study area: periodic mass mobilization of people to clean the main and distributary canals. While at Kinda this is important in the previously irrigated area, it has become a critical factor in weed control in, and hence operation of the LMC. Farmer-managed irrigation systems in many parts of the world routinely mobilize irrigators to clean and repair their main canals as well as the watercourses. Irrigation agencies have almost uniformly been unable or unwilling to follow this example. Instead, water-user fees are collected by the central government and budget allocations used by the agencies to maintain canals.

Mass mobilization for irrigation maintenance builds upon the practice of District and Village Tract authority to use citizen labor for public projects. By joining local government
authority with the organizing and supervision capability of ID there is an effective mechanism for mobilizing labor. In addition, mass mobilization puts the burden of paying for maintenance squarely on the community receiving most benefits. Participation by individuals is not voluntary, but at least for these irrigation structures the benefits are visible and compliance is almost universal.

7.10 It would be useful to examine ways of institutionalizing such mass labor mobilization within the management of the canals by using only irrigators to do the work. Such maintenance responsibility could easily be more closely linked to irrigation benefits by proportioning the work to farmers according to their irrigation allocation. The right to irrigation water coupled with a responsibility for maintenance might provide incentive for improved governance and result in changes in cropping pattern and more equitable irrigation distribution. However, the magnitude of the necessary mobilization needed makes it difficult to establish and enforce local control without strong state support.

7.11 State Interventions: an Inconsistent Instrument. Myanmar stands out in OED's regional impact study by the degree of state intervention in the irrigation cycle, especially in planning cropping patterns and rotations, in blocking canals when water is scarce, and in successfully mobilizing corvee labor. Such intervention has been part of the conditions of rural life in Burma since dynastic times. Interventions at this level are driven by policy considerations, and are not always consistent with the state's economic interests: for example, whenever ASC allocates paddy to headenders, which is a common practice, and, if it anticipates a water shortage, ya-crops to tailenders—the opposite of what soil conditions would dictate.

7.12 What is remarkable is that the state does not intervene where, for many farmers, intervention is most needed—in protecting tailender rights to water against the selfish behavior of headenders on the same tertiaries. Whether irrigator groups will emerge with sufficient cohesion and mutual respect to ensure equitable treatment for tailenders is open to question. The fact that in the oldest part of the Kinda system, along the Panlaung diversion canals, the members of a watercourse still cannot guarantee equitable treatment illustrates, perhaps, the limits of self-governance. In many other parts of the world, the same breakdown of apparently agreed group covenants during periods of water shortage is found. In one case—Taiwan—the irrigators reverted to a two phase system, where the groups took decisions during periods of water abundance, but a public agency took control of rotations during periods of extra stress. Government—presumably the Township and Village Tract LORCs—has this choice in Myanmar. It has shown itself effective in imposing the rule of order. But it chooses not to enter the irrigation cycle at this point.

37. But not everywhere. D. Vermillion points out "Breakdown of group agreements during periods of water stress is common but not universal, as the warabundi, Balinese subak rotational distribution, Sri Lankan betma and Indonesian factor K systems often work reasonably well during periods of water scarcity." (personal communication, January 19, 1996)
### Kinda irrigation system seasonal and annual system level efficiency.

#### Annex I

**Monsoon (1 July-31 November)**

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<tbody>
<tr>
<td><strong>Water Supply</strong></td>
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<tr>
<td>Reservoir release (A-ft)</td>
<td>508,362</td>
<td>401,117</td>
<td>679,806</td>
<td>522,068</td>
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<tr>
<td>Rice (monsoon)</td>
<td>68,837</td>
<td>72,034</td>
<td>83,879</td>
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<td>78,132</td>
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<td>Other</td>
<td>7,593</td>
<td>18,571</td>
<td>34,083</td>
<td>5,807</td>
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<td><strong>Crop water requirement (A-ft)</strong></td>
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<tr>
<td>Rice (monsoon)</td>
<td>204,231</td>
<td>213,821</td>
<td>248,981</td>
<td>240,646</td>
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<td>Rice (premonsoon)</td>
<td>3,293</td>
<td>76</td>
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<td>Other</td>
<td>10,124</td>
<td>24,761</td>
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<td><strong>Total Water Demand (A-ft)</strong></td>
<td>217,748</td>
<td>238,659</td>
<td>297,510</td>
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<td>253,584</td>
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<td><strong>System Level Efficiency for monsoon (%)</strong></td>
<td>43</td>
<td>59</td>
<td>44</td>
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<td>67</td>
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<tr>
<td><strong>Average Annual Efficiency 1990-94 (%)</strong></td>
<td>51</td>
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**Premonsoon (1 February-31 June)**

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<td><strong>Water Supply</strong></td>
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<tr>
<td>Reservoir release (A-ft)</td>
<td>438,404</td>
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<td>303,156</td>
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<tr>
<td>Rice (premonsoon)</td>
<td>15,617</td>
<td>362</td>
<td>14,635</td>
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<td>36,208</td>
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<tr>
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<td>8,863</td>
<td>21,876</td>
<td>7,745</td>
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<td>Sesame</td>
<td>21,089</td>
<td>14,147</td>
<td>32,516</td>
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<td>Chilies</td>
<td>9,442</td>
<td>5,994</td>
<td>22,696</td>
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<td>Other</td>
<td>9,084</td>
<td>16,801</td>
<td>5,223</td>
<td>100</td>
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<td><strong>Crop water requirement (A-ft)</strong></td>
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<tr>
<td>Premonsoon rice</td>
<td>72,762</td>
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<td>68,187</td>
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<td>Cotton</td>
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<td>82,241</td>
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<td>Chilies</td>
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<td>17,702</td>
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<td>Onion</td>
<td>5,568</td>
<td>6,022</td>
<td>7,383</td>
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<td>Other</td>
<td>20,439</td>
<td>37,802</td>
<td>11,752</td>
<td>225</td>
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<td><strong>Total Water Demand (A-ft)</strong></td>
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<td>122,119</td>
<td>293,594</td>
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<td><strong>System Level Efficiency for premonsoon (%)</strong></td>
<td>49</td>
<td>93</td>
<td>97</td>
<td>49</td>
<td>91</td>
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<tr>
<td><strong>Average Annual Efficiency 1990-94 (%)</strong></td>
<td>69</td>
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**Winter (1 December 31 January)**

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<td><strong>Water Supply</strong></td>
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<tr>
<td>Reservoir release (A-ft)</td>
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<td>111,706</td>
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<td>Wheat</td>
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<td>Beans</td>
<td>1,529</td>
<td>3,629</td>
<td>1,767</td>
<td>6,120</td>
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<tr>
<td>Other</td>
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<td>546</td>
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<td><strong>Crop water requirement (A-ft)</strong></td>
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<tr>
<td>Paddy (monsoon)</td>
<td>36,885</td>
<td>38,598</td>
<td>44,945</td>
<td>43,441</td>
<td>41,866</td>
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<tr>
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<td>6,197</td>
<td>6,703</td>
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<td>7,660</td>
<td>5,276</td>
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<tr>
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<td>10,217</td>
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<td>15,762</td>
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<td><strong>System Level Efficiency for winter (%)</strong></td>
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<td>3</td>
<td>14</td>
<td>25</td>
<td>35</td>
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<tr>
<td><strong>Average Annual Efficiency 1990-94 (%)</strong></td>
<td>10</td>
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**Summary**

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<td><strong>Total Annual Supply (A-ft)</strong></td>
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<td>644,561</td>
<td>1,206,628</td>
<td>1,169,421</td>
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<td><strong>Total Annual Demand (A-ft)</strong></td>
<td>439,433</td>
<td>370,994</td>
<td>601,033</td>
<td>541,852</td>
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<td>58</td>
<td>50</td>
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<td><strong>Overall System Average Annual Efficiency 1990-94 (%)</strong></td>
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**Note:** January 1995 inflow was estimated for the winter 1994/95 season based on December 1994 data. Water demand was estimated using the Irrigation Department average monthly irrigation requirement chart since adequate rainfall and evapotranspiration data was not available to compute crop water demand based on actual conditions.
### Area, Yield and Production Estimates 1993/94

<table>
<thead>
<tr>
<th></th>
<th>Cropped Area (‘000 acres)</th>
<th>Yield (tons/ha)</th>
<th>Incremental Production (tons)</th>
<th>Economic Price Ratio</th>
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<tbody>
<tr>
<td></td>
<td>PreProject Area</td>
<td>Incremental Area</td>
<td>Total Area</td>
<td>PreProject</td>
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<td>42.9</td>
<td>66.4</td>
<td>.57</td>
</tr>
<tr>
<td>N</td>
<td>7.3</td>
<td>7.3</td>
<td>14.6</td>
<td>.25</td>
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<tr>
<td>Sesame E</td>
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<td>36.1</td>
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<tr>
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<td>8.6</td>
<td>17.2</td>
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### OED Impact Study 1995

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<th>Yield (tons/ha)</th>
<th>Incremental Production (tons)</th>
<th>Economic Price Ratio</th>
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<tr>
<td></td>
<td>PreProject Area</td>
<td>Incremental Area</td>
<td>Total Area</td>
<td>PreProject</td>
</tr>
<tr>
<td>Paddy E</td>
<td>50.7</td>
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<td>104.5</td>
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<td>5.6</td>
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<tr>
<td>Cotton E</td>
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<td>(16.5)</td>
<td>7.0</td>
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<td>7.3</td>
<td>14.6</td>
<td>.47</td>
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<tr>
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<td>(11.6)</td>
<td>1.7</td>
<td>.22</td>
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<td>41.2</td>
<td>.12</td>
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<tr>
<td>Chillies E</td>
<td>9.8</td>
<td>(2.8)</td>
<td>7.0</td>
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<td>1.9</td>
<td>7.3</td>
<td>6.2</td>
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<tr>
<td>N</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5.1</td>
</tr>
<tr>
<td>Other E</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>
Notes:

a. Full Development for SAR; average of 92/93 - 94/95 for OED Impact.

b. Cropped area in acres, to correspond to ID scheme measurements. Yields in tons per ha, converting at 2.47.

c. E is irrigated, N is dryland.

d. Total expansion or reduction ( ) throughout scheme command area, entered on one line (the E line).

e. For E, if Column 2 is positive, multiply Column 1 by difference between Columns 5 and 4.
   If Column 2 is negative, multiply Column 3 by difference between Columns 5 and 4.
   For N, multiply Column 1 by difference between Columns 5 and 4.

f. If Column 2 is positive, multiply it by Column 5.
   If Column 2 is negative, multiply it by Column 4.

g. Cotton and Sesame: assume all reduction comes out of Pre-project irrigated area.

Sources:
SAR Areas and Yield
OED Areas—Table 4.1
Yields—Field survey for Post/Project Paddy, Cotton and Sesame
PCR for all others (pp. 26-27)
Kinda: Farm Income Calculations
(3 Ha, Farm)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (ha)</th>
<th>Yield (ton/ha)</th>
<th>Production (ton)</th>
<th>Gross Income</th>
<th>Cost of Production</th>
<th>Net Income</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Farm Gate Price (K/ton)</td>
<td>Income (K)</td>
<td>Total Cost (K)</td>
</tr>
<tr>
<td>Left Main Canal Pre Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Premonsoon</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monsoon</td>
<td>Sesame</td>
<td>3</td>
<td>0.2</td>
<td>0.6</td>
<td>47,700</td>
<td>28,620</td>
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<tr>
<td>Total Net Farm Income</td>
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<td></td>
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<tr>
<td>Post Project</td>
<td></td>
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<tr>
<td>Premonsoon</td>
<td>Paddy</td>
<td>3</td>
<td>3.1</td>
<td>9.3</td>
<td>13,150</td>
<td>122,295</td>
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<tr>
<td>Monsoon</td>
<td>Paddy</td>
<td>3</td>
<td>3.6</td>
<td>10.8</td>
<td>13,150</td>
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<tr>
<td>Total Net Farm Income</td>
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<td>Premonsoon</td>
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</table>

Incremental Net Income

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (ha)</th>
<th>Yield (ton/ha)</th>
<th>Production (ton)</th>
<th>Gross Income</th>
<th>Cost of Production</th>
<th>Net Income</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Farm Gate Price (K/ton)</td>
<td>Income (K)</td>
<td>Total Cost (K)</td>
</tr>
<tr>
<td>Premonsoon</td>
<td>Paddy</td>
<td>1.5&lt;sup&gt;f&lt;/sup&gt;</td>
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<td>3.8</td>
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<td>98,625</td>
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<tr>
<td>Total Net Farm Income</td>
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</table>

Right Main Canal Pre Project |           |                |                  |              |                    |            |

Post Project |           |                |                  |              |                    |            |

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (ha)</th>
<th>Yield (ton/ha)</th>
<th>Production (ton)</th>
<th>Gross Income</th>
<th>Cost of Production</th>
<th>Net Income</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td>Farm Gate Price (K/ton)</td>
<td>Income (K)</td>
<td>Total Cost (K)</td>
</tr>
<tr>
<td>Premonsoon</td>
<td>Paddy</td>
<td>3</td>
<td>3.1</td>
<td>9.3</td>
<td>13,150</td>
<td>122,295</td>
</tr>
<tr>
<td>Monsoon</td>
<td>Paddy</td>
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<td>3.6</td>
<td>10.8</td>
<td>13,150</td>
<td>142,020</td>
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<tr>
<td>Total Net Farm Income</td>
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Incremental Net Income

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (ha)</th>
<th>Yield (ton/ha)</th>
<th>Production (ton)</th>
<th>Gross Income</th>
<th>Cost of Production</th>
<th>Net Income</th>
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<tbody>
<tr>
<td></td>
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<td></td>
<td>Farm Gate Price (K/ton)</td>
<td>Income (K)</td>
<td>Total Cost (K)</td>
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<td>Premonsoon</td>
<td>Paddy</td>
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<td>9.3</td>
<td>13,150</td>
<td>122,295</td>
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<tr>
<td>Monsoon</td>
<td>Paddy</td>
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<td>3.6</td>
<td>10.8</td>
<td>13,150</td>
<td>142,020</td>
</tr>
<tr>
<td>Total Net Farm Income</td>
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<td></td>
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</table>

Notes:

b. OED Survey, reduced for unirrigated conditions
c. OED Survey
d. Acreage of controlled and free price
e. Low input cotton budget
f. Assumes 1 crop every other year.
### Kinda: Economic Rate of Return Calculations
(Cash Flow in Million Kyats)

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</tr>
<tr>
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<tr>
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</tbody>
</table>

### OED Impact Adjustments

- Increase all Capital costs by 15%

|       | 7   |     |     | 8   |     |     |     |     |     |     |     |     |     |     |       |     |     |     |       |        |     |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-----|-----|-----|-------|--------|-----|
| Line 3, adjustment (-)      | (17) | (39) | (43) | (36) | (20) | (5) |     |     |     |     |     |     |     |        |     |     |     |       |        |     |
| Line 6, adjusted (TPNB)     | (132) | (293) | (288) | (149) | (62) | 71 | 238 | 278 | 303 | 311 | 324 | 336 | 346 | 369  | 389 | 420 | 400 | 369   | 355   | 19.4 |

- And Reduce Agricultural Benefits by 64%

|       | 9   |     |     | 10  |     |     |     |     |     |     |     |     |     |     |       |     |     |     |       |        |     |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-----|-----|-----|-------|--------|-----|
| Line 1, adjustment (-)      | (3)  | (14) | (30) | (42) | (61) | (155) | (191) | (216) | (232) | (251) | (268) | (282) | (301) | (301) | (301) | (301) | (301) | (301) | (301) |     |
| Line 4, adjustment (+)      | 1    | 2   | 4   | 7   | 9   | 23  | 31  | 39  | 47  | 55  | 62  | 70  | 71   | 71    | 71   | 71   | 71   | 71    | 71    | 9.7  |
| Line 8, adjusted (TPNB)     | (132) | (295) | (300) | (175) | (97) | 19 | 106 | 118 | 126 | 126 | 128 | 130 | 134 | 139  | 159  | 190  | 170  | 139  | 125   | 9.7   |     |

- And Reduce Paddy Benefits by 66%

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**Notes:**

- a. SAR figures compressed into one column
- b. Power Rehabilitation Costs Averaged
- c. 95% on cropping
- d. Figures on Line 6 actually give 21.6 ERR, 21.3 is in the SAR ERR.
- e. 70% of 60% reduction (costs deleted)
- f. 66% of 34% (actual paddy)
IRRIGATION O&M AND SYSTEM PERFORMANCE IN SOUTHEAST ASIA:
AN OED IMPACT STUDY

REVIEW OF THE DAU TIENG IRRIGATION PROJECT
VIETNAM

June 27, 1996

Operations Evaluation Department
# Abbreviations and Acronyms

<table>
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<th>Description</th>
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<tbody>
<tr>
<td>Bank</td>
<td>World Bank</td>
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<tr>
<td>BVND</td>
<td>Billion Vietnamese Dong</td>
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<td>DTIE</td>
<td>Dau Tieng Irrigation Enterprise</td>
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<td>EIA</td>
<td>Environmental Impact Assessment</td>
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<td>ERR</td>
<td>Economic Rate of Return</td>
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<tr>
<td>HCMC</td>
<td>Ho Chi Minh City</td>
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<td>IDA</td>
<td>International Development Association</td>
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<td>IIMI</td>
<td>International Irrigation Management Institute</td>
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<td>MWR</td>
<td>Ministry of Water Resources</td>
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<tr>
<td>O&amp;M</td>
<td>Operation and Maintenance</td>
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<td>OED</td>
<td>Operations Evaluation Department</td>
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<td>PAR</td>
<td>Performance Audit Report</td>
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<td>PAS</td>
<td>Provincial Agricultural Service</td>
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<td>PCR</td>
<td>Project Completion Report</td>
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<td>PIMC</td>
<td>Provincial Irrigation Management Company</td>
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<td>SAR</td>
<td>Staff Appraisal Report</td>
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<td>WUG</td>
<td>Water User Group</td>
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This report was prepared by Edward B. Rice (Task Manager), with support from Vinh Le-Si (Bank), Robert Yoder, Jayantha Perera, Annemarie Brolsma, Sinee Chuangcham and Tran Kim Thanh (Consultants), who visited this project in November 1994 and June 1995. Afí Zormelo and Megan Kimball provided administrative support.
1. Introduction

A. Background

1.1 The Dau Tieng dam is on the Saigon River 65 kilometers north west of Ho Chi Minh City (HCMC). The Saigon River is one of a number of rivers that flow southeastward towards a confluence with the Dong Nai River, which empties into the South China Sea. The Dong Nai basin lies adjacent to, but is not part of the Mekong River delta. Dau Tieng is the largest irrigation scheme in Vietnam, and the only one where an agency of the central government maintains control of the headworks and main canals. The reservoir area above the dam was described as jungle and bush and lightly populated before the war; the command area below the dam was more densely settled but depopulated during the war by massive American bombing, ground warfare and evacuation. The irrigation scheme was to occupy parts of five districts of Tay Ninh Province and the Cu Chi District of HCMC Province. Both these areas were politically charged during the conflict: Tay Ninh Province not only bordered Cambodia but was the center of the militant Cao Dai religious sect; Cu Chi was the headquarters of the National Liberation Front of South Vietnam. Apart from the Dau Tieng site's potential for a large-scale irrigation scheme, resettlement, recovery and stabilization of these sensitive areas was an important strategic objective for government.

1.2 Dau Tieng was the Bank's first operation in Vietnam, approved in 1978 twenty-one years after Vietnam joined the Bank. The renewed partnership was politically attractive to Bank management as well as to Vietnam. In March 1977, nine months after reunification, the Borrower and the Bank began discussing several prospects for a first IDA credit. Dau Tieng took priority. A cadre of irrigation engineers from north Vietnam had already been relocated permanently to the south in 1976 as the Southern Institute for Hydraulic Survey and Design, to prepare and implement this and other irrigation schemes. It is one of the few Bank operations where the pressure to lend was admitted without embarrassment by Bank management. Bank staff were encouraged to bring the appraised project to the Board as soon as possible.

1.3 The Project Completion Report (PCR)\(^1\) and the Project Performance Audit Report (PAR)\(^2\) discuss in detail the inadequacy of the topographical surveys and maps and other essential design data that was assembled in this accelerated preparation/appraisal exercise. The low relief of the area, and the 1:25,000 U.S. Government maps in use (accurate only to +/- 2 meters), compromised the accuracy of planned canal alignments. Some of the technical design errors were corrected after Board approval and before construction commenced; others were corrected during construction, in a series of "ingenious" adjustments which the PAR highlights; still others were not then detected, and help explain the remaining, built-in engineering flaws which continue to limit scheme performance, although many of them are now gradually and finally being addressed. Fortunately, the serious design problems relating to the headworks and main canals were caught and corrected before construction.

---

1.4 IDA Credit 845-VN of $60 million was signed on August 24, 1978. The project was co-financed by an additional US$10 million equivalent each from OPEC, the Kuwait Fund and the Government of the Netherlands. In 1984 the Kuwait Fund approved a supplemental US$20.4 million credit. The IDA Credit was extended twice and closed on December 31, 1986. Total project costs were estimated at US$110 million at appraisal, and US$124 million at completion. The first water for irrigation was released from the dam for the 1984/85 dry season. Thus, at the time of this impact study in 1995 there had been ten years of on-farm development.

B. Characteristics of the Command Area

1.5 The project as first proposed by government would have irrigated 172,000 ha: (1) from two main canals (east and west) taking off from the dam (72,000 ha); and (2) from at least eight pumping stations on the rim of the reservoir, supplying higher land designated for sugar cane (100,000 ha). The Bank recommended the sugar component be postponed indefinitely and, because of a shortage of donor funds, divided the rest into the appraised project of 42,000 ha and a second stage of 30,000 ha (see end-Map 8). For reasons explained in the PCR, 14,000 ha of the original stage 1 area were subsequently dropped from the design, while a comparable area from stage 2, which government started on anyway without anticipating IDA funding, was later incorporated in "the project" and made eligible for Bank reimbursement (Map 9). Thus, the 42,000 ha total area of the first stage was preserved. Government continued to expand the scheme in the rest of the stage 2 area using its own funds. For this impact study the distinction between the two stages is artificial, because they are now geographically integrated into a single scheme (Map 10). With the exception of an extension of a primary distributory from the east main canal in Cu Chi District, by an aqueduct presently (1995) under construction, the basic canal network is complete (Map 11). The scheme occupies the right bank of the Saigon River, and the drainage channels carry the excess water toward the Vam Co Dong River running parallel to most of the scheme's southern boundary. The majority of the proposed sugar land has been planted with rubber and other dryland crops and is no longer in the grand design.

1.6 With the 100,000 ha sugar block deferred and later deleted, the dam was over-dimensionalized in relation to the two-stage 72,000 ha irrigation scheme. The surplus has been released directly into the Saigon and Vam Co Dong Rivers, and serves to support other irrigation downstream (called "indirect" irrigation from the reservoir) as well as repel salinity intrusion. In 1993, after further review of the potential for expansion of the Dau Tieng gravity scheme and the record of water-use to date, government decided to limit expansion of the present irrigated area of stages 1 and 2 from 45,000 ha in 1995 (see para. 3.2) to 60,000 ha. Almost all of the room for that expansion lies just beyond the tail ends of the distributaries in the existing network. There are no new blocks of land under consideration, except for the 2,000 ha to be developed at the end of the aqueduct.

1.7 The command area is characterized by broad plains of gently rolling topography with elevations between 6 and 29 m above sea level. All the soils in the project area were formed

3. The balance of US$303,000 was canceled in July 1989.
4. Cu Chi District is not within the Bank "project" area.
5. The 60,000 ha includes about 3,000 ha which are already being supplied, with official approval, by small, private pumps directly from the main (and, to a lesser extent, the primary) canals. The other 57,000 ha are or will be gravity fed.
from alluvial sediments. They are not high quality soils, and exhibit varying levels of acidity. About 75 percent of the command area had been committed to rainfed paddy in monsoon seasons before the project, though much of this was abandoned during the war. Farmers along the Saigon and Vam Co Dong Rivers and their tributaries abstracted water in the dry season for adjacent paddy fields and gardens, but there was no prior irrigation network (as there was further downriver nearer HCMC). The remainder was used for upland crops, fruit trees and sugarcane, also under rainfed conditions. In the lower part of the Mekong delta paddy farmers are now able to harvest two rainfed paddy crops a year, a rotation made possible after the introduction of shorter season rice varieties. However that rotation is not possible in the project area, where the soils are not as good. Pre-project paddy farming was mostly limited to one rainy season crop.

1.8 Tidal action moves seawater up the flat gradient of the rivers. Increased flow from irrigation drainage together with regulated reservoir releases to the Saigon and Vam Co Dong Rivers has pushed the saline intrusion about 30 km downstream from the before-project maximum penetration. Gravity diversion and pumping from these rivers indirectly provides Dau Tieng reservoir water to irrigate over 41,000 ha in five provinces (para. 3.22, first bullet). Those indirect benefits can be added to the direct benefits of the Dau Tieng irrigation scheme.

1.9 The SAR assumed that most of the project beneficiaries would be grouped into production cooperatives and cultivate their lands collectively. A production cooperative, farming 150 ha, was considered the preferred socio-economic unit in the rural sector. In the north of Vietnam the system had spread rapidly. But the establishment of production cooperatives in the south since reunification had been slow, and, after the economic reforms sanctioned by the Sixth Congress of the Communist Party in 1986 got underway, and especially after de-collectivization was approved in 1989, further progress stopped. The PCR in 1989 noted that the extent of cooperative development fell substantially short of appraisal expectations. In 1995 the prevailing mode of production is one in which independent farmers cultivate on average one hectare of irrigated land, leased on long term from the state, using water provided by a state-owned irrigation system. The 150 ha unit is preserved only as the dimension of the Water User Group.

1.10 The physical and economic recovery of this area since the war has been remarkable. Cu Chi District, once the site of a major American airbase, of a legendary grid of guerrilla tunnels beneath it, and of devastation everywhere, is now, along with many parts of Tay Ninh Province, considered among the most progressive agricultural regions in the country. Rapid economic growth in the HCMC metropolitan area has not yet led to the massive emigration of labor from the irrigated farms to the city, as it has around other Southeast Asian cities. Farming families remain more or less intact, though some young men go to the city for work during the day, returning to the fields in the evening. But conditions are changing rapidly, and the relative isolation of scheme villages in the midst of rising industrial and commercial prosperity 50 kilometers away will not last long. A corridor of business enterprise is already developing along the highway from HCMC through Cu Chi town and the middle of the scheme to the provincial center at Tay Ninh.

C. Structure of the Irrigation System

1.11 A 2.1 km-long earth-fill dam about 26 m high together with a 27 km-long dike form the reservoir. The reservoir has a storage capacity of about 1,100 Mm$^3$. The reservoir catchment is
2,700 km², 17 percent lying in Cambodia. The estimated mean annual inflow to the reservoir is about 1,800 Mm³. Government says that actual inflows are on target.6

1.12 The west main canal is 39 km long and the east main canal 41 km long. The canal network terminology used in the rest of this report conforms to local usage. It calls the first distributaries off the mains the "primaries," the next the "secondaries," and, below the "tertiary" turnoffs, either tertiary distributaries or, in limited terminal commands, the watercourse itself with its irregular grid of farm ditches. That is the standard; in small sub-networks, some of the levels are missing. None of the big canals—main, primary and secondary—are lined except to protect weak sections. Twenty-two percent of the Dau Tieng scheme is in Cu Chi District, on the east main canal. The other 78 percent is in Tay Ninh Province.

1.13 Both the east and west main canals are designed for a maximum discharge of 70 m³/sec. The area now planned for irrigation from both canals will require about 40 m³/sec at full development (60,000 ha), giving the main canals excess capacity which to some extent simplifies their operation. The gentle slope of the command area allowed the main canal to be laid out with few check and drop structures. Off-takes from the main canal, with the exception of siphon pipes installed by individual farmers with agency permission, are all hand-operated gated rectangular orifices.

1.14 Primary canals were designed and constructed with simple metal sliding gates providing offtakes to secondaries or directly to field watercourses. Subsequent operation exposed problems with structure and canal placement for optimal distribution. Inadequacies of topographical detail at appraisal, and failure to consult with farmers and local officials, are a large part of the explanation. Some of these problems were corrected by remodeling structures; some problems cannot be corrected without major reconstruction. The provincial irrigation management companies (PIMC) have selectively approved additional offtakes from primary and secondary canals to compensate for many of the earlier errors.

1.15 The Ministry of Water Resources (MWR, formerly the Ministry of Water Conservancy) was the implementing agency for the project and responsible for construction of all sections of canal to the tertiary turnoffs, that is, to blocks of about 150 ha. The PIMCs were responsible for construction of the field-level distribution system down to blocks of about 20 ha. Farmers were responsible for digging the ditches. One of the defining characteristics of the Dau Tieng scheme is that the tertiary canals and subsidiary watercourses and ditches are poorly developed in relation to the primaries and secondaries (which since 1990 have been under PIMC control). Development of the field-level distribution system is only about 50 percent complete in the design command area. At the fringe of the irrigated areas and especially in lower regions where only paddy is grown, the farmers generally rely on field-to-field irrigation. There are exceptional locations in the paddy zone where the network of field channels is dense and provides each bunded paddy plot with direct access to water. In most locations, however, water is delivered to all fields within 200 to 300 m of primary and secondary canals, but channels to take water beyond that point are missing or incomplete. The engineering of field-level structures where construction is underway is done by provincial technical staff, who then supervise the

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6. The Staff Appraisal Report projected an inflow 30 percent larger. Government claims its original estimate was indeed 1,800 Mm³, but that this had been set aside by the Bank in favor of the larger figure after an analysis based on another, similar basin.
farmers in layout and construction. Farmers dig the channels but receive assistance for construction of concrete structures.

1.16 Construction of the drainage system was the responsibility of the provincial governments and started about two years after the main and primary canals. Only the main and a few of the primary drains have been completed. This consists primarily of cleaning and enlarging natural drains. Plans and designs are in place for a complete drainage system. The logic being followed for drain construction is to stay abreast of need. Priority plans prepared each year are for areas where fields are frequently inundated by flooding or the height of the water table makes cropping impossible. The PAR commented on impending problems with waterlogging, evident in 1990. The most serious of those problems appear to have been corrected by drain construction, though small areas on many of the longer distributaries have gone out of production. In some locations drains are not essential until further field development is complete, and it is cost effective to delay construction. In other locations, where additional drains in the upper reaches of the system would provide irrigation supplies to farmers on lower lands, delay in drain construction does have economic costs.

D. Water Availability and Efficiency

1.17 The maximum monthly rate of irrigation release necessary to irrigate the planned 60,000 ha when the design command area is fully developed is well within the capacity of the dam and the main canals. Measurements are not available for discharge in primary and secondary canals so comparison of actual and planned capacity at those levels is not possible. However, judging from reported problems of irrigation delivery in some of the primary canals, it is unlikely that all of the primary and secondary canals can accommodate the increase in water delivery necessary to serve the planned area. In other words, the water constraint is in the delivery capacity of the primary and secondary canal systems.

1.18 The Bank is currently appraising an irrigation rehabilitation project for Vietnam that would finance construction at ten sites in the country. One of them is an incomplete irrigation scheme begun in 1960 between the Saigon and Vam Co Dong Rivers and between Cu Chi and HCMC, the Hoc Mon/North Binh Chanh Irrigation Project totaling 12,000 ha. During preparation all available meteorological and hydrological records were used to assess water availability from the Dau Tieng reservoir, in the near and distant future, to substitute for and then supplement supplies for the Hoc Mon Project from another dam yet to be built in the Dong Nai basin (the Phuoc Hoa dam). The report concluded that any development of the Dau Tieng irrigation scheme beyond 55,000 ha before the other dam was built would preclude releases sufficient to fully satisfy plans for currently agreed abstractions for HCMC, for salinity control in the Saigon and Vam Co Dong Rivers, and for irrigation requirements of the Hoc Mon Project. On the other hand the report implies that, even in years with lower than average rainfall, the Dau Tieng irrigation scheme would have sufficient water for irrigation of the full command area, up to that 55,000 ceiling. The ceiling of 55,000 ha is 10,000 above the area reported by the PIMC as irrigated in 1995, but 5,000 ha less than the maximum scheme perimeter of 60,000 ha. There is room therefore for further extension of the Dau Tieng network. However, if Hoc Mon goes ahead on schedule but the new dam is delayed, by the year 2000 the abundance of water now enjoyed at Dau Tieng will end.

1.19 In many irrigation systems water delivery depends upon adequacy of the design, and the quality of operation and maintenance. Expansion of the capacity of the primary and secondary
canals at Dau Tieng is an expensive way of extending the scheme to full command. For Dau Tieng farmers the relatively easy access to groundwater provides an alternative irrigation supply option. Since the start of the project, the water table appears to have risen from about 5–8 meters to about 2–3 meters throughout much of the command area.

1.20 The PCR estimates an efficiency rate for the canal system at Dau Tieng of 40 percent. An OED review of data bearing upon the measurement of actual efficiency of water use within the Dau Tieng project reveals a slightly more positive situation. The review was restricted to the east canal command. Assuming that the reservoir release was the only source of irrigation water for the entire 25,000 ha reported as irrigated from that canal in 1994, then the overall efficiency that year was about 44 percent. For the dry season (November through March) the efficiency appears to have been well over 70 percent. These levels are surprisingly high, especially when set against the poor operational performance of the canal network.

1.21 The analysis for the Hoc Mon Project assumes an efficiency rate of 60 percent. Though the basis of that calculation conforms to the normal methodology, experience at Dau Tieng suggests it may be optimistic. The basis for the Dau Tieng 44 percent efficiency estimate includes another factor, the recovery of water applied near the canal network that moves through the drains, fields and ground to farmers at the low end.

1.22 These impressive water-efficiency rates are not enough, however, to yield a satisfactory re-estimated rate of return, as shown below. Also, were it not for this return use of the water, the efficiency rating and overall performance standard of the canal operation would be dismal.

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7. It is impossible to assess the irrigation efficiency of the west canal because unquantified water released from the dam through a channel direct to the Vam Co Dong River is included in release figures for the west canal.
2. Operation and Maintenance

A. Institutional Arrangements for O&M

1. Agency

2.1 Management of the reservoir and main canal is the responsibility of the Dau Tieng Irrigation Enterprise (DTIE), created in 1987. The General Manager of DTIE is appointed by the MWR, and a Management Board regulates the Enterprise and looks after the interest of the water users. The Board allocates the reservoir water among the provinces, following review of their water plans and other claims such as HCMC urban and industrial uses and requirements to repel saline intrusion. While irrigation is DTIE’s primary responsibility, it runs several other productive enterprises. It is responsible for developing recreation and tourism and other income-generating activities that use the reservoir. It owns and manages hotels and restaurants, in HCMC, Tay Ninh city and near the reservoir. In 1994, about 3 billion Vietnamese Dong (BVND) net profit from the reservoir enterprises was used to cover part of DTIE’s 17 BVND (approximately US$1.5 million) budget for operation, maintenance and improvement of the dam and main canal structures. Another 1.2 BVND was generated from DTIE’s construction groups. Only 1 BVND was available to DTIE from water fees. The deficit is made up by the MWR. It is government policy now at national and provincial levels to oblige public companies to reduce subsidies as much as practicable.

2.2 DTIE has established a monitoring and communication network to manage water discharge and regulation in the main canals and maintenance of all structures. Each of the Enterprise’s 16 field stations, which are located at head regulators and other major structures on the main canals, have resident staff responsible for operation and minor maintenance such as grass and weed removal from canal banks and greasing of gates.

2.3 The PIMC, public companies controlled by provincial governments, are responsible for operation and maintenance of the primary and secondary canal network below the main canal offtakes. For example, the Tay Ninh Irrigation Management Company manages 40 primary and over 1,000 secondary canals with a total length of 1,500 km and over 10,000 structures. In principal, PIMCs control all infrastructure down to and including the tertiary turnoff—on average to units of 150 ha. Farmers are responsible below those points. But there are many canal configurations supplying terminal command areas of less than 150 ha next to the main canals, where primaries feed tertiaries directly. In these cases the farmers themselves take control of the small, primary turnoff. In Tay Ninh Province the PIMC O&M activities are administered from five Sectional Offices, plus a Sub-Section for terminal systems within the perimeter of Tay Ninh city. Since 1992, the boundaries of Sections have followed the primary and secondary canal hydraulic boundaries. Previously, they corresponded to district boundaries. The PIMC do not have an administrative relationship with DTIE. Rather they contract to pay DTIE 20 percent of the irrigation fees they collect from farmers for the irrigation delivery service DTIE provides.

2.4 The intent is that the PIMC become self-supporting. In Tay Ninh Province the PIMC’s income comes primarily from farmer’s fees. In 1994 a total of 1.0 BVND (approximately US$90,000) was collected and retained by the PIMC. The 3.3 BVND budget for 1995 called for
income of 1.7 BVND from contract fees and 1.6 BVND to be paid by the provincial government. Thus the budgeting process of the provincial government, to some extent, controls the nature and timing of maintenance activities. Since 1993 the PIMC requires prepayment of 30% of the farmer's contract fee in order to mobilize maintenance in the early part of the season, before disbursements are made by the provincial governments.

2. Irrigators

2.5 PIMC assist farmers in service areas of up to about 150 ha to form Water User Groups (WUG). The WUG are also organized along hydraulic boundaries and are responsible for irrigation O&M in their service area. Occasionally, they assist with cleaning of secondary canals. The term "WUG" refers both to all the irrigators within the service area, and to a small team drawn from the area who manage the system. Each WUG elects a leader whose appointment is ratified by the PIMC. The term is for one year, and can be renewed. The other members of the WUG team are also elected and each is responsible for a block of about 20 ha. In principle, individual irrigators contract with the WUG leader or another team member for water delivery and pay user fees to the PIMC for the service. The "contract" spells out the irrigator's rights and responsibilities. The leader liaises with village and hamlet committees with regard to agricultural work and seeks their support in recovering water fees and settling irrigation-related disputes.

2.6 A WUG is a legal body, recognized by the PIMC, and comes directly under a primary-canal manager at one of the PIMC Section Offices. From time to time the manager issues directives for the WUG to carry out. The manager signs a contract with the WUG leader before issuing water to the WUG's command area. If there is no functioning WUG in the command area, PIMC may sign the contract with the hamlet leaders and collect water fees directly from farmers. It is the WUG leader's responsibility to identify farmers who are irrigating and convince them to sign a contract and pay fees. The leader signs water fee contracts with individual farmers and collects water fees from each of them. A leader gets 20 percent of the total collection of water fees as his/her team's commission. Of this amount, the WUG leader pays 2 percent to the village committee and 2 percent to the Section Office.

2.7 Fees are proposed by the PIMC, approved by the provincial government, and conform to MWR guidelines. They are fixed by area irrigated and not by volume of water supplied. They refer to the full year. They vary depending on which seasons (of three) are covered and whether the water is gravity fed or pumped. They do not specify the crop. The dry season is the one most frequently covered. The fees are low: even if collected from all irrigators, they would not come close to covering the PIMC O&M budgets. In 1995 the highest gravity irrigation fee was the equivalent of US$32/ha for dry season paddy.

2.8 The WUG leader has no powers to punish free-riders or those who damage irrigation structures. He must seek assistance from the village committee to deal with wrong-doers. A WUG leader can mobilize his fellow farmers to provide unpaid labor to maintain irrigation infrastructure, over and above the mandatory 15-day-a-year each adult Vietnamese farmer must contribute to public works. In some areas of the Dau Tieng system the village committee allows the 15 day obligation to be used partly on irrigation works; in other areas the village uses it all on other works, forcing farmers to contribute additional days to the irrigation system (or in some circumstances pay a cash equivalent).
2.9 Where primary and secondary canals are long, the WUG may be formed at the tertiary
canal level with the PIMC managing the primary and secondary canals. However, in cases
where a secondary or even a primary canal serves less than 150 ha, the WUG may be fully
responsible for operation of the irrigation delivery at that level but receive assistance from the
PIMC with maintenance of the structures. The WUG relates closely to the PIMC, but plays a
subordinate role to the village leadership wherever their authorities overlap.

2.10 The WUG at Dau Tieng are not grass-roots organizations. In many cases they are not
organizations at all. In effect, the WUG leader is the field extension of the PIMC Section Office
and there is little interaction among group members outside the team. While the WUG leader
has an important role, the WUG itself has almost no responsibility or authority. The PIMC may
rearrange the boundaries of a WUG, remove a leader, and appoint one of its own employees
instead. The Tay Ninh Provincial Irrigation Company wants to reduce the number of WUGs in
the project area. Fewer WUGs mean a smaller supervision burden on the Section Office. The
Company believes that if a leader is given a larger area, he/she would collect water fees
efficiently as the broader commission would give him/her a more attractive income. Such an
autocratic policy would diminish farmer participation and increase more external intervention
and control over irrigation and agriculture.

2.11 For the OED team, with an admittedly small sample of farmers interviewed and little
time to observe irrigation practices in the field, the lack of organized irrigation activities was
striking. Neither group discussion nor farmer interviews identified strong cooperative effort to
construct lower level canals and manage water distribution. When water delivery in the primary
canal was reported to be inadequate, there was little evidence that farmers used organized group
effort to improve the supply. One hard-hitting 1994 annual report from a Section Office in Tay
Ninh complained that during "tense" times of water stress and irrigator conflict, the leaders
disappeared. Instead, the farmers seek individual solutions by pumping from drains or
groundwater or by damaging structures elsewhere.

2.12 In many countries the objective of forming WUGs is to provide a means for transferring
responsibility for some O&M costs to farmers. While the Dau Tieng WUG identifies farmers
and establishes links to a leader via a contract that carries rights and responsibilities, that leader
functions as an extension of the PIMC rather than a representative of farmer interests. His role is
viewed by farmers as tax collector rather than a spokesman and organizer for irrigation services.
The Dau Tieng WUG system as presently structured does not foster local governance that would
help build the institutions and management of activities that is essential to more effective
operation and maintenance of the system.

B. Operational Performance

2.13 The Dau Tieng canal irrigation system is operating well below its potential. An
abundance of water in the reservoir, and oversized main canals filled to levels at or near design
capacity, are important, unexploited advantages. They are offset by operational deficiencies in
the primary and secondary canal systems and the limited extension of the tertiary and
watercourse network.

2.14 DTIE releases water into the east and west main canals at rates adequate to maintain
water levels to supply an area at least 50 percent greater than fields presently served. The head
regulators on the main canals are set to provide water to the primaries "on demand," that is
without limits other than the capacity of the canal system below the mains. There is no rotation from the mains canals.

2.15 A number of factors explain the shortfall in flow below the mains. First, design errors, such as sub-optimal placement of outlets to primary and secondary canals, and inappropriate alignments, sizing and/or slope of the canals, that can be traced to the original hasty construction. Dau Tieng is an exception to the practice in other countries of either oversizing the whole of the system to give extra flexibility to scheme management, or building it at a size corresponding exactly to the water requirements of the expected crop rotation. At Dau Tieng the mains are oversized and many of the primaries and secondaries are undersized (partly because farmers plant paddy in areas mapped for upland crops.) Second, failure of DTIE to supply the mains consistently at full design level, despite ample water availabilities at the headworks. A few centimeters drop in the water level in the mains can have a large effect on supply through the primary gates.

2.16 Third, weeds and silt deposition in primaries and secondaries that are not cleaned at the required frequency. The sedimentation problem may be attributable in some distributaries to poor survey work and design error, which has left sections with inadequate or non-uniform gradient. More generally, the weed and silt problem is explained by the inadequate budget of the PIMC, and the absence of an institutional apparatus that can quickly press farmers into service to assist the PIMC.

2.17 These first three factors reduce the flow below design capacity. The next three factors increase the demand for water above design expectation.

2.18 Fourth, the preference mentioned above for farmers to substitute paddy for other field crops compared with the original plan, abstracting more water at the head-ends of all the terciaries and smaller watercourses than the hydraulic design can accommodate. Fifth, the tendency of many irrigators to plant several crops in the same area, despite different moisture requirements, and then irrigate up to the levels of the most demanding crop. This is a common dry season situation.

2.19 A sixth factor is the absence of any common concern for water rotation below the mains. The general appearance of the system is of water provided on demand at each level, except on the longer distributaries where adequate supplies do not reach the most distant watercourses. Gates on the primaries and secondaries are usually left open for most of the cropping season, unless the irrigators below (behind, i.e., served by) the gate want them closed. The process of calibrating discharge measurement and controlling all gated flows to design specifications, wetness reports and cropping patterns, which is the target if not the practice in irrigation systems in other countries, is not even recognized at Dau Tieng.

2.20 PIMC and Section reports, as well as group leaders interviewed by OED, discuss the attempts to impose rotations. They are usually planned to start from the tail-end of the secondary canal and move upward. The rotations are administered by WUG leaders acting in concert. The control and distribution of water on rotation is complicated by the fact that many of the secondary canal gates are missing. As a result, straw, wood blocks and clay are used to block gates. But such blockages can easily be removed by farmers who want more water on their holdings.
2.21 However, although rotations are practiced, they are uncommon and often unsuccessful. In general, farmers do not consider rotations an effective method of water distribution. In interviews they indicated that in most cases when rotation was really needed, to preserve equitable distribution of water in short supply, it has not been successful because farmers in advantaged positions always take water first anyway and the rotation soon breaks down. When rotations are practiced in a water-abundant regime, simply to increase the predictability of the delivery system, they work. When they are needed most—during water shortages—they do not.

2.22 Competition between WUGs on a common secondary, and between farmers within a WUG along a common watercourse, seem less under control in Dau Tieng than the other Southeast Asia country case studies examined by OED in the regional impact study. Group interviews and discussions with agency staff brought out repeated complaints about advantaged farmers drawing water in excess of needs. This includes such obvious methods as siphoning from, or digging a ditch through, a major canal.

2.23 But if the level of complaint is relatively high at Dau Tieng, it does not indicate a state of anarchy. Many of the complaints focused on the period of the New Year celebrations of Tet, in January/February. The Dau Tieng system is then fully closed down for four days, at the peak of the dry season. When the releases start again, the headenders take a disproportionate share, thereby prolonging tailender anxiety. That commentators single out specific, time-bound events of this sort suggests that the periods of real stress between farmers in the canal network were few. The frequency of deliberate damage to structures also seems to be much lower at Dau Tieng than at schemes in the other countries in OED's regional review.

2.24 Abundant water in the Dau Tieng system provides a substantial benefit to almost all irrigators within the area of command, reducing sharply the appetite for retaliation. Even tailenders, and a large number of the farmers with fields beyond the direct reach of any of the ditches, have been able to add a second crop despite their disadvantaged position—because of the flows of water in drainage channels, from field to field, and, of increasing importance, the rising groundwater table.

2.25 The imperfections of canal operations are reflected in the failure of PIMC and the WUGs to sign contracts covering the whole of the command. Of the 45,000 ha total reported as irrigated in the 1994/95 dry season within the Dau Tieng scheme perimeter, only about 15,000 ha, or 33 percent, was under contract. Information provided OED by village and agency officials suggests that the degree of under-reporting by the contractees themselves of their own crop area supplied directly by the scheme is about 30 percent. Thus, the coverage by canal irrigation of area farmed by contracted farmers is about 20,000 ha (roughly 130% of 15,000). There is a gap of 25,000 "irrigated" hectares (45,000–20,000) farmed by irrigating families without contract.

2.26 These farmers are "free riding," but not all maliciously so. Most of them are farmers with uncertain access to sufficient year-round water—within a scheme perimeter that was supposed to provide just that. The contracted farmers occupy the band of land close to the secondary and tertiary canals. Beyond that the PIMC cannot guarantee water on demand, even

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8. Provincial field agents in consort with village authorities report routinely on land holdings, field sizes, cropping patterns, crop conditions and whether plots are irrigated. These data do not distinguish source of irrigation. That is, irrigators are not distinguished by whether they access the canals, drainage channels, gravity flows from irrigated fields at higher elevation, or shallow hand-dug wells.
though the mains are full. Disadvantaged farmers are in a position to refuse to sign contracts, because the contractual relation is supposed to guarantee delivery of water sufficient to supply designated crops and areas. PIMC is as reluctant as the farmers to sign under these uncertain conditions, because the contract obliges the agency not only to reduce fees if the supply is short but to compensate the farmer for crop losses. One alternative, to charge lower fees in non-assured areas, has not been tried.

2.27 The ability to collect the fees stipulated in a contract is another indicator of system performance. In Cu Chi District about 70% of the fees are collected and in Tay Ninh Province the PIMC has a similar level of fee collection. The other 30 percent are not paid for several reasons. The farmer may decide as the season approaches not to grow a crop because of poor market prices or household cash and labor constraints. If they do not grow a crop they refuse to pay. It appears that the two most common reasons, however, are that (1) farmers refuse to pay if they consider poor water delivery adversely affected crop yield, and (2) they are satisfied with the status quo, receiving a benefit without paying for it. Nevertheless, it is safe to assume that the fee-paying farmers in the contract area received the most reliable and sufficient irrigation.

2.28 Of course, contracts and fee collection are not exclusively dependent on the reliability of water supply. Persistence, hard work and the administrative skills of the PIMC, WUG leaders and village authority contribute to success in bringing free riders under contract. But the OED mission was told everywhere that a reliable water supply is the dominant factor. The two districts in the scheme with the best collection records, Cu Chi and one of the Tay Ninh districts close to the headworks, are said to owe that achievement to the mixture of effective water delivery throughout the district and strong administration.

2.29 The good side of this otherwise disappointing situation is the scope for improved operational control and water management as farmers and agencies gain more experience. Few of these farmers have more than ten years of irrigation experience. Rotations and appropriate water applications can either be learned or imposed, and so far government has shown no intention of forcing the pace. Nevertheless, everywhere OED was told that management is getting better.

C. Maintenance Performance

1. Agency

2.30 In contrast to the operational record, maintenance standards are quite satisfactory. The reservoir facilities and main canal structures are in good condition. All gates and structures under DTIE's control examined by the OED team were in working order. Weeds and sediment in the main canals are presently not a problem. In 1994/5 DTIE spent over US$1.3 million to repair and improve structures. In 1994, as part of preparation of the irrigation project downstream

9. There are reports of fee collections at Dau Tieng averaging as little as 10%. But that refers to collections against the total design command area, and not the contract area.

10. The priority large-scale repairs were: replacement of seals on the spillway gates; repair of the reinforced concrete spillway structure using grout injection to fill cracks; strengthening the upstream slope of the dam by reinforced concrete; raising by one meter the level of the dam where wave action during wind storms threatened overtopping; and repair of several main canal off-takes and side spillways. In addition, the DTIE carried out considerable minor maintenance such as painting steel components; removing and refurbishing the reservoir outlet main gate;
from Dau Tieng (para. 1.18), a consultant engineer assessed the dam, dike and appurtenances. His findings were consistent with earlier evaluations, that the structures were basically sound and well maintained. The engineer on OED's impact team came to the same conclusion.

2.31 Three distinct levels of maintenance by the provincial companies were identified. Each year the Tay Ninh PIMC through its Section Offices carries out routine maintenance. This consists of minor repair and cleaning of weeds and silt from the primary and secondary canals. The Tay Ninh company spent about 0.2 BVND on routine maintenance in 1993-94 and mobilized about 9,000 person-days of labor for cleaning the secondary canals. While some level of routine maintenance is generally done each season, preparation for the critical winter/spring irrigation program that begins in late November is intensive. The main canal is shut down on October 31 for two weeks to facilitate routine maintenance of all canals. Secondary canals are only reopened if upon inspection the Section Office staff judge the secondary, tertiary and field-level canals to be in good condition for water delivery. Tertiary or field-level canals are considered the property of the farmers and their maintenance is not otherwise monitored by PIMC.

2.32 In addition to routine maintenance, emergency repairs to prevent failure or to rebuild structures that have failed are carried out throughout the irrigation season. In their annual report, one Section Office in Tay Ninh claimed they had reinforced canal embankments in 32 locations during one season. The repairs were carried out in time to prevent failure.

2.33 The third level of maintenance is to carry out more substantial repairs in selected primaries as the budget permits. These may be reported as "rehabilitation," but the majority deal with the cumulative impact over several years of inadequate cleaning, after which the canal profile has been seriously compromised and must be reshaped. Nevertheless, this is still a job requiring mostly labor rather than heavy equipment. The task does give the PIMC the opportunity to correct some of the inherited design errors. In addition to removing silt and weeds to restore the original canal profile, weak sections of canal are rebuilt and outlet, drop, and spillway structures are repaired as needed. Budget conditions do not permit the company to enlarge the canal profiles and thereby significantly expand the flow below the mains. That would entail moving one of the embankments.

2.34 The structures and canals comprising the primary and secondary distribution system are in most cases functional. Most gates operated by the PIMC are in working condition. The team saw some gates that were not functional, and structures with gates missing altogether. That would appear to be the minority. The structures and canals show signs of wear and there is evidence of tampering but, for the most part, not wanton destruction or decay and abandonment. Sediment and weeds cause the greatest operational problems. Periodic seasonal cleaning is not sufficient to adequately overcome these problems.

2.35 In short, there is no evidence that maintenance of physical infrastructure above the terriories is materially deficient. However there is ample evidence that routine and emergency maintenance as well as rehabilitation are continually being carried out, though not at the scale strengthening embankments, roads, the main dam and dike; establishing new grass on embankments; removing 130 termite colonies from the dike; and maintaining access roads. The fact that the dam had to be raised one meter answers a question posed in the PCR as to whether the original dam height of 28 feet above sea level was excessive. The dam had to be raised because of water turbulence caused by unusually high winds.
necessary to keep the system from slowly deteriorating. Structures do fail and must be rebuilt. But the larger problem is caused by the weed and sediment that reduces conveyance capacity in the primaries and secondaries. Labor would have to be mobilized, or financed from PIMC budget more frequently than at present to significantly remove that problem.

2.36 One of the impressive features of the maintenance program is the interest and involvement of PIMC engineers in field conditions. In both the Tay Ninh PIMC and the Cu Chi District Irrigation Management Company the engineers play a hands-on role in anticipating, observing and responding to deficiencies. The fact that they could readily identify the sections along all canals with design flaws or excessive siltation, and could talk as well about a schedule already agreed for attacking most of those problems, indicates that the problems are gradually being overcome. Also, even where farmers on the mains and primaries were siphoning or pumping water directly, that access was restricted, patrolled, and charged in the contract.

2.37 The work of the PIMC is impressive. The allocation of limited funds between operations and maintenance also is appropriate. The low turnover of PIMC staff provides a valuable resource of experience that is lacking in most irrigation systems. Staff understand their jobs and take them seriously. Establishing a job performance contest among WUG leaders is one example of an innovation to improve management.

2. Irrigators

2.38 Farmer maintenance of their canals and structures reflects a different set of incentives than those that face the agencies. There is no evidence that the irrigators were incapable or neglectful of maintaining their watercourses when cleaning and minor repair were necessary to keep the water moving. The team observed ditches in all conditions, from recently cleaned to clogged and overgrown. But the timing of OED's visit was out of phase with the periods of acute water demand, and the claims that the clearing of the watercourses would be carried out in time for the next supply were convincing. The fact that the field network has not been extended at the rate anticipated, so that only 50 percent of the potential grid is actually in place, is not a maintenance problem. It is explained by other factors: reluctance of farmers in the network to permit neighbors to dig channels through their property to connect to the system; absence of mechanisms or motivation at the village level to induce farmers on the network to allow outsiders right of way, especially if competition for water and losses to those already connected might result; reluctance of farmers outside the network to connect and risk having to enter a contract if they feel they are reasonably well served by drains, field-to-field flow and groundwater; and a lack of confidence that headenders will cooperate.

2.39 Balancing the interests of advantaged and disadvantaged farmers plays a big part in explaining the one category of maintenance where the farmers do poorly—which is the lack of care almost everywhere for the gates that were part of the original architecture. Many of the gates, in structures designed for gates, from the tertiaries on down are missing, and the structures are often in a state of disrepair. This is not a failure of maintenance through indifference, incompetence or lack of funds. This is the result of deliberate interference or deliberate neglect. In either case it is a sign of protest against the main purpose of the gates, which is to restrict access to water by farmers below the structure.

2.40 The social bonds between headenders, tailenders and farmers on the fringe in the villages within the Dau Tieng perimeter are too weak to oblige advantaged families freely to reduce their
favored position, or for the disadvantaged to successfully press their claims in the WUG or village institutions. The team heard stories about headenders and tailenders breaking structures near their adversaries for selfish reasons. But the majority of the damaged and missing gates is the result of farmers selfishly breaking or removing their own gates to let more water through. This is not a maintenance but an operational issue.
3. Impacts

A. Agricultural Impact

3.1 *Net Cultivated Area.* The Tay Ninh Provincial Agricultural Service (PAS) provides province-wise statistics on cropping patterns, intensities and yields. They are inconsistent and unreliable, and do not separately identify the project area. The PCR presents its own data, based on other investigations as well as PAS reports. The PAR accepted the PCR data, and claimed that the total area irrigated by the time of the audit in 1991 comprised the 42,000 ha within the "project" defined by the Bank, plus another 10,000 ha already developed and under command in stage 2.

3.2 Impact study investigations indicate that that total of 52,000 ha must be adjusted downward. Within the "project" boundary, now an artificial concept, the maximum area irrigated is about 26,600 ha, not 42,000 ha. Another 17,900 ha of stage 2 is also irrigated, including part of Cu Chi District. The total irrigated area in 1995 is about 45,000 ha. Of that, as discussed above, only about 20,000 ha can be considered reliably supplied by gravity irrigation feed. Nevertheless it is appropriate to consider all 45,000 ha as under scheme command, regardless of how the irrigation water from the Dau Tieng reservoir arrives. Annex 1 shows the relationship between these various area estimates, and bridges the gap between the 42,000 ha project area and the 45,000 ha under command in the whole scheme and "irrigated" in 1995.

3.3 The government’s revised grand design of 1993 for the application of Dau Tieng reservoir waters for direct irrigation anticipates the expansion and intensification of the existing network to bring water by gravity to 57,000 ha, plus approximately 3,000 ha supplied by private pumping directly from the canals (most of them already installed—see Annex 1). The 57,000 ha target is quoted by all concerned agencies (Ministry, DTIE and the PIMCs). Annual PJMC work plans aim towards it. The Ministry mentions 1996 as the expected year of completion. Work continues slowly on extending the field network, as well as completing the aqueduct and the service area below it. There is little doubt government intends to complete the grand design, pushing the network to the scheme perimeters, but the target year is unrealistic. As shown above, if Hoc Mon is built and the Phuoc Hoa dam is deferred, rapid completion to full design at the Dau Tieng scheme will cause shortages there and/or elsewhere (assuming the hydrological estimates are accurate: para. 1.18).

3.4 *Cropping Intensity.* Recent PAS area and cropping data does not provide a basis for updating PCR estimates of cropping intensities. The PAR quotes PCR estimates, which show intensities for the pre-monsoon ("summer/autumn" in local terms), monsoon ("rainy"), and dry ("winter/spring") seasons of 33 percent, 100 percent and 81 percent respectively, for an aggregate intensity of 214 percent on the "project" 42,000 ha. Both documents suggest the intensity was likely to increase. Interviews with groups of farmers show an appreciable

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11. The 45,000 ha and 20,000 ha include about 3,000 ha and 2,000 ha respectively served by private, low lift pumping direct from the canals.

12. The PCR table of cropped areas (page 13) divides paddy and groundnut into irrigated and rainfed categories, acknowledging that the system in 1988 was not yet fully developed. It implies that the intensity would rise further. It does...
improvement over that figure and significant changes in the cropping patterns and relative importance of the cropping seasons. Overall intensity based on evidence from the group interviews is 277 percent, with triple cropping covering practically all the area controlled by the farmers present at the meetings. This supports the PIMC and Ministry claims, that three crops is now the norm for the fields under contract.

3.5 The farmers present in the group sessions were disproportionately drawn from that select group of contractual farmers who enjoy relatively reliable and sufficient supply from the canals, the so-called "advantaged" farmers. Thus the 277 percent cropping intensity estimate is best applied only to the 20,000 ha operated by farmers under contract. There is no available quantitative evidence with which to estimate cropping intensity achieved by the larger group of farmers occupying 25,000 ha who do not pay fees, who one way or another receive reservoir water anyway, but receive it without the reliability offered by proximity to the secondary and tertiary canals. To the extent these farmers are moving toward conjunctive use, supplementing canal water with groundwater pumped from shallow dug-wells, their overall intensities could be at least as high as the "advantaged" farmers. At present most lag behind, and many are satisfied simply to harvest a second crop either in the pre-monsoon or dry season. A more modest estimate of cropping intensity than 277 percent is needed for this group of farmers. The study assumes 230, a percentage close to the SAR estimate (226 percent).

3.6 A weighted estimated average for the two groups of farmers operating the 45,000 ha irrigated in dry season 1994/95 is 250 percent, combining the two ratios 277 and 230. Independently of OED's subsequent analysis, the director of the Cu Chi District Irrigation Management Company had already estimated a cropping intensity throughout his area of exactly that: 250 percent. That is a substantial improvement above SAR, let alone PCR, intensity estimates.

3.7 Although farmers in the project area were new to irrigated agriculture, they have learned how to irrigate their lands and cultivate three crops a year. Excessive water in the reservoir, and the structural flaws in the irrigation system which encourage them to innovate in on-farm water management, particularly with groundwater, facilitate this skill learning.

3.8 Cropping Pattern. The group interviews reveal the dominance of paddy in the cropping pattern. It occupies almost all land cultivated in the pre-monsoon and monsoon seasons, and a smaller but significant share of dry season cultivation. Altogether, paddy covers 72 percent of the gross cultivated area; groundnuts, the traditional cash crop, 22 percent; tobacco, a new crop, 4 percent; and all other crops 2 percent. Two noticeable shifts since the PCR was written are a rapid expansion of paddy farming in the pre-monsoon season, groundnuts having lost their prominence in that rotation, and the increased prominence of groundnuts in the dry season, rising from 30 percent to 60 percent of total area. This refers to the fields cropped by farmers who attended the group interviews. Since these are mostly the farmers with secure water, and

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not claim that the relationship between paddy and groundnut would stay the same after full supply for the 42,000 ha was achieved. The breakdown of the 214% overall intensity as reported in 1988 was 182% irrigated and 32% rainfed.

13. OED could not find any evidence for large-scale fallowing by farmers of land in the pre-monsoon season, as reported in the PCR and repeated in the PAR.

14. The Hoe Mon report projects an intensity of 250% for the triple paddy model, and 240% for the upland paddy model.

15. On a much smaller cropped area.
since the number of scheme farmers with secure water will continue to grow, the patterns discussed in these sessions may well represent the future trend.\textsuperscript{16}

3.9 Several hundred hectares of tobacco and cassava cultivation were noted. Tobacco was introduced by a private company in Ho Chi Minh City which provides production kits to farmers and buys tobacco leaves from them. Cassava cultivated mainly on un-irrigated highlands but increasingly on irrigated land is exclusively to make starch for the textile industry. Diversification into higher value irrigated crops, such as melons and cucumbers, is occurring, though the speed of this conversion is disappointing.

3.10 \textit{Yields.} The impact study confirms the PCR finding that paddy yields at Dau Tieng are significantly below appraisal estimates. The SAR projected monsoon and dry season yields at 3.8 ton/ha and 4.2 ton/ha respectively. Comparable figures reported in the PCR (and PAR) are 2.2 and 3.4, and 2.2 ton/ha for pre-monsoon. OED's information from the field shows yields only marginally better than the PCR figures: 2.6, 3.2 and 2.4. For bunded fields that are currently producing rice three times a year, the OED total harvest is 8.1 ton/ha, which compares favorably with the PCR aggregate of 7.8 ton/ha but is substantially below the implicit SAR total of 12 ton/ha for three crops (the SAR did not expect pre-monsoon paddy). OED's figure is only 68 percent of that at appraisal.\textsuperscript{17} Low rice yields are mainly a result of poor soil quality, the slow adoption of fertilizer, and widespread use of low quality seed. The last two factors can and are being corrected over time, e.g. as the government's New Seeds and Credit Program gathers momentum.

3.11 Groundnut yields have grown faster than paddy yields during the last seven years, particularly in the pre-monsoon season. PCR yield estimates for the dry season and pre-monsoon groundnut crops were 1.6 ton/ha and 1.3 ton/ha. OED interviews raise those figures to 1.9 and 2.9. It is not clear why the irrigators have been shifting from groundnuts to paddy in pre-monsoon, when improvements in groundnut yields have far outstripped paddy yields in that season.

3.12 \textit{Production.} Annual total production of paddy and groundnut as estimated at appraisal and completion and as reported now is summarized in Annex 2. In 1995, seven years after the SAR anticipated "full development" (1988), paddy production in the 26,600 ha "project" area, measured in tons of unhusked rice, is only 48 percent of the SAR target. Groundnut production is 44 percent of the target. The 1995 figures are less than the PCR (and PAR) "actuals" as well, by a smaller margin.\textsuperscript{18} The PCR assumed the 42,000 ha "project" area was not only all under command (or about to come under command), but that that automatically implied the water would reach all the fields. As explained above, that is not the case.

\textsuperscript{16} Assuming relative prices stay the same.

\textsuperscript{17} All of these recent estimates are shaky, and each institution has its own best guess. The Ministry estimates are higher than OED's, totaling 9.5 for the three crops. But the Tay Ninh Provincial Agricultural Service claims that the monsoon yields have actually fallen in the last several years and, at 2.0 tons/ha, are below any of these other estimates. OED's discussions at Dau Tieng suggest that figure is too low.

\textsuperscript{18} Those documents had already noted the shortfall from appraisal expectations. OED estimates are 76 percent of gross tonnage of both crops reported in the PCR (Annex 2. Groundnut tonnage was weighted by a factor of 2.7 to reflect the present price differential over paddy). The main reason the PCR estimates were below the SAR targets was the reduced yield factor. The main reason OED's 1995 estimates are below the PCR estimates is that the PCR exaggerated the net cultivated area.
B. Financial Impact, Farmers’ Level

3.13 The SAR reported that average family holdings of irrigated land were about one hectare, and current information suggests that is still the case (the Hoc Mon report uses the same figure). Crop budgets per hectare calculated by OED at 1995 financial prices and exchange rates indicate net incremental incomes of about US$400 for a farm dedicated to paddy, and US$1,000 for a farm which plants groundnut in the dry and pre-monsoon seasons and paddy in the monsoon (Annex 3). The two separate budgets reflect the difference in cropping patterns according to the two dominant land types. The first is a farm in low lying areas, where only paddy can be grown due to fine textured soils and/or poor drainage conditions. The other is representative of well drained paddy land, found above the low-lying area, where paddy as well as upland crops (mostly groundnuts) are grown.

3.14 These incremental incomes, representative of the contracted farmers who receive more water than they need, can be compared with appraisal projections for the average scheme farmer. At US$400, the lowland farms receive about half the comparable appraisal target. At US$1,000, the better-drained farms receive roughly 20 percent above the appraisal target. The difference in outcomes between the paddy and groundnut farmers is explained by the sharp decline in the farm gate financial (and economic) price of paddy, attributed to Vietnam passing from an importing to an exporting nation after the agricultural reforms of the late 1980s as well as to the decline in international rice prices. The real value of the farm gate price per ton, projected and actual for 1990, has fallen by a factor of at least 2 between 1978 and 1995.

3.15 The Hoc Mon preparation report shows even lower incentives for paddy farmers in that area, 20 km down river from the edge of the Dau Tieng scheme. Average net incremental incomes per hectare per year there are projected at only US$312 equivalent for the triple paddy model, and US$455 for the upland paddy/groundnut model. That is for the household, not per capita.

C. Economic Impact

1. Command Area

3.16 The SAR economic rates of return (ERR) were estimated at 17 percent for stage 1 and 20 percent for stages 1 and 2 combined (the stages as defined at appraisal). The PCR re-estimates were 5 percent and 7 percent. The PCR attributes the decline to higher project costs (about 6 percent above the SAR estimate), delays in benefits (about three years), lower incremental production (as discussed above), and the lower international rice price. The PAR adjusted the PCR benefit streams to test several alternatives, in particular the effect of maintaining the SAR paddy and groundnut prices, and the effect of adding indirect benefits from the “flushing” of

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19. The SAR worked with different models: a two hectare pre-project family holding and the same family as a member of a 150 ha post-project cooperative. The SAR showed net incremental family incomes (for one hectare) of US$510 for a two crop paddy/paddy rotation, and US$990 for a three crop, all groundnut rotation. OED's models allow for three paddy crops, in the first case, and one paddy and two groundnut crops, in the second case. In the analysis, the SAR two-paddy rotation has been intensified to match the OED three-paddy rotation, and the SAR three groundnut rotation has been switched to the OED two groundnut/one paddy rotation.

20. The PCR says 4 percent (page 19), but its net benefit stream gives 4.9 percent.
saline water from other real and potential downstream irrigation sites. In neither case did the adjustment substantially change the outcome: the SAR prices raise the stage 1 ERR from 5 percent to 6 percent; the flushing benefits raise it from 5 percent to 7 percent. These small effects are testimony to the marginal gains available to irrigated rice investments that do not achieve early and substantial yield increases. Adding stage 2 improves the returns, because a large new area is brought to production without any additional investment in the headworks. But even the PCR and PAR calculations of stages 1 and 2 combined show ERRs consistently below 10 percent.

3.17 The complete economic analyses carried out at appraisal and completion have not been repeated for the impact study. Rather, as for the audit, several adjustments were made to the PCR cost and benefit streams to test alternate scenarios.

3.18 First, it is clear that the reduced production benefits revealed during the impact study would depress the low ERRs even further. OED compared the combined paddy and groundnut production figures for the impact and PCR studies (Annex 2). The new estimate was 76 percent of the PCR estimate. The re-estimated ERR is 3.6 percent. Adding stage 2 would not lift the overall operation above 6 percent. The Dau Tieng irrigation project has proven to be a poor economic investment, measured against the standard opportunity cost test.

3.19 Second, even if a large proportion of the investment costs are removed from the calculus, and attributed to other benefits that are not associated with stage 1, or stages 1 and 2 combined (see paras. 3.21ff), the economic justification remains precarious. If 25 percent of the investment costs are removed, the equivalent of about half the costs of the dam and headwork appurtenances, the ERR only increases from 3.6 percent to 5.5 percent.

3.20 Third, the long construction delays did not materially affect that outcome. If the six initial years of large investment costs are compressed into three, and nothing else changes in the analysis (except removing 25 percent of the total investment cost, equal to 50 percent of the dam and headwork costs), the ERR increases from 5.5 percent to 5.9 percent. These reestimated ERR streams are shown in Annex 4.

3.21 The impact study is concerned primarily with results within the perimeter of the irrigation project, and with the performance and influence of O&M. No quantitative analysis was carried out of the appreciable benefits that have been reported outside the scheme. By removing a part of the investment costs of the dam and other headworks (50 percent was removed for illustrative purposes in para. 3.19), the evaluator draws attention to the fact that sunk-cost assumptions about dam and other headwork investments allow planners of downstream projects to "free ride" on the Dau Tieng irrigation scheme. Total returns to the dam, the

21. See Footnote 18.

22. OED adjusted downward all figures in the "agricultural benefit" stream for the PCR's revised stage 1 by 75 percent, except for the 22-year tail, for which the PCR value was retained (this implies that OED accepts that the scheme potential at full development, as projected by the PCR, is eventually reached. One can work with other assumptions about the speed and extent of recovery. This is a generous one.

23. OED did not recalculate an ERR for stages 1 and 2 combined, because the PCR cost data for stage 2 is not defined and unreliable.

24. The PCR shows that 48% of total project costs was attributable to the headworks, down from about 60% in the SAR.
irrigation infrastructure and other downstream works might well be above opportunity costs. The PAR concludes that, provided the scheme potential is eventually reached or closely approximated, this plus the indirect impacts will ultimately justify the operation. For the government and the Ministry there is no such qualification. They are satisfied that the Dau Tieng dam and irrigation scheme can already be called successes.

2. Indirect Impacts

3.22 Among these uncounted indirect benefits are:

- irrigation activities on and off the Saigon and Vam Co Dong Rivers downstream of the Dau Tieng dam, drawing upon (1) water released into the Saigon River directly, (2) water released into the channel that conveys it directly to the Vam Co Dong River, and (3) water that is drained from or seeps through the Dau Tieng irrigation scheme into the Vam Co Dong River. The Ministry estimates that 41,000 ha additional to the Dau Tieng scheme benefit from gravity, tidal or pumping irrigation flows attributable at least in part to the dam;
- specifically, the proposed Hoc Mon/North Binh Chanh Irrigation Project, which is expected to draw about 60 percent of its water requirements from Dau Tieng releases into the Saigon River, at least initially until releases from other sources come on stream. The 7,000 ha benefiting in this project are not included in the 41,000 ha aggregate figure given in the preceding paragraph;
- the repelling of saline water in these and other downstream rivers of the Dong Nai basin. The Ministry calculates that the upper limit of saline intrusion in the dry season has been pushed back at least 30 km on both the Saigon and Vam Co Dong Rivers. This benefit is associated with the indirect irrigation benefits mentioned above, but the beneficial affects of salinity control are broader than the irrigation impacts;
- potable and industrial water supplies to the Ho Chi Minh City metropolitan area. Dau Tieng has only recently begun supplying water to a purification plant on the perimeter of the city. Construction is nearing completion on a much larger plant, and a smaller one at a nearby, satellite city. The volume of water supplied is expected to grow substantially. The economic value of this water to commercial, industrial and residential customers would far exceed the benefits of equal flows to paddy irrigators.
- other minor benefits, such as flood control, the creation of a fishery in the reservoir, and the use of the exposed reservoir land for cropping in the dry season when the lake water recedes.

D. Environmental Impacts and Resettlement

3.23 Environmental Impacts. No data was available to the OED team to measure environmental impacts of either the reservoir or the irrigation scheme. The whole area was heavily bombed during the war, which ended five years before construction started. The pre-project flora and fauna populations, including the river fishery, were therefore themselves poorly established, and do not provide a baseline. Also, Tay Ninh and Cu Chi medical reports and other social indicators for a baseline were non-existent or only a few years old. In short, the instability
of the recent past precludes any meaningful environmental impact assessment that can distinguish the dam from the conflict.

3.24 An Environmental Impact Assessment (EIA) was carried out in 1994 for the Hoc Mon Project. Its projections of likely effects of or on pesticides, fertilizers, water-borne diseases, the aquatic ecosystem, and the disposal and drainage of acid sulphate soils are relevant to speculation of the ex-post impacts at Dau Tieng. In short, the EIA finds no significant detrimental effects. The one issue of note is the acid soil problem, which occurs to a much lesser extent at Dau Tieng. During construction, and later as a consequence of irrigation, chemicals are leached from these acid soils that lower the quality of the river waters. Here to, however, the EIA concludes the negative impact of this issue on the surrounding environment "could be" less serious than originally expected, and explains why.25

3.25 Resettlement. Approximately 500 families had to be removed from the vicinity of the dike. They had been settled there by government after the war ended in 1976. In these circumstances, the phrase "involuntary" settlement carries less alarm. The government had anticipated, but misjudged, the height of the reservoir when planning the original settlement. Most of the 500 families were resettled to nearby villages, with a cash payment for the demolished home, a new house plot already leveled, a prepared farm plot proportional to family size (one hectare for an average family of six members), and the promise of credit to get going. This was a standard package provided by a government that had already resettled 150,000 families in the region. The first years for these displaced persons were very difficult, from physical dislocation in 1984 to when irrigation water was made available to some of them in 1989. By the time of the impact study, half of these ex-refugees (many of whom had not had a farming background before their initial settlement) had left the area. They relocated mostly to Ho Chi Minh City.

3.26 The OED team visited the hamlet of one village, close to the dam, with 51 resident resettled families: the largest collection in any hamlet. Discussions with them and other villagers indicate that (1) they have somewhat less land on average than the other villagers; (2) their yields are also lower, primarily because few of them were farmers before they were initially settled at the site for the reservoir; (3) they have been assimilated: their lifestyles are not noticeably different than their neighbors and (4) they are over-represented on the hamlet committee, with two positions out of seven, and on the village committee with 4 positions out of 33 (for a village of 1,241 households). There is no information on the conditions of the ex-refugees who left the site.

4. Conclusions: Influence of O&M Performance on Agro-Economic Impacts

4.1 The defining feature of this two-stage investment operation, which helps explain the modest agricultural and economic progress to date, is the failure to extend the canal architecture to provide full coverage of the command area. The absence of rotations in the delivery system is a weakness of the operating system, and restrictions to canal flow caused by uncontrolled sedimentation and weed growth is a sign of inadequate maintenance. Thus poor performance in both O and M help explain the shortfalls from design discharge everywhere below the main canals. But the extension of the field network would have brought into the formal O&M system the more than half of the farmers within the nominal command area who are now taking water from the system (without full security) but contributing nothing to maintain it.

4.2 Ultimate responsibility for pressing on with construction of the field conveyance system rests with the PIMC, supported by the village authorities. The farmers are responsible for O&M below the tertiary turnoffs once the network is installed. But they cannot by themselves construct the tertiary system, and trespass on land needed for water conveyance, without institutional authority, technical advice and financial support. The mistake appears to have been in assuming that aggressive, collective action by actual and would-be irrigators would materialize spontaneously to expand the network well beyond the secondaries, even in the absence of an equally aggressive stance by PIMC or instructions from village authorities.

4.3 Do weaknesses in O&M performance contribute substantially nonetheless to the shortfall in production? The high water-use efficiency ratios quoted in para. 1.20 are attributable to the successful recovery of water applied lavishly by farmers at the headend of the network. This outcome is peculiar to the hydraulic profile of groundwater at Dau Tieng. The rapid increase in groundwater use is thus compensating for inefficiencies in canal use. Any discussion of O&M failures is tempered by the high recovery factor.

4.4 Maintenance standards are relatively high. With respect to maintenance of the structures, the headworks, canals and gates, the record of DTIE and the PIMCs is satisfactory. The farmers in the network also demonstrate a capacity and willingness to keep the canals, water courses and ditches already built and receiving water in good condition. The only problem is the poor condition of the gates at and below the secondaries. But since the farmers at those gates would have kept them open anyway, their condition does not affect farm production. Also, what the outsider perceives to be a non-functional gate, may be called functional by the farmers, since they have many materials at hand to restore the structure and block water when they want to. The losses imposed by broken offtake gates are further down the distributary, where tailenders not only suffer shortages themselves but resist letting farmers on the fringe connect through their properties and compete for an already inadequate supply.

26. DTIE has no control over these decisions.

27. In other systems, more of the water applied in excess of requirements for evapotranspiration would percolate to levels out of reach of shallow dug-wells and/or pass on to other rivers.
4.5 The most troublesome maintenance problem is the PIMC's inability to keep a timely schedule for cleaning silt sediment and weeds from the primary and secondary canals. It is impossible to quantify this loss, or to rank this and other factors that limit the discharge from the main canals through to the tertiary turnoffs. These include the cleaning problem, the design flaws, and the lavish use of water at the heads of each level of canal. The cleaning problem seems to be pervasive at Dau Tieng. It is attributable to constraints that would respond to better management. To the extent that lack of timely cleaning in the primaries limits the discharge from the main canals into the secondaries, and the abundant water running through the mains passes rapidly on into the main drains and the Vam Co Dong River, then this water is indeed lost to all the Dau Tieng farmers. But, given the high water-use efficiency ratios reported above, those pass-through losses do not seem so large as to have materially affected production to date.

4.6 The negative influence of O&M performance on production has been largely offset. However, as demand for Dau Tieng reservoir water expands, the constraints imposed by inadequate cleaning, and inefficiencies of water management in the canals and watercourses and on the farms, will become increasingly apparent. Rotations along these channels, and stricter application of water to crops according to their requirements, will become necessary. Whether incentives and institutions to guide those developments are put in place in anticipation of the impending shortages, and thereby limit the losses, depends on wise policy and institutional initiatives being taken in the near future.

4.7 At present, however, it appears that any enforced shift to gating and rotations is unlikely to increase production. The farmers who presently get the canal water do better by applying more than is required by paddy, because the flooding ensures continuous standing water that limits weed growth and saves labor. There is no indication that they overwater to the extent it reduces yields. In short, under present conditions and until the network is fully extended, it would appear unreasonable to expect an O&M system any better than the one now in place (provided the cleaning problem can be reduced).
5. Other Conclusions

5.1 Impact. The Dau Tieng Irrigation Scheme has abundant water available and, ten years after project completion, should be performing better than it is. Improvements projected in the PCR in 1988 and the PAR in 1991 have not materialized. The shortfalls have been in (1) moving enough water into and through the secondary canals, and (2) extending the field delivery network below the secondaries. Despite the excess of water flowing through the two main canals, ostensibly serving 60,000 ha, only 45,000 ha are "irrigated" and only 20,000 ha adequately supplied directly from the canals. The PIMC are gradually extending the network, with farmer assistance. But progress is slowed by budget considerations and an unwillingness to press either the present network irrigators to share water or the remaining farmers into action. The result is that production of paddy and groundnuts from the stage 1 area is only 47 percent of appraisal expectations and the economic rate of return of 17 percent quoted at appraisal is now re-estimated at less than 4 percent.

5.2 The Fringe. The operational map that would best describe Dau Tieng would show four concentric bands of farms. The innermost band surrounds the secondaries to a distance of about 300 meters and can count on reliable water supplies for triple cropping. The next band includes those farmers within the network of established tertiary systems who are too far from the secondary supply to count on reliable deliveries. These are the nominal "tailenders," and they sometimes challenge the headenders. The third band is described above as being on the fringe, where the water courses do not reach but who take increasing advantage of groundwater, as well as drainage and field-to-field flooding, and are listed by village authorities as irrigators. The second and third bands both profit from the excess water applied in the first band, and the efficiency of this whole system is high.

5.3 If these three bands defined the whole of the Dau Tieng scheme potential, there would be reason to question whether completion of the tertiary grid is economic. The conjunctive use of groundwater and drains along with gravity supply from the irrigation canals and field-to-field flooding already provides a reasonably efficient system. Only when fossil fuel prices rise to levels where pumping from wells and drains becomes uneconomic, then the lower operating costs of gravity canal flow would reassert its advantage and a strong economic argument would emerge to complete the grid as designed. Of course equity argues in favor of extending the grid to cover all three bands, as that is the only way to ensure all participating irrigators are brought into the formal O&M system and share its costs.

5.4 But the design command area includes another, outer band, which is still incorporated seamlessly in all scheme maps. This fourth band comprises those farmers beyond the fringe, who do not yet irrigate but who are nevertheless included in the plans for full scheme development and for whom reservoir water is available. This group is concentrated at the far ends of the longer primaries and secondaries, and involves an area estimated at about 15,000 ha (para. 1.6). This mapping model is obviously an oversimplification, but serves to make sense of

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28. The area within the "project" perimeter (stage 1) that was classified as "irrigated" in 1994 was 26,600 ha, which compares with 42,000 ha nominally under command and reported in the PAR. Within those 26,600 ha, the area provided with reliable supplies for triple cropping was only 8,000 ha.
an irrigation site that is otherwise hard to understand. The immediate justification for extending the tertiary grids at the ends of the longer distributaries is to finally serve this zone.

5.5 Potential. At the time of the field mission in 1995, there were 20,000 ha in the first band, 25,000 ha split in unknown shares between the second and third bands, as well as 15,000 ha in the fourth band. The Ministry's intention is to extend the network, with full design discharge, to all 60,000 ha. The whole is nominally commanded by the existing main canals, though the primaries and secondaries need some rehabilitation and more frequent cleaning to make the complete system work. Each year the system is gradually being extended, although every year also an area that can be almost as large as the new land added is taken out of production to allow PIMC to clean and upgrade. There is no reason to believe the Ministry and the PIMC will stop before the entire, redesigned command area is developed. Because of the groundwater resource, the conjunctive use of canal and well waters will proceed the advance of a fully reliable network. The potential of this conjunctive application for triple cropping throughout the scheme would appear quite high. At that point it will be hard to convince government that they do not have a successful operation, the low ERR notwithstanding. They will have an operating scheme of which the Ministry "can be proud." 29

5.6 Incentives. Training in "best practices" for the PIMC staff, WUG leaders and village leaders has been prescribed as one way to address water management problems. However, training courses that teach farmers they can grow crops with less water misses the challenge facing farmers. From a household financial and labor management point of view, there is high incentive to take extra water to reduce labor inputs during land preparation, to control weeds, to decrease the time necessary to apply water, and especially to avoid having to irrigate at night. Extra water simplifies farm management, but conflicts with the DTIE and PIMC goal of efficient uniform water use. Farmers must have sufficient social and/or financial incentives to make efficient water management worthwhile. Village and state agencies at Dau Tieng have shown themselves singularly unprepared to coerce the farmers of this area into compliance.

5.7 Water User Group Development. WUG leaders currently function as an extension of the PIMC rather than representing farmer group interests. If field-level irrigation management is to improve it will require the discipline and support that an active WUG can give. To change the current pattern of management would require a major reorientation, in effect the transfer of management rights and responsibilities from the PIMC to the WUG, and the scaling up (or federation) of WUG responsibilities to the secondary canal level. Training and support to accomplish this would be expensive and represent a real cost to farmers because it would effectively give them the burden of paying for operation and maintenance.

5.8 A serious question remains, what incentive will motivate irrigators to work as a group to develop the social capital necessary for successful management? Successful locally managed irrigation systems accomplish this when farmers recognize that individually they cannot access irrigation while collectively they can. At Dau Tieng this cohesion will be difficult to engineer, because the privileged farmers see no benefits presently in uniting with the farmers on the tailend, let alone the fringe. In some Dau Tieng primary canals, however, the benefit from maintenance—that is, continual weed and sediment removal—might provide the necessary incentive for farmers to form active WUG and to federate the groups along the primary canal to

29. This phrase was used in the PCR to complement the Ministry for completing the construction of the Bank's "project." That commendation may have been premature. Here it is used in anticipation of full extension to scheme boundaries.
manage all their irrigation activities. This labor-intensive activity is ideally suited to mass mobilization of workers, such as the OED team saw on the Kinda scheme in Myanmar. But mobilizing labor requires strong institutions that are currently not in place in the Dau Tieng scheme.

5.9 The OED mission was told that the Tay Ninh PIMC has just started an experiment with several village committees to let them take control and manage the secondaries in their area. There is no information yet on the success of this initiative, but it is obviously pointed in the direction recommended in this report.

5.10 **Supplementary Irrigation by Pumping.** Farmers in the Dau Tieng system have already started developing an alternative option to increased participation in managing the gravity distribution. Without a more extensive survey the extent of this development is only speculation but supplemental irrigation may already be in place on between 25 to 50 percent of the area reported by the PIMC to be irrigated, that is up to 22,000 ha in 1995. This has happened rather quickly, and continues to accelerate. The audit mission in 1990 remarked on the absence of much groundwater activity and recommended it be given high priority.

5.11 But with an excellent groundwater reservoir only a few meters below their fields, farmers can now compare the cost of (1) participating in canal maintenance, getting involved in managing water delivery, and paying higher fees for gravity service to that of (2) installing and operating a pump. The large number of pumps already in use suggests this trend is a viable option at current market rates and unless conditions change will dominate in all but the locations with good access to service, such as the area already under contract. This has important implications in deciding future management options and in structuring methods for paying for gravity irrigation service.

5.12 Even if analysis determines that improving scheme management and enabling WUG to distribute water uniformly over the entire area is cheaper than the aggregate cost of developing and operating lift irrigation, PIMC's ability to put such a plan into action, when opportunities exist for individual farmers not to participate, is uncertain. A period of substantial institutional strengthening lies ahead. At present, without equitable and reliable delivery, farmers refuse to pay the water fee and the PIMC does not have capacity or the will to monitor and enforce payment.

5.13 **Fees.** It is clear that at present collection of contract fees does not cover the cost of operation and maintenance. The current PIMC strategy is to use field-level canal development as a means to improve and expand service for which farmers will sign contracts and pay fees. That strategy is constrained by budgetary considerations. The PIMC also suggests that the fee rate be increased. Increasing the rate may encourage more farmers to become independent of the system by developing groundwater. An alternative that could be offered would be for farmers to take over O&M of the entire primary. Faced with such a prospect, it is likely that farmers would prefer the current arrangements, with the PIMC managing the primary canal and fees being collected on areas where gravity irrigation delivery is reliable. Farmers with intermittent gravity feed would continue to develop pumping capacity to supplement the supply they receive. Variable fee schedules, which allow for different levels of supply reliability, and which charge as well for groundwater extraction, will be difficult to administer but may be inevitable if 100 percent farmer participation in reducing the subsidy is the goal. There is no simple institutional solution.
5.14  *Contracts.* The experience at Dau Tieng suggests that the present contract system may not be the most efficient method to raise funds for O&M from participants, at least when water delivery is unreliable. The contract is an obligation from provider to user, and is compromised whenever the service is less than expected. The user either does not sign, or ignores his contractual obligations and turns away from the deal. The WUG as presently established, as an arm of the PIMC, is unable to enforce the system. One option is to reshape the WUG as an arm of the participants, obliging them to involve themselves in seeking a solution to the water shortage. At present, the contract system diminishes their sense of responsibility to help make the scheme work.

5.15  The contract system could be remodeled, to ensure greater WUG participation while preserving the close relationship which the present contract establishes between the companies and some of the irrigators. OED suggests that further study of the advantages and disadvantages of the present contract system is appropriate, especially if it is going to be adopted by subsequent Bank-supported irrigation investments. An interesting series of comments and proposals on the contract/fee issue at Dau Tieng, submitted to OED during the drafting of this report by Douglas Vermillion, a staff member of the International Irrigation Management Institute (IIMI) and Coordinator of IIMI's Irrigation Management Turnover Group, is presented in Annex 5.
### Dau Tieng Irrigation Project

**Planned, Reported and Actual Irrigated Areas (ha)**

<table>
<thead>
<tr>
<th>Project Proposal</th>
<th>Original Project</th>
<th>Appraised Project</th>
<th>Adjusted Project</th>
<th>PAR (&quot;Completed&quot;)</th>
<th>Plan Study (Completed)</th>
</tr>
</thead>
</table>

#### Sugar (Pumping)
- 100

#### Paddy, etc.
- 72

#### Stage 3 (sugar)
- Stage 1, adjusted: 42*
- (Completed)
- (Under Construction)
- Stage 2, adjusted: 10
- Completed & UC: 55

#### 1993 Plan
- Gravity Flow
  - Completed & Planned: 57
- Pumping
  - Completed: 3
  - (Postponed): (7)
- Stage 1, adjusted: 26.6*
- Stage 2, adjusted: 19.9

**Totals**
- 172
- 172
- 42
- 97
- 52
- 60
- 45.1

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* The "Project."
1. Rounded.

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Annex 1
### Dau Tieng Irrigation Project

**Reestimated Production of Paddy and Groundnuts from Stage 1 Project Area**

<table>
<thead>
<tr>
<th></th>
<th>SAR (42,000 ha)</th>
<th>PCR (42,000 ha)</th>
<th>OED Impact (26,600 ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paddy</td>
<td>Groundnuts</td>
<td>Total</td>
</tr>
<tr>
<td><strong>Monsoon</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area (ha)</td>
<td>31.0</td>
<td>11.0</td>
<td>33.5</td>
</tr>
<tr>
<td>Yield (t/ha)</td>
<td>3.8</td>
<td>2.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Production (t)</td>
<td>117.8</td>
<td>22.0</td>
<td>73.7</td>
</tr>
<tr>
<td><strong>Dry Season</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area</td>
<td>31.0</td>
<td>11.0</td>
<td>24.1</td>
</tr>
<tr>
<td>Yield</td>
<td>4.2</td>
<td>2.0</td>
<td>3.4</td>
</tr>
<tr>
<td>Production</td>
<td>130.2</td>
<td>22.0</td>
<td>81.9</td>
</tr>
<tr>
<td><strong>Premonsoon</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area</td>
<td>0</td>
<td>11.0</td>
<td>7.9</td>
</tr>
<tr>
<td>Yield</td>
<td>0</td>
<td>2.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Production</td>
<td>0</td>
<td>22.0</td>
<td>17.4</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unweighted</td>
<td>248.0</td>
<td>66.0</td>
<td>173.0</td>
</tr>
<tr>
<td>Weighted¹</td>
<td>248.0</td>
<td>178.2</td>
<td>173.0</td>
</tr>
<tr>
<td>Area Adjustment²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relation of Totals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OED/PCR 76%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Groundnuts grossed up by a factor of 2.7, reflecting 1995 price differential vis à vis paddy.
2. To reduce area from 42,000 ha total to 26,600 ha in Stage 1.
## Dau Tieng Irrigation Project
### Reestimated Crop Budgets
(US $ per ha)

<table>
<thead>
<tr>
<th></th>
<th>Paddy Farm</th>
<th>Upland Farm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(3 paddy crops)</td>
<td>(2 Groundnut crops)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1 paddy crop)</td>
</tr>
<tr>
<td>Incremental Yield per Ha (tons)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paddy</td>
<td>6.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Groundnut</td>
<td></td>
<td>4.3</td>
</tr>
<tr>
<td>Farmgate Prices ($)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paddy</td>
<td>132</td>
<td>132</td>
</tr>
<tr>
<td>Groundnut</td>
<td></td>
<td>363</td>
</tr>
<tr>
<td>Gross Incremental Income</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paddy ($)</td>
<td>818</td>
<td>79</td>
</tr>
<tr>
<td>Groundnut</td>
<td></td>
<td>1,561</td>
</tr>
<tr>
<td>Incremental Costs of Production ($)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paddy (3 crops)</td>
<td>402</td>
<td></td>
</tr>
<tr>
<td>Paddy (1 crop)</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Groundnut (2 crops)</td>
<td></td>
<td>588</td>
</tr>
<tr>
<td>Total Net Incremental Income ($)</td>
<td></td>
<td>416</td>
</tr>
</tbody>
</table>

1. Upland farm incremental costs are assumed to be zero for the paddy, yield increase from 2 to 2.6 tons/ha.

*Source: OED Impact Team. Based on PCR pre-project estimates.*
### Dau Tieng Irrigation Project

#### Reestimated Economic Rates of Return

<table>
<thead>
<tr>
<th>Year</th>
<th>Foreign</th>
<th>Local (2)</th>
<th>Total</th>
<th>O &amp; M Cost</th>
<th>Agricultural Benefits</th>
<th>Net Incremental Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>With</td>
<td>Without</td>
<td></td>
</tr>
<tr>
<td>1979</td>
<td>39.2</td>
<td>0.3</td>
<td>39.5</td>
<td>(39.5)</td>
<td>Same (29.7) (38.9)</td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>10.5</td>
<td>1.6</td>
<td>12.1</td>
<td>(12.1)</td>
<td>Same (9.2) (33.5)</td>
<td></td>
</tr>
<tr>
<td>1981</td>
<td>19.9</td>
<td>2.8</td>
<td>22.7</td>
<td>(22.7)</td>
<td>Same (17.1) (34.8)</td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>17.7</td>
<td>4.1</td>
<td>21.8</td>
<td>(21.8)</td>
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#### PCR Calculations

#### OED Impact Recalculations

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#### ERR

| | 4.9 | 3.6 | 5.5 | 5.9 |

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1. Reduce PCR Agricultural Benefits, With * Stream by 75%.
2. And Remove 50% of Headwork Investment Costs (or 25% of total Investment Costs).
3. And Compress Construction Period from 6 to 3 years.
Comments on the Dau Tieng Scheme Cost Recovery Program
Douglas Vermillion, International Irrigation Management Institute
(December 30, 1995)

- It is a common mistake in irrigation development strategies for agencies to first develop main and secondary canal networks, start delivering water and then to try to organize water users associations and persuade them to develop the tertiary network after the main investments have been made and the service is already coming. For rice irrigation this is particularly debilitating because of the option farmers often have of field-to-field and drainage recapture delivery. The opposite approach of first doing the organizing, making formal agreements with farmers for joint investment in irrigation development (including agreements to build the tertiary network and pay a substantial O&M fee) before the service is delivered (as is done in the USBR) would, I think, work better. I agree that the main problem appears to be this, even more than poor O&M.

- Aggressive collective action would have been more likely to have happened had the villages first been told that they would have to pay for a substantial part of the cost of irrigation development and O&M. Then extension of infrastructure and service contracts would have been in the interests of everyone because it would create a larger base of payers and help lower the average cost to farmers.

- Transfer of management from the PIMC to WUGs would require a "scaling up" or federating of the WUGs at least to include secondary canals, if not primaries as well. Given the current policy environment, does the government intend to carry on with this lavish level of subsidy for irrigation O&M? If not, then canal extension should be supported more for financial than hydraulic or production reasons--i.e., to expand the pool of payers. This has to be a policy declaration. Water should be sold to the main system and from there again sold to secondary level WUGs, where it can be volumetrically measured and assessed. If it can be measured and volumetrically assessed down to the offtakes into tertiary, all the better, because this would be an easier level at which WUGs could assess individual farmers. Fees from farmers could be estimated on an area basis, using the group level volumetric assessment as the base figure. This is how it is done in de-collectivized China. The current approach to try to persuade farmers to join the contract, when the government still subsidizes and farmers don't have to pay, isn't just slow, it isn't working.

- The government should act soon and decisively to begin charging farmers who are pumping groundwater at, perhaps, half the rate of charges for farmers under canal water contract. Once the precedent of farmers getting free groundwater gets entrenched, it will be very difficult to try to initiate such a charge later. Charges could be made by WUGs in the future, even on a semi-volumetric basis, such as according to water table movement during a season, or estimations of volume based on area served.
In Maharastra, (Ozra system) the WUGs which have taken over minor canals are charging farmers who pump groundwater within the command at half the volumetric rate of those receiving canal water directly; through assessment of water table levels at the beginning and end of the irrigation season.

Farmers should not be given the option of free riding; strong government policy and enforcement is needed. A study should be recommended to determine how much of the groundwater comes from the project. This could help in setting the level of fees charged for pumping.
IRRIGATION O&M AND SYSTEM PERFORMANCE IN SOUTHEAST ASIA:
AN OED IMPACT STUDY

PRINCIPAL FINDINGS OF THE PERFORMANCE AUDIT
DRAINAGE AND FLOOD CONTROL II PROJECT (CREDIT 1184-BD)
BANGLADESH

June 27, 1996
Introduction

1. OED audited this project in association with a regional impact study of irrigation and drainage projects in South and South East Asia. The other projects selected for the regional study were for gravity irrigation operations in Thailand, Myanmar and Vietnam. The Bangladesh project was included to provide a rough comparison of operation and maintenance (O&M) performance on flood control works with the more detailed assessment of O&M performance on irrigation works. The regional impact study reports have been prepared in tandem with this audit report.

2. The concern for flood control and drainage (FCD) operations in Bangladesh, vis-à-vis irrigation (I) operations, is dictated by the geographic conditions of this largely deltaic country. About 90 percent of the schemes built and managed by the Bangladesh Water Development Board (BWDB) are labeled FCD. The Bank has supported seven projects dedicated to FCD, all of them designed with low capital costs per protected hectare. The project under audit is the second in a series of four, out of the seven, aimed at one or a few medium-scale schemes.

3. In the aftermath of devastating floods in both 1987 and 1988, the world's aid donor community proposed that a plan for developing a better strategy to control and manage floods in Bangladesh be prepared. This became the Government of Bangladesh's Flood Action Plan (FAP), which commenced its work in 1990. It comprises twenty-six separate studies, five of which have particular relevance to this audit. FAP-2, 4 and 6 are regional studies dealing respectively with the Northwest, Southwest and Northeast regions of the country, where the three subproject sites are located. FAP-12 and FAP-13 deal with agricultural and O&M issues respectively, from the national perspective. For FAP-12 the consultants selected 17 operating FCD and FCD/I schemes for field survey, from all regions of the country, including one of the three under audit (Chalan Beel). FAP-13 concentrated on the same schemes. All five reports (FAP-2, 4, 6, 12, and 13) provided useful background information for the audit, in addition to the detailed work on Chalan Beel.

Project Objectives and Preparation

4. The primary objective was to promote an increase in rice and other crop production. The objective was to be met by providing flood control and drainage to three subproject areas (see end-Map 12). These were Chalan Beel Polder D in the northwest (38,000 ha), Satla Bagda Polders 1, 2 and 3 in the southwest (21,000 ha), and an area referred to as Hail Haor (19,000 ha) surrounding the haor (a depression with permanent standing water) by that name in the northeast. The areas would be empoldered by building embankments to eliminate or at least reduce flooding from the surrounding rivers, accompanied by improvements in gravity drainage through and out of the polders. The embankments were expected to (1) reduce direct flood damage to standing crops, (2) increase cropping intensities due to more land becoming available for double cropping during the wet (monsoon) and dry (winter) seasons, and (3) increase crop yields due to the introduction of improved varieties (with associated chemical inputs) that were less tolerant of floods and required better control of water levels. The emphasis everywhere was on the rice (paddy) crops: Aus in the early wet (kharif) season, Aman in the main wet (kharif) season, and Boro in the dry (rabi) season. Varietal changes would include a shift from broadcast to transplanted Aus and Aman, and from local to high-yielding (HYV) Aus, Aman and Boro.
5. Although the investments were aimed mostly at FCD, small, gated irrigation inlets penetrating the embankments were included in the design for Satla Bagda, and added later for Chalan Beel. These works along with the improved control over early flooding were expected to accelerate the expansion of Boro and other rabi cropping. A fisheries study, and infrastructure investments for fisheries development, were also approved for Hail Haor. The Bank was concerned about the potential adverse effects of project embankments on fish populations and fishermen at all sites, but considered the threat at Hail Haor to be exceptional.

Implementation Experience

6. Chalan Beel and Satla Bagda were completed generally in accordance with appraisal proposals, after substantial delays. With the exception of peaty soils used for construction of part of the embankment at Satla Bagda, Bank supervision staff generally reported reasonably good quality for all works and structures, especially the main regulators. The fact that the western embankment at Chalan Beel held against the 1987 and 1988 floods, with only two natural breaches, is cited in evidence. At both sites the number of drainage structures in the embankments proved inadequate and had to be increased.

7. The major obstacle to timely completion and operation at Chalan Beel, apart from delays in land acquisition, was the practice of unauthorized cuts of the new embankment. The pattern that developed soon after the embankments were finished in 1986 was for "outsiders" to break through the wall on the western side of Polder D, in order to reduce flood levels in the Sib River, and for "insiders" to cut roadways inside the polder one after the other until finally breaking through the dike on the eastern side of Polder D. This action allowed the flood waters to sweep across the polder along an west-east corridor from the Sib to exit into the Fakirni River. These hydrological pressures were not anticipated in any of the feasibility reports.

8. The Hail Haor subproject was changed appreciably from appraisal proposals, and suffered even longer delays. The major factor interrupting work, and leading eventually to substantial redesign, downgrading of project works, and reallocation of funds, was the removal of the "North Flood Embankment" from the flood control plans and the elimination of the one, large regulator. These had been the premier components of the Hail Haor plan from the time it was first drafted. What the Bank ultimately helped finance in the original project area is best described as a roads project. It included the North Flood Embankment, but this is now redundant as a flood control structure and serves simply as a highway.

9. The fisheries study at Hail Haor was completed four years later than planned and did not influence public expenditures on fisheries in that area. The subproject had a minimal impact on flood control, and no effect on fisheries.

10. In short, implementation achieved the project's major targets with varying levels of success, viz: (1) nearly full protection of the three Satla Bagda Polders from river flooding, apart from the two exceptional years; (2) partial protection of Chalan Beel Polder D, except where natural breaches and unauthorized cuts occurred in response to unanticipated water pressure; (3) flood control works of different alignment and substantially smaller import than planned within the Hail Haor area, reinforced by a more effective dike that had not been contemplated at appraisal, outside the project area at the immediate source of the floods; (4) shortfalls in drainage work everywhere; (5) good roads leading to the project sites and along and within the
embankments; (6) a profusion of minor irrigation structures so far of modest use; and (7) an ineffectual fisheries study.

Operation and Maintenance

11. For over a decade the Bank has pressed government and BWDB to adjust its priorities and expand its budget for operation and maintenance on all FCD/I schemes. The ongoing BWDB Systems Rehabilitation Project (SRP), approved in 1990, is a response to the Bank's concern. But it has not performed as expected. FCD projects are at a disadvantage to irrigation projects in O&M in two respects. First, BWDB budget allocations to O&M for FCD schemes are significantly smaller than to irrigation schemes, both by international standards and in proportion to BWDB's own assessments of requirements. The low budgets are reflected in the deterioration of structures and equipment almost as soon as they are installed. Second, whereas BWDB in the last decade has promoted farmer organization for participation in O&M on irrigation schemes, this activity has never been extended to FCD. Bangladesh distinguishes itself, in the set of countries selected by OED for the regional review of irrigation projects, by its relatively weak institutional framework for participatory action by benefiting farmers.

12. With a growing number of its own senior staff convinced that O&M must be upgraded, BWDB has substantially increased its commitments to O&M in recent years. Nevertheless, the response has been inadequate, and the Bank's confidence in BWDB's endorsement of SRP has been shaken. The three schemes of DFC II are not yet listed for rehabilitation. But unless there is a change in revealed preference at BWDB, and in the finance and planning ministries where overall budget priorities are set, maintenance practices are unlikely to improve sufficiently and the DFC II works will continue to deteriorate.

Outcome

13. Impacts of FCD projects are measured in the first instance by favorable changes in the onset, depth and duration of flooding and, as a consequence, changes in cropping systems and yields.

14. Chalan Beel. FAP-12 found that over most of the project area the objectives of delaying the onset and reducing normal depths of the flood had been achieved, though to a smaller extent than expected. It explained the shortfall from the quantitative targets established at appraisal partly by the unanticipated hydrological forces which kept a significant fraction of the cultivable area out of production in the monsoon season. The expectation of similar flash floods explained why farmers in that perilous corridor appeared to have voluntarily reduced cropped area and, hence, intensities at the time of FAP's field investigations in 1991. Nevertheless, because of relatively low per-hectare investment costs, FAP calculated an ERR based exclusively on agricultural benefits within the polder of 26 percent. However, the overall rate of return to the Polder D investments is lower due to indirect costs to other interested parties. First, the FAP report discusses in detail the injury caused by the embankments to the capture riverine fisheries sector, losses in excess of those anticipated at appraisal and estimated at 40-60 percent of the traditional catch. Second, the report notes that the Project had major negative impacts outside the Project area, on conditions in adjacent areas which subsequently suffered higher flood levels. FAP did not attempt to calculate those indirect costs; neither has OED. For a global ERR that
incorporates all gains and losses, OED settles on the rough statement "a maximum of 10 percent."

15. **Satla Bagda.** This audit supports the view that the most impressive increases have been in the Boro crop harvested in lower-lying fields that were formerly flooded and out of production all year. The impact of the embankment on Boro cropping appears to be partly attributable to project investments in irrigation inlets, despite the fact the majority of those installed are currently out of use. The functioning inlets provide control over twice-daily tidal flows into the lower lying areas suited to Boro. Control of river flooding has had a positive impact on wet season cropping as well, and encouraged the shift from broadcast to transplanted Aus and Aman predicted in the SAR. OED was unable to re-estimate an ERR for Satla Bagda from field data, as there is no survey study comparable to FAP's in Chalan Beel. Thus, the audit calculates the returns to a model of paddy cropping comparable to a conservative assessment of the Satla Bagda investment, yielding an ERR of 11 percent. This does not reflect indirect costs internal or external to the polder, and can also be considered a maximum.

16. There is no dispute that the embankment at Satla Bagda has provided better control over inundation levels. There is dispute about who exercises control and who receives the benefits. One of the problems at Satla Bagda, common throughout the delta, is that due to the flat topography small variations in surface water levels have a large effect throughout the polder, and the resulting positive and negative benefits of any change to an individual farm are very sensitive to its elevations. What farmers on the lower lands call a flood, or congested drainage, is what their neighbors on slightly higher ground need to adequately serve their crops. This problem is one of the reasons group action in what is ostensibly a single, small hydrological unit is so difficult to organize.

17. At Satla Bagda an outspoken advocate of social justice, a bishop resident in Dhaka who supervises a community of Protestant schools and a convent just inside the northern embankment, has frequently protested the indifference of officials and donors to the indirect costs brought by better flood control. Among his complaints are some unique to his part of the delta and some common to other parts of Bangladesh: (1) reduction in river transport; (2) loss of fertility; (3) polluting of the soil by chemicals; (4) increase in the height of the river beds; and (5) loss of river and flood fisheries. The validity of these claims notwithstanding, the position of government and the Bank, supported by the conclusions of FAP-4 (the study of the southwest region), is that the benefits of poldering in this part of the region offset the negative effects.

18. **Hail Haor.** The North Flood Embankment was never brought to completion as a dike providing full flood protection. The original project design was substituted by reconstruction and extension of embankments along three other rivers north of Hail Haor. These embankments provide protection for both Hail Haor and the plains between it and the three rivers. Internal dikes in the haor do delay the onset of floods to ensure a safe Boro harvest, but the area affected is much less than projected for the original scheme. OED has not recomputed an ERR for Hail Haor. The fact that large landowners and laborers alike in the area (Moulvi Bazaar) have alternative sources of income and are disinclined to **rabi** cropping made the original assumptions about cropping impacts even more precarious.

19. **Overall Rate of Return.** Given the rough character of the data base described above, and the lack of information on many of the indirect costs, the audit does not provide a point re-estimate for the project's ERR. In any case it would only include 70 percent of project costs,
because the audit did not review the uses and results of the US$12 million that were reallocated to flood damage repair throughout the country. With a weighting that reflects proportional representation in actual project costs (Chalan Beel - 47%, Satla Bagda - 45%, Hail Haor - 8%), an overall rate of return in the range of 5-10 percent seems defensible. Defensible, provided the assets can themselves be defended against inadequate O&M.

Sustainability

20. The improved cropping systems will be sustained as long as the embankments serve their purpose. Those works are threatened by the inadequate O&M budget and lack of organization of the farmers for self-help for maintaining FCD structures.

Findings and Lessons

- The growth in national food production will continue to depend on expansion of dry season farming based on shallow tube wells and low lift pumps. However, the potential contributions of the Boro and monsoon crop—in response to FCD investments—are also important considering both the ample scope for increasing HYV coverage through reduction of flood depth, and the low cost of the investments. The project under review is not a good platform from which to make that case. Results at two of the three sites were well below expectations and probably unrepresentative. A full audit of the two other FCD projects now completed through the ICR stages is desirable. They offer a stronger base on which to propose a sustainable, low-cost FCD strategy for the Bank.

- The Bank should adjust FCD design to regional hydrological patterns. The project included two schemes, out of a total of three, whose designs were seriously compromised by hydrological forces outside the range of normal concerns at preparation and appraisal.

- In future FCD operations the Bank must insist on remedial action to help offset losses to the fisheries subsector. Site-specific studies may be necessary to identify appropriate responses. To the extent FAP achieves a shift in FCD strategy toward reducing and "living with," rather than deflecting, the flood, the pressure on riverine fisheries will diminish. But the breeding grounds inside the embankments will remain at risk.

- Government and BWDB's stubborn and slow response to the urgent need to radically improve O&M must be accelerated. They as well as the Bank should be alarmed at the continuing erosion of FCD assets as a result of poor maintenance. The decline in the prospects of accomplishing the primary objectives of SRP is particularly distressing. The O&M shortfall applies to irrigation as well as FCD, two lines of investment that the Bank should refuse to support until O&M (and particularly maintenance) is given the attention everyone agrees it requires. This means not only securing BWDB's commitment but also changing the culture and skill mix at BWDB so that the reforms can proceed. BWDB's professional staff needs a better balance of water management experts and civil engineers. The recent trial organizational reform establishing a separate field authority and staff for operations and routine
maintenance on one sub-project is a step forward and must be consolidated. Introducing the necessary cultural and organizational reforms are among the main objectives of SRP, but BWDB must absorb them as its own.

- The effects of the failure to organize farmers to help plan, manage and maintain the FCD structures are self-evident. Farmers in the polders have no tradition of association at the community level on polder problems. Consequently, the introduction of participatory water management cannot appeal to traditional processes of problem solving. The "tragedy of the lowlands" is that FCD schemes contain both winners and losers, and constructing organizations that bring them together calls for skills in social engineering that BWDB does not possess. Those skills must be created, a lesson for both the Bank and BWDB. The TA team considers its pilot activities in local participation to be among its most important contributions. However, BWDB should not be expected to handle this job alone: other government departments, specialized rural development consultants, and NGOs with appropriate skills and concerns for polder communities have to be brought on board.
SOUTH/SOUTHEAST ASIA
OED IMPACT STUDY: IRRIGATION PROJECTS AND IRRIGATION O & M

- Kinda COMPLETED PROJECTS UNDER STUDY
- NATIONAL CAPITALS
- MAJOR RIVERS
- INTERNATIONAL BOUNDARIES

This map was produced by the Map Design Unit of The World Bank. The boundaries, colors, denominations and any other information shown on this map do not imply, on the part of The World Bank Group, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries.
VIETNAM DAU TIENG IRRIGATION PROJECT
PROJECT ENVISAGED AT APPRAISAL

STAGE I STAGE II

Main Canal

Secondary Canals (Not all secondaries are delineated)

Pumping Stations

Stage I Irrigation Area
Stage II Irrigation Area
Stage III Sugar Cane Pump Project
Stage I Sample Area
Tiêu Khu Temporary Benefit Area

Rivers

Drainage Channels (to be Improved)

Roads

International Boundaries

KILOMETERS
VIET NAM
DAU TIENG IRRIGATION PROJECT
DEVELOPMENT THROUGH 1988

STAGE I

STAGE II

MAIN CANALS

KILOMETERS

CAMBODIA

THAILAND

VIET NAM

Cambodia

Map of Map

© Ho Chi Minh City

WEST CANAL

Location

Area

No.)

(he.)

Gravity

1

27,040

5

12,000

Pumped

2

1,150

6a

5,040

Total

28,190

14,040

EAST CANAL

Location

Area

No.)

(he.)

Gravity

3

13,119

7

12,642

Pumped

4

977

8

10,000

9

6,042

10

2,000

Total

14,096

9,684

OCTOBER 1991
VIET NAM
DAU TIENG IRRIGATION PROJECT
DEVELOPMENT THROUGH 1995

ACTUAL IRRIGATED AREA

MAIN CANALS

0 5 10 15 20 KILOMETERS

DAU TIENG DAM

CAMBODIA

CHINA

THAILAND

VIET NAM

CAMBODIA

DECEMBER 1995
KINDA DAM MULTIPURPOSE PROJECT
Rehabilitation and Construction of Irrigation Facilities and Drainage Works

PROJECT AREAS (ACRES)

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<td>29,000</td>
<td>300</td>
<td>28,500</td>
</tr>
<tr>
<td>TOTAL</td>
<td>201,500</td>
<td>68,000</td>
<td>113,500</td>
</tr>
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BANGLADESH
DRAINAGE AND FLOOD CONTROL II PROJECT
SUB-PROJECT SITES

PROJECT SITES

MAJOR RIVERS
ROADS
RAILROADS
SELECTED TOWNS AND VILLAGES
INDUSTRIAL CANALS
NATIONAL CAPITAL
INTERNATIONAL BOUNDARIES

Bay of Bengal

INDE

MYANMAR

Bay of Bengal
MYANMAR
TANK IRRIGATION PROJECT
KINMUNDAUNG SUBPROJECT

Proposed Irrigable Area
- Main Canals
- Secondary Canals
- Tertiary Canals
- Drains
- Dam and Reservoir
- Existing Roads
- Roads for Rehabilitation
- New Roads
- Railways
- Rivers
- Villages

KILOMETERS

MILES

0 1 2 3

0 1 2 3 4 5

Chamrapur

Pyakareikkon

Santwea

Nyaungyin

Bongon

21°00'

20°00'

19°00'

18°00'

00°00'

180°00'

120°00'

60°00'

0°00'

The boundaries, limits, descriptions and any other information shown on the maps do not imply the official endorsement or acceptance of any sovereignty or jurisdictional claim or any entitled or unenforced claim of legal status or legal capacity of any entities or by any government of any kind.