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Report No. 12891

PROJECT COMPLETION REPORT

MYANMAR

GROUNDWATER IRRIGATION PROJECT I
(CREDIT 1381-BA)

MARCH 29, 1994

Agriculture and Natural Resources Operations Division
Country Department I
East Asia and Pacific Regional Office

CURRENCY EQUIVALENT
(Kyats per US$)

YEAR	EXCHANGE RATE
1982 - 83	7.70
1983 - 84	7.95
1984 - 85	8.25
1985 - 86	8.45
1986 - 87	7.48
1987 - 88	6.78
1988 - 89	6.35
1989 - 90	6.60
1990 - 91	6.45
1991 - 92	6.01
1992 - 93	6.24

FISCAL YEAR
April 1 - March 31

WEIGHTS AND MEASURES
(FPS System)

ac.	=	acres
cyd	=	cubic yards
metric ton	=	1000 Kg. (2205 pounds)
long ton	=	2240 pounds
ft.	=	feet
1 cusec	=	28.3 litres/sec
viss	=	Measure for Cotton, Chillies and Onions
basket	=	Measure for Wheat, Paddy, Groundnuts, Sesame and Pulses

ABBREVIATIONS and ACRONYMS

AC	-	Agricultural Corporation
CCA	-	Cultivable Command Area
EPC	-	Electric Power Corporation
ERR	-	Economic Rate of Return
GOM	-	Government of Myanmar
HYV	-	High Yielding Variety
ID	-	Irrigation Department
MAF	-	Ministry of Agriculture and Forests
MAS	-	Myanma Agriculture Service
M&E	-	Monitoring and Evaluation
O&M	-	Operation and Maintenance
PCR	-	Project Completion Report
PSC	-	Project Steering Committee
SAR	-	Staff Appraisal Report
SMS	-	Subject Matter Specialist
TOR	-	Terms of Reference
UNDP	-	United Nations Development Program
VEM	-	Village Extension Manager
VTEM	-	Village Tract Extension Manager
WUG	-	Water User Group

THE WORLD BANK
Washington, D.C. 20433
U.S.A.

Office of Director-General
Operations Evaluation

March 29, 1994

MEMORANDUM TO THE EXECUTIVE DIRECTORS AND THE PRESIDENT

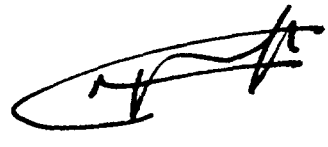
SUBJECT: Project Completion Report on Myanmar
Groundwater Irrigation Project I (Credit 1381-BA)

Attached is the Project Completion Report on Myanmar - Groundwater Irrigation Project (Credit 1381-BA). Parts I and III were prepared by the East Asia and Pacific Regional Office. No comments have been received from the Borrower.

The project was a first attempt in Myanmar to expand irrigation on a substantial scale through the use of groundwater resources. About 20,000 hectares were developed, using 120 tubewells. The project included the provision of electric power to these tubewells, irrigation and drainage channels, the development of extension and research services and provision of input supplies. The early stages of the project were dogged by preparation/appraisal deficiencies. Complex procurement procedures resulted in equipment and supplies being delayed and received in the wrong sequence, and basic soil and groundwater data were inadequate. The project was extended by three years and its physical objectives were then attained.

Water users' groups were established to operate the individual systems, but they remain dependent on official support. Institutional development is judged to have been modest. The ERR was re-estimated at 10 percent compared to 22 percent at appraisal, due to implementation delays, and to slower uptake of irrigation, and higher value (but more risky), crops by farmers. Use of irrigation continues to expand and sustainability is considered likely. Overall, the project outcome is considered marginally satisfactory.

The completion report provides an adequate account of project implementation. No audit is planned.



Attachment

PROJECT COMPLETION REPORT

MYANMAR

GROUNDWATER IRRIGATION PROJECT I (Credit 1381-BA)

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GROUNDWATER IRRIGATION PROJECT I

CREDIT 1381 - BA

Preface

This Project Completion Report (PCR) reviews implementation of the Groundwater Irrigation Project I in Myanmar for which Credit 1381-BA in the amount of US$ 14.0 million was approved on June 7, 1983. The Credit was closed on June 30, 1992 and is fully disbursed.

The Preface, Evaluation Summary, and Parts I and III of this Report were prepared by a staff member of the Environment and Sustainable Development Division of Asia Technical Department (ASTEN), and were reviewed by the Agriculture and Natural Resources Operations Division, Country Department I, East Asia & Pacific Regional Office.

The Borrower was requested to prepare a PCR in March 1992, to be available to the Association (IDA) in October 1992, but none was received. Preparation of this PCR is based on, inter alia, the Staff Appraisal Report (No. 4323-BA dated May 16, 1983), the President's Report, No. P 3576-BA dated May 18, 1983), the Development Credit Agreement, dated July 18, 1983, IDA supervision reports, correspondence between the IDA and the Borrower, and other internal documentation available within the World Bank. The staff member responsible for the preparation of the PCR visited the project area in March/April 1993.

PROJECT COMPLETION REPORT

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GROUNDWATER IRRIGATION PROJECT I

CREDIT 1381 - BA

Evaluation Summary

1. Introduction. In the central dry zone of Myanmar, lack of reliable irrigation water had long been identified as the dominant constraint to increasing agricultural production. Surface irrigation potential was limited and large seasonal fluctuations in river levels made pump irrigation schemes costly and technically difficult. In the absence of a reliable and economic source of surface water, groundwater was considered to be the best alternative. Country wide reconnaissance studies selected four areas with groundwater potential for irrigated agriculture covering some 1.1 million acres for more detailed surveys. Thus, the project covered by this PCR was the first groundwater irrigation development financed by IDA and was expected to play an significant role in expanding the irrigation subsector, through crop diversification and improvement of the regional balance in Myanmar's future agricultural development.

2. Objectives. The main objective was to increase crop production and farm incomes by expanding the irrigated area from an existing 2,000 acres in 1983 to about 20,000 acres at project completion in 1989 through development of groundwater resources. A second objective was to strengthen the capability and inter-agency coordination of the institutions involved. Although not explicitly stated in the Appraisal Report, it was assumed that the project would be the first of a series of groundwater development operations using electrical power supply. Lessons learned and institutional strengthening were expected to have important benefits beyond the project area as the groundwater development program expanded.

3. Implementation Experience. The project became effective in October 1983 but virtually no progress was made until early 1987. The project was therefore only under effective implementation for about five years with the Credit closing date extended for three years until June 30, 1992. Once the start-up problems were resolved, the components were generally implemented to satisfactory standards and the institutions performed to be best of their ability given the uncertain country circumstances through the project period.

4. The main reason for slow start-up was the delayed and unpredictable delivery of equipment and materials due to complex and bureaucratic procurement procedures. As a consequence, the work program was undertaken in the wrong sequence with a negative impact on planning and design for most project components. For example, irrigation civil works were constructed before the quality and quantity of the groundwater and soils were established. In addition, the consultant services had limited benefit, because their terms of reference focused on irrigated agriculture on the assumption that many tubewells would be operational during the contracted period. Fortunately, except for problems related to siting of some tubewells, the various start-up delays tended to cancel each other out for most components.

5. By mid 1988, most procurement problems were resolved and shortage of fuel and lubricants was addressed through a bulk import arrangement for all IDA supported projects. By early 1989, progress had improved sufficiently to justify an extension of the Credit closing date to June 30, 1989. The closing date was further extended until June 30, 1992, since there was no reason to terminate the Credit given the good progress made in the previous year. In fact, about 75 percent of the useful project activities were completed after the original Credit closing date. Other reasons for extending the Credit closing were to : (a) expand the scope by about 15 percent (using cost savings) to more fully develop the groundwater and land resources in the project area; (b) consolidate the lessons learned under the first project and to provide continuing work program for the staff with specialized experience in groundwater development; and (c) give more attention to O&M arrangements and project sustainability.

6. Results. The ERR re-estimated for the PCR is about 10 percent compared to 22.0 percent at appraisal. The shortfall in ERR compared to appraisal reflects: (a) serious delays in project implementation; (b) slower than expected response by farmers to irrigation; and (c) shortcomings in the planning and design. However, the PCR analysis is conservative in the assumptions that: (a) irrigation intensity at full development will be about 125 percent compared to 150 percent predicted at appraisal; (b) some 7 percent of the tubewells will not be fully operational because of poor water quality and soils, or for technical reasons; and (c) farmers will continue to put about 40 percent of the irrigated area to irrigated sesame, giving low returns but minimizing their risks. In addition, the PCR analysis does not fully reflect the recent farmers' response to the incentives created by opening free markets for agricultural produce and thus more fully utilize the irrigation service.

7. Sustainability. The tubewell systems have been effectively turned over to the water-user groups with limited technical support and back-up from the Irrigation Department and Agricultural Services through their local offices. However, long term, project tubewells may be difficult to maintain because most equipment was imported from a wide variety of sources. To the extent possible under the Credit, preventive maintenance action has been taken by procuring about five years worth of spare parts for mechanical and electrical equipment. The electrical power network should be sustainable and there is considerable operational flexibility to accommodate any power shortages by extending the daily running hours to include night irrigation.

8. Findings and Lessons Learned. IDA had reason to assume that the project would be successful given the four year "pilot phase" (preparation) sub-project under UNDP. With hindsight, although the "pilot phase" produced some useful data for the project, the result was a feasibility study and should have been treated as such since the project area was evaluated to little more than reconnaissance level. Shortcomings, which emerged as the project moved to the implementation phase, included: (a) insufficient study of physical resources (soils, groundwater topography, etc.); (b) unproven assumptions on irrigation and on-farm water management; and (c) an assumed farmers' response to groundwater irrigation which had not been demonstrated. Furthermore, project performance depended on GOM taking hard policy decisions on sensitive issues related institutional strengthening, full budget provision for recurrent expenditures, and basic improvements to procurement and other administrative procedures. The rapid appraisal of the project following the "pilot phase" subproject indicated that the Bank did not fully identify the potential risks in the first 'project scale' operation to develop groundwater.

9. IDA supervision performance was generally satisfactory, but lack of focus on key issues earlier in the project period allowed many problems to develop unchecked with the project seriously diverted from the work program envisaged at appraisal.

10. The lessons to be learned by the Borrower and agencies involved relate to improvements in: (a) procurement procedures; (b) institutional capability, responsibility, accountability and coordination; (c) the use of technical assistance; (d) quality control of planning and design and appropriateness of the technology; (e) O&M of completed tubewell schemes; and (f) monitoring and reporting. A fundamental lesson to be learned by GOM is that diagnostic analysis of planning, design and implementation must be undertaken if the project is a new initiative in a sector and similar new investments are to benefit from the lessons to be learned.

11. Conclusion. The project should perform at full development as predicted at appraisal. The many challenges, particularly in the mid 1980's, resulted from difficult country circumstances in Myanmar, and were unpredictable at the time of appraisal. Many problems which caused or compounded the start-up delays, could not be addressed under the project since they were national or sectoral issues, particularly those related to institutional capability and Government procedures such as procurement. One discouraging outcome has been that GOM has still to recognize fully the importance of the many lessons to be learned, not only for this project but for the overall irrigation subsector. It is concluded that GOM needs to take strong actions to ensure that the full developmental impact from this project is obtained as quickly as possible. It is also concluded that the project has performed well enough for GOM to consider continuing its program to develop its groundwater resources.

PROJECT COMPLETION REPORT

MYANMAR

GROUNDWATER IRRIGATION PROJECT I (CREDIT 1381-BA)

PART 1. PROJECT REVIEW FROM IDA'S PERSPECTIVE

1. Project Identity

Project Name	:	Groundwater Irrigation Project I
Credit No.	:	1381 - BA
RVP Unit	:	East Asia & Pacific Regional Office
Country	:	Myanmar
Sector	:	Agriculture
Subsector	:	Irrigation

2. Background

2.1 In the 1960's and early 1970's, the value added in agriculture rose only about 1.6 percent per annum, well below the prevailing population growth rate of about 2.2 percent per annum. As a result, the rice export surplus declined to less than 200,000 tons compared to more than 3.0 million tons pre-war. This unsatisfactory performance was attributed mainly to: unsettling changes in land policy; inadequate farmer incentives; and the initial failure of imported high yielding varieties (HYVs). Faced with this situation, the Government of Myanmar (GOM) responded with a series of policy reforms designed to improve farmer incentives and provide flexibility in the agricultural sector including: increase in crop procurement prices; reduction in mandatory procurement quotas; and decontrol of certain commodities. In addition, there were also a major tax and exchange reform and GOM also became more willing to accept foreign assistance, enabling more investment in irrigated agriculture. In this respect, expansion of irrigated agriculture was given high priority. While irrigation had been an important feature in Myanmar for centuries, in 1981/82 the total irrigated area of some 2.6 million acres was only about 10 percent of the total cultivated area. During the 1980's, the Association (IDA) supported projects developed about 150, 000 acres of new irrigation and rehabilitated some 95, 000 acres served by existing irrigation schemes.

2.2 In the central dry zone of Myanmar, lack of reliable irrigation water had long been identified as the dominant constraint to increasing agricultural production. Surface irrigation potential was limited and large seasonal fluctuations in river levels made pump irrigation schemes costly and technically difficult. In the absence of a reliable and economic source of surface water, groundwater was considered to be the best alternative. However, prior to the early 1970's, groundwater development has been restricted to private sector development of limited areas with shallow water tables which could be exploited either manually, or by simple pump sets, from open well or shallow boreholes. Government recognized that to more fully exploit the groundwater irrigation potential, deep tubewells were necessary. Thus, the proposed project was expected to play an significant role in expanding the irrigation subsector, through crop diversification and the improvement of the regional balance in Myanmar's future agricultural development.

2.3 Project Preparation. A World Bank Agricultural Sector Mission in 1977 reported that suitable conditions for groundwater development existed in some areas of the central dry zone of Myanmar. On these recommendations, GOM, UNDP and IDA decided in 1978 to include a Groundwater Exploration and Pilot Development Sub-project (the "pilot phase") under the UNDP (Myanmar) Umbrella Project, for which the Bank was the executing agency. A specific objective was to increase Myanmar's experience in large scale groundwater development with the Irrigation Department (ID) designated to carry out a "pilot phase" with the assistance of consultant services.

2.4 As a result of country wide reconnaissance studies, four areas with sufficient groundwater potential for irrigated agriculture covering some 1.1 million acres were selected for more detailed surveys. Three areas were located in the dry zone of Myanmar and one in the intermediate rainfall zone. Work

started on the "pilot phase" in 1978 and continued through December 1983. The program included groundwater resource surveys using some 86 exploration boreholes, of which 50 were converted into diesel driven production wells ranging from 0.5 to 2.0 cusecs (serving command areas of some 25 to 150 acres per well).

2.5 It was assumed that GOM would progressively develop the areas with groundwater potential identified under the "pilot phase" sub-project through a series of groundwater irrigation operations of which the project under review was the first. One of the four areas delineated under the "pilot phase" investigations was in Sagaing Division near Monywa (see Map IBRD 16582R). This was selected for the first IDA-supported project because: (a) there was contiguous area with sufficient groundwater resources for large scale irrigation development and relatively easy access to a reliable electrical power supply; and (b) some 25 pilot production wells serving about 2,000 acres had been completed. The "pilot phase" consultants submitted a draft Feasibility Report in August 1982 which formed the basic of the project appraisal in September 1982 (para 4.1).

3. Project Objectives and Description

3.1 The main project objective was to increase crop production and farm incomes by expanding the irrigated area from an existing 2,000 acres in 1983 to about 20,000 acres 1/ at project completion in 1989 through development of groundwater resources. A second objective was to strengthen the capability and inter-agency coordination of the institutions involved. Although not explicitly stated in the Appraisal Report, it was assumed that the project would be the first of a series of groundwater development operations using electrical power supply and that lessons learned and institutional strengthening would have important benefits beyond the project area 2/ as groundwater development in Myanmar expanded.

3.2 At appraisal, the project had six components: (a) construction of some 106 new deep tubewells including provision of pumping equipment and pumphouses; (b) construction of irrigation and drainage systems for the new tubewells; (c) construction of a power distribution system from an existing 33 kV line to the new tubewells and to the 25 existing diesel driven tubewells; (d) provision of agricultural support including extension and applied research; (e) provision of fertilizers and chemicals; (f) technical assistance and training; and (g) support of monitoring and evaluation activities. With respect to item (a), the number of new tubewells was increased in 1990 from 106 to 120 and related project components expanded accordingly. In addition, in response to the country-wide shortage of fuel, a new component was added in 1988 to procure petroleum products sufficient for all on-going project activities (para 5.3). The project also supported operation and maintenance (O&M) activities during the construction phase (para 1.28).

4. Project Design and Organization.

4.1 Project Design. The project appraisal benefited from the four years of experience gained from the "pilot phase" (para 2.3) with the comprehensive Feasibility Report submitted to IDA in August 1982. The World Bank's confidence in the status of project preparation was reflected by the almost immediate departure of the appraisal mission in September 1983. This timing was to maintain the momentum of the"pilot phase" and enable the appraisal mission to discuss the feasibility study with the "pilot phase" consultants whose key staff remained in Myanmar until December 1983.

4.2 Although the "pilot phase" produced a useful data base for the project, it was prepared as a feasibility study and should have been treated as such. The four areas for potential groundwater development (including the project area) had only been identified to reconnaissance level and appeared to

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1/ The existing irrigated area was served by the 25 "pilot phase" production wells. The proposed development was expected to reduce rainfed crop production on the surrounding area since farms are fragmented and most farmers owned land inside and outside the proposed irrigated area. It was assumed that farmers would give up some rainfed agriculture as they concentrated on new irrigated areas and would also take some 2,000 acres out of production to provide the right-of-way for irrigation infrastructure.

2/ All supervision missions until about 1988 used resources for the identification of a possible follow-up project and UNDP funds were sought to update the Groundwater Irrigation II preparation report.

accept the technical and institutional assumptions in the feasibility study without detailed evaluation. Shortcomings resulting from lack of detailed preparation emerged as the project moved to the implementation stage. These included: (a) insufficient detail on physical resources (soils, groundwater topography, etc.); (b) unproven assumptions on irrigation and water management efficiency; and (c) an assumed developmental impact in groundwater irrigated areas which had not been demonstrated.

4.3 In addition, the appraisal generally underestimated the institutional risks inherent in moving from a pilot activity to a large scale operation and the challenges associated with: (a) electrification of the project tubewells for the first time in Myanmar; (b) inter-agency coordination; and (c) the practicality of delivering a work program (to a tight schedule) given the procurement procedures in Myanmar. None of these issues had to be tackled in detail under the "pilot phase" sub-project. Finally, the appraisal (and the project) could have taken more advantage of lessons learned from other World Bank-supported groundwater irrigation projects, particularly in India 1/, which were, at the time of appraisal, demonstrating improved and innovative technologies.

4.4 The project period of five years seemed reasonable given the apparent experience gained under the "pilot phase" and that some 48 tubewell sites had already been selected in the project area with detailed surveys completed on 24 sites. However, a critical assumption in the implementation schedule was that procurement of materials and equipment under many separate small contracts would be achieved, as predicted in a detailed annex of the Staff Appraisal Report (SAR). In addition, the appraisal did not recognize the growing shortage of petroleum products and imported construction materials in Myanmar, although these constraints had already been identified as serious problems on other IDA supported projects. Finally, it was optimistically assumed that the Electric Power Corporation (EPC) would: (a) enter into a working agreement with the ID prior to Credit effectiveness; (b) finalize the detailed design for the power supply system in the first year; and (c) commence major construction of the power supply network during the second year with the first new tubewells to be commissioned before the dry season of the third year (para 5.8).

4.5 Project Organization. The Ministry of Agriculture and Forests (MAF) had overall responsibility for project implementation. The main implementing agencies were: (a) the Irrigation Department (ID) for exploration and development of groundwater resources; (b) the Agricultural Corporation (AC) for related extension and adaptive research; and (c) the Electric Power Corporation (EPC) for the construction and operation and maintenance (O&M) of the power distribution system. A Project Steering Committee (PSC) was responsible for project coordination with representatives from the Planning and Statistics Department of MAF, Settlement and Land Record Department and the Ministry of Planning and Finance (in addition to the main implementing agencies). Other agencies associated with the project were the Myanmar Agricultural Bank, the Textile Industries Corporation, the Food Industries Corporation, and the Agriculture and Farm Produce Trade Corporation.

4.6 Groundwater irrigation development was undertaken by three ID Divisions (Drilling, Civil and Mechanical Engineering) which were respectively responsible for: (a) hydrogeological investigations, drilling, and well construction and testing; (b) design and construction of irrigation and drainage systems and on-farm development; (c) and mechanical engineering and workshops. Appointment of the Project Director and Executive Engineers for each of the three key Divisions was a condition of Credit effectiveness. The AC was responsible for: (a) construction of six crop production camps; (b) project adaptive research; (c) procurement of fertilizers and chemicals; and (d) strengthening of agricultural extension. The EPC was responsible for construction and O&M of the power distribution system (as a Sub-contractor to the ID which procured equipment and materials according EPC specifications). A project Electrical Engineering unit was set up in the ID to undertake their responsibilities related to the power supply component.

5. Project Implementation

5.1 General. The project became effective in October 1983, but virtually no progress was made during the first three years until the project took off early in 1987. The project was only therefore

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1/ INDIA - Second Uttar Pradesh Public Tubewells Project, SAR, Report No. 4167-IN, February 24, 1983.

effectively under implementation for about five years with the Credit closing date extended for three years until June 1992. Once the start-up problems were resolved, components were generally implemented to satisfactory standards and the institutions involved performed to be best of their ability given the uncertain country circumstances throughout the project period.

5.2 The main reason for the slow start-up was the delayed and unpredictable delivery of equipment and materials due to complex and bureaucratic procurement procedures (para 5.25). As a consequence, the work program was undertaken in the wrong sequence with a negative impact on the planning and design for most project components. For example, irrigation civil works were constructed before the quality and quantity of groundwater and soils were established and the consultant services had little impact because their terms of reference assumed that many tubewells would be operational during their contracted period (para 11.1). Nonetheless, except for problems related to siting of individual tubewells, the start-up delays tended to cancel each other out for most components.

5.3 By mid 1988, most procurement problems were resolved and shortage of fuel and lubricants was addressed through a bulk import arrangement for all IDA supported projects. By early 1989, progress had improved sufficiently to justify extending the Credit closing date by one year to June 30, 1989. The closing date was further extended until June 30, 1992, since there was no reason to terminate the Credit and the benefits gained from the good progress made since 1987. In fact, about 65 percent of the useful project works were completed after the original Credit closing date. Another reason for extending the Credit closing date were to expand the project scope (using cost savings) to more fully develop the groundwater and land resources in the project area. In addition, the project concept assumed that there would be a second groundwater irrigation project which would strongly benefit from lessons learned under the first project. The Credit extensions provided continuity of work for the staff with special experience in groundwater development.

5.4 Planning and Design. Planning and detailed design of project works was virtually complete before the first electrified tubewell systems were commissioned. This meant that there was little opportunity to monitor operational tubewell systems and incorporate lessons learned as the project progressed. It is concluded that improvements could have been made to all project infrastructure, particularly the detailed design of irrigation distribution systems. Furthermore, insufficient consideration was given to future expansion of the project area in the spatial layout of the well points. Similarly, the 11 kV electric transmission lines were not specifically designed to accommodate future expansion of the well field or access for other users (para 5.8). As yet, the project planning and design process have not been fully evaluated to establish what lessons learned could apply to future groundwater development both in the project area and elsewhere in Myanmar.

5.5 Well points. The critical activity and main expenditure items under the project were the siting and construction of individual tubewells. Although site selection criteria and implementation procedures were carefully described in the SAR, these could not be followed. Unfortunately, the sequence in which technical decisions had to be made to site well points depended on all the equipment, materials and institutional resources being available in a timely manner. Thus, to undertake the efficient drilling program required, inter alia: experienced specialist staff; operational drilling rigs with reliable fuel supplies; availability of consumable spares such as drilling bits and drilling materials; ancillary equipment; and materials including casing and screens to make the boreholes. The procurement arrangements meant the coordination of at least six key and separate contracts to enable drilling to progress to schedule. This drilling package was not put together until early 1986 and then work was delayed because of shortage of essential consumable items, the most important of which was fuel. As a result, in the first year only four tubewells were completed using surplus materials purchased under the "pilot phase" (para 2.5). The drilling program was then stopped for about a year until the items procured for the project started to arrive. Once sufficient materials arrived to commence the program about July 1986, it was then recognized that there would be a shortage of drilling capacity (compounded by the breakdown of a rig) if the project was to be completed on schedule. This problem was overcome in April 1987 by unexpected assistance from the Australian Bilateral Assistance Program which arranged transfer to the project of four surplus drilling rigs originally purchased for a deep tubewell project in Bangladesh.

5.6 Once the drilling program finally got underway, good progress was made. Unfortunately, although well construction was efficient and generally of good quality, the tubewell locations were already fixed by the layout of the completed irrigation systems (para 5.7) and the agreed site selection procedures could not be followed. The problem was not just the siting of each individual well point, but that hydrological data obtained during the drilling of wells could not be used to improve the layout of the project well fields and alignment of the electrical power network. As a result, 8 tubewells had to be re-sited once the water quality was tested and the irrigation systems abandoned and at least 8 operational tubewells cannot be utilized because of very poor water quality or poor soils. Shortcutting the siting criteria and procedures because of procurement delays has compounded the technical problems and added to project costs. Nonetheless, the ID has learned an important lesson related to program scheduling should it consider further groundwater development in Myanmar.

5.7 Irrigation Systems. In spite of the drilling program delays, the project started construction of irrigation systems for selected tubewell sites, primarily to keep the civil works staff occupied. An attempt was made to reduce the design risks (related to quantity or quality of groundwater resources) by only building part of the irrigation distribution systems. This precaution had little impact and most irrigation and drainage systems were completed (99 out of 106 units) in advance of developing and testing the well points. This resulted in almost all irrigation systems being completed before physical resource data was collected to confirm the design assumptions. Well points were sited on the basis of hydrogeological and soil data collected at the investigation stage and there was no water supply to test completed layouts. The command layouts were made as symmetrical as possible with equally spaced laterals (i.e., following an idealized layout given in the "pilot phase" feasibility studies). The irrigation channels were also designed to standard sections and slopes which were not always varied to reflect local topography, or the actual well discharge (since this could not be measured). By the time these design problems were recognized when the first tubewells became operational in December 1987, there were few remaining well sites to be selected. Furthermore, even when wells could be tested, there were insufficient resources and skilled staff to undertake the testing of hyrogeological and soil quality determinants. Another problem which may cause problems as tubewell utilization increases is that the irrigation operating principles were not fully decided when the layout designs were finalized and water user groups (para 5.18) were set up. Aside from the design problems, the small lined canals and earth laterals were generally constructed to satisfactory standards. However, before they finally became operational, many systems needed remedial work, particularly drainage, because they had been finished and left unutilized for an extended period of time.

5.8 Power Distribution System. The main difference between the "pilot phase" and the project was the adoption of electrical rather than diesel power supply for wells because of serious fuel shortages. Thus, the project area was divided into four clusters of wells (some 29 to 35 wells per cluster) each served by a dedicated 11 kV power line from a separate 33/11 kV substation. The original design assumed that each 11 kV line would have a 'ring' configuration so that each well could receive power from two directions if a power line failed. During the implementation phase, the 'ring' concept was dropped for Rings 1 and 2 and replaced by separate lines from the sub-stations. Although power lines were dedicated to the project, there was spare capacity for further development of new wells and for other potential consumers near the project wells, particularly for community and public village buildings. However, use of this spare capacity was restricted because the lines were laid out before the groundwater resource surveys were completed. Nonetheless, this spare capacity did enable some 14 additional tubewells to be built under the project, but rural electrification potential was never exploited.

5.9 There was an 18 month delay before the EPC and ID entered into an agreement on their respective project roles (even though the need for an agreement was discussed and minuted at negotiations). As a consequence, it was not until December 1987 that the first 30 wells (on Ring 2) were energized with the delay primarily due to slow procurement of the many separate items needed for the electrical networks. Connector wire, substation equipment, transformers, lighting arrestors, poles, tubewell electrical equipment, etc. were all procured separately although all items had to be present on site for power distribution lines to be completed. The electrification program was finally completed early in 1991 and became another important reason for extensions of the Credit closing date. Generally the quality of construction of substations and the 33kV and 11kV power lines has been acceptable and performance satisfactory to date. If the implementation schedule set at appraisal had been followed, the design of the electrification works could probably been improved with some cost savings.

5.10 Agricultural Support. The main agricultural challenge was to help farmers in the transition from rainfed to irrigated agriculture. Project support was through specialized extension services, crop demonstrations, adaptive research programs, and provision of fertilizers and other agricultural inputs. The technical assistance component was primarily designed to support irrigated agricultural support activities (para 11.1) but was less than successful because the consultant services were essentially completed before the first electrified tubewells became operational. The appraisal assumption that the 25 existing tubewells (constructed under the "pilot phase") would provide an opportunity to undertake agricultural support activities did not work out because their irrigation service was unpredictable. The consultants prepared a detailed guideline for land levelling, but these were never fully tested because of the late arrival of agricultural equipment and lack of fuel. As a result, few fields were effectively levelled under the project. The crop diversification objectives were partly achieved with a few new crop varieties introduced and tested at the three research farms. A series of trials for various crops produced some useful results, but many experiments and studies remained inconclusive or incomplete. The main problem was lack of interest in monitoring and evaluation (para 5.19) given the uncertain irrigation supply (which was generally not measured), and to a lesser extent, unpredictable supplies of other agricultural inputs. The inability to easily test water or soil quality and other parameters further reduced the value of agricultural data collected and it is still not possible to relate agricultural performance to soil types and irrigation service with any certainty.

5.11 Extension Activities. Sufficient extension staff were recruited and assigned to project activities, but resources and facilities provided (in particular, transportation) were inadequate for staff to operate effectively in the field. This situation developed unchecked, because there was little real need for agricultural field activity until about 1990, since few wells were operational. Unfortunately, the consultants had already left before there were sufficient operational wells to test and demonstrate the extension duties and procedures and the recommended packages for irrigated crops on the farmers' fields. In addition, procedures for efficiently applying lessons learned from research farms and reporting requirements of extension staff have not been fully tested and evaluated. Coordination between the extension staff and the ID was not formalized and most extension staff did not fully understand the opportunities and limitations of a groundwater irrigation service - just as most ID staff were not familiar with irrigated agricultural challenges.

5.12 Agricultural Equipment and Materials. The project supported purchase of agricultural equipment to undertake crop demonstrations, adaptive research and also assist in the land levelling requirements. The equipment was scheduled to arrive in 1984 but did not reach site until 1988 and resulted in few measurable benefits. The procurement of fertilizer and chemicals was also delayed and, although they were beneficially used in the project area, most chemicals did not arrive in time to be used for adaptive research and demonstrations undertaken by the consultants. As a result, present applications of fertilizers and chemicals are substantially less than that recommended in the appraisal (on both the research farms and the farmers' fields).

5.13 Training. The project provided for fellowships abroad and short term overseas training and tours for both ID and AC staff. It was assumed that the consultants would assist in arranging for these activities and also provide on-the-job training through the demonstration effect of their work. Three ID staff were sent abroad for post graduate training and one visited the consultant's headquarters for short term training in groundwater modeling. None of these staff are still working on groundwater related programs. Attempts were made to organize some overseas tours, but these never materialized. On-the-job training was severely constrained by the start-up delays and lack of operational wells while the consultants were in Myanmar (para 11.1). As a result, training impact under the project has been limited. Nonetheless, there are now a considerable number of ID and some AC staff who have gained useful experience in groundwater development, primarily because they had to undertake the work programs virtually by themselves. Also, World Bank supervision missions provided comprehensive aide memoires which focused attention on the lessons learned.

5.14 Operation and Maintenance (O&M). The appraisal recognized that, unlike surface irrigation schemes which can be mistreated and still deliver a service, sustainability of groundwater development depends heavily on efficient operation and preventive maintenance. The challenge related to O&M was to be addressed through institutional strengthening activities and by involving farmers closely in scheme

implementation and management through formation of water user groups. It was assumed that O&M of tubewells and irrigation facilities would be transferred from the construction division after tubewell systems were completed to a maintenance division with units responsible for civil and mechanical maintenance. The EPC was to operate and maintain all 33 kV facilities and the four 33/11 kV substations and train ID staff to maintain 11 kV lines and tubewell transformers. The AC was expected to continue an intensive agricultural extension program until the service could be reverted to normal levels of extension after the irrigated agricultural development phase.

5.15 The O&M arrangements have not fully worked out as planned. During the construction stage, O&M of completed works was only partially successful because construction staff could not devote sufficient attention to O&M as the number of completed tubewells increased and on-going construction sites became more isolated from completed wells. A related problem was that well operators were employed and administered by construction staff who had no long term interest their welfare or the project O&M requirements. Recognizing the potential risks, an important justification for extensions of the Credit closing date to June 30, 1992 was to put in place effective O&M arrangements to manage the project in the post construction stage. Useful progress was made until about mid 1992 with an effective O&M unit established in Monywa and sufficient spare equipment and materials were procured (using cost savings) to service the project for at least five years. However, the policy change within the ID (under a new Minister of Agriculture) diverted most staff and resources to a crash program to complete on-going projects in Myanmar. This has, in the short term, seriously depleted the O&M capability of the project, but may be corrected when the on-going irrigation projects are completed.

5.16 The challenges related to O&M are technical, administrative, and financial. A general technical problem is that the approach to maintenance appears to be 'curative' (i.e., the minimum necessary to keep essential project elements working) rather than 'preventive'. The cause of the problem is primarily budgetary constraints. It also appears that the project 'operational' principles have been given insufficient attention, since these are considered to be a users' responsibility. Specific roles and responsibilities related to operation (and maintenance) tasks have yet to be fully defined and allocated to staff. In addition, the monitoring and reporting of O&M needs to be substantially strengthened if management is to be kept informed. Administrative actions which need to be taken, include: (a) full provision of staffing, office facilities, transportation and routine equipment for monitoring; (b) sufficient and predictable annual budgetary provisions; and (c) strengthening the linkage between the ID (O&M) and the AC units in Monywa and other agencies involved in sustaining the project.

5.17 The project O&M status reflects a general policy challenge throughout the ID and cannot be resolved on a project basis. The recurrent expenditures needed to sustain projects are small compared to construction costs, but appear to have little priority. GOM has not yet recognized that the negative impact on benefits will be substantial if completed irrigation schemes are not effectively sustained.

5.18 Water Users Groups. Water User Groups (WUGs) have been set up on all project tubewells and appear to working reasonably well. Their main tasks are to mange the well point and operator, including arrangements for repairs and maintenance of the pump set and irrigation works; plan and supervise the irrigated agricultural activities; and distribute the irrigation water supplies. One initial problem now mainly resolved is that most WUGs were set up long before the tubewells became operational and it was hard to maintain farmers' interest in irrigation or preventive maintenance of works which were not functioning . Also ID supervision of WUG activities needs to be strengthened since performance records are not standardized and kept in a way that can be checked. It appears that WUG committees are not generally selected on competence, but on the age, rank or position of the farmers in the local society. Although the present WUG arrangements are functioning satisfactorily, the management task is relatively easy since present irrigation service in 'on-demand'. Once demand increases and they may be shortage of water, the present informal WUG arrangements may be open to abuse which cannot be easily monitored by the ID.

5.19 Reporting and Monitoring. The financial and physical progress was generally reported in a satisfactory manner and provided sufficient information for the World Bank to supervise and GOM to manage project implementation. However, little diagnostic analysis was done of the data collected to establish the extent and causes of the project problems and delays. In almost all cases, it was World Bank missions which requested that specific monitoring exercises be undertaken, indicating that

performance data collection has not been not a high priority for Government.

5.20 The monitoring and evaluation (M&E) of the physical resources and technical aspects of groundwater development are essential element of the implementation process (as reflected in the need for site selection criteria and procedures). However, this activity was never undertaken in a comprehensive and complete manner, thus limiting lessons learned and allowing technical problems (i.e., soil and water quality) to remain unchecked until curative action had to be taken. In addition, many experiments and studies have remained inconclusive because facilities were not available to test water or soil quality and other parameters (and thus relate crop production to soil types). For example, considerable work was done under the agricultural development and research activities, but virtually no trials were designed to record the quantity or timing of irrigation water used. Thus, the irrigation performance related to irrigated agricultural production cannot be rigidly evaluated, even though the basic project objective is to provide an irrigation service.

5.21 The O&M record keeping at tubewell sites and O&M offices in Monywa was varied and often incomplete. Bank review missions since 1989 made detailed recommendations to improve M&E procedures, designed the data collection activities and indicated how data should be checked, processed and analyzed. Although substantial field data was collected, the information was not effectively collated or routinely checked for accuracy or consistency and there was little data evaluation. Procedures were not introduced to cross-check data from various sources and thus confirm the validity of records (in particular, pumping hours, water used per irrigated area, and power consumption). It has therefore not been possible to correlate irrigated cropped area recorded by the AC and ID, or to establish a relationship between irrigated area and tubewell running hours. In addition, there were unexplained differences between power consumed as measured at individual tubewells and that reported at substations.

5.22 Hydrogeology. World Bank review missions strongly emphasized the need to routinely collect and analyze hydrogeological data to confirm water quality and quantity at each project tubewell. Data was needed to evaluate water and soil quality (salinity and alkalinity problems) and monitor performance of groundwater resources of all aquifer layers. It was also needed to run the groundwater simulation model prepared by the consultants (but never used operationally). The construction of some 60 observation wells in 1991/92 should improve the situation, but even before the observation well network was completed, static groundwater level could have been routinely measured from the "pilot phase" wells and open wells in the project area. This monitoring work appears not to have been done because there was no qualified hydrogeologist available and insufficient equipment and materials for routine sampling and testing. Although project staff recognized the problem, it was not possible for them to take appropriate action because of bureaucratic and budgetary constraints.

5.23 Cost Recovery. At appraisal, cost recovery was not considered to be a major challenge because the main source of the recovery rate (estimated at 58 percent) would come from indirect taxation, through procurement of 'controlled' crops - including cotton, wheat and mung beans- at below the crop export or import prices. The post construction risk was not considered to be cost recovery, but to maintain enough production incentives to farmers to fully participate. However, in the last year of the project, the compulsory procurement for wheat by the Industrial Corporation I (3 baskets per acre) and for paddy through the Trade Corporation I (2 baskets per acre) applies whether the crop is irrigated or rainfed. Thus, procurement of 'controlled' crops is not a water charge, but a general agricultural tax. Nonetheless, since controlled procurement is the same for irrigated and rainfed land, it should provide an incentive to irrigate to increase yield per unit acre, but apparently does not. In 1991, the crop tax equals about Kyat 750 per acre for wheat and Kyats 140 acre for paddy (i.e., the difference between the Government procurement and open market price).

5.24 The cost recovery issue is how to ensure that there are sufficient funds available to the WUGs to sustain the project works. Groundwater development has a low capital investment per unit area but high O&M costs. As wells are more fully utilized, O&M costs will increase through increasing electrical charges (billed at about Kyat 700,000 in 1990-91). In this respect, performance data indicate that irrigation efficiency of project tubewells is varied and low and farmers do not appear to value water supplies. Government recognizes that water charges will have to be introduced, but no decision has yet been made because of the political sensitivity of the issue. It has however been generally accepted that charges would cover at least O&M costs, (i.e., establishment, power, routine maintenance and repairs to

equipment) and the recovery system would be designed to encourage farmers to use irrigation facilities and service efficiently. Still undecided is whether to charge directly or indirectly for water and, if directly, how water charges would be assessed, billed and collected. One option under consideration is a two tier water charge system consisting of a flat charge of each irrigable acre with an additional charge on a hourly basis for irrigation used.

5.25 Procurement. The implementation schedule at appraisal assumed that it would take about 14 months from initiation of a procurement activity through to delivery of the goods. It was also assumed that the procurement process would be started under the "pilot phase" to take advantage of the presence of the "pilot phase" consultants. Draft tender documents were submitted to MAF's specification committee in mid 1983, but only the contracts for well component and materials were floated by January 1984. It was soon recognized that there would be serious delays in procurement and the ID was asked to undertake a detailed review of the procurement process. This revealed that for each contract some 37 steps were needed, some with 15 sub-steps, and the typical processing time to delivery was over two years - assuming there was no contract or bidding problem. Unfortunately, the key contract related to well components had to be re-tendered and delivery was finally made in July 1986. The appraisal did not recognize the special risk with groundwater development that all the various equipment, spares and materials had to be available for works to proceed on schedule. This risk should have been predicted at appraisal and appropriate guarantees sought to compensate for the GOM procurement procedures. Once into the project, IDA appeared unable to persuade GOM to improve the situation. In fact, the inefficient procurement process has remained substantially the same through to Credit closing as reflected by procurement delays for additional equipment and spares - initiated in 1990 and delivered in early 1992.

6. Project Results

6.1 Introduction. The project objective to expand irrigated agriculture through groundwater development has been generally achieved, although with at least a three year delay compared to the appraisal estimate. The second objective of developing an institutional capability and inter-agency coordination in the groundwater subsector has been less successful because a planned follow-up project was not taken up. As a result, the ID staff who have gained experience from the project and the ID implementation divisions and their equipment have now been transferred to other work programs. Thus, many lessons painfully learned under the project may now be lost since there is no groundwater development program on which to test and demonstrate alternatives

6.2 The performance of the irrigation service of the project is detailed in Annex 1. Most tubewells are operated 'on demand', since at present water supply exceeds demand. There is no need to efficiently manage the irrigation systems or to formalize a procedure to deal with water disputes. In fact, since there is no water shortage, the arrangements designed by the consultants for sharing water between farmers has not been fully tested or demonstrated. Water is informally allocated by the WUGs and/or tubewell operators and there are no operational guidelines to assist WUGs in the management of tubewells. Although there has been no detailed evaluation, irrigation system efficiency appears to be low, as would be expected with supplies exceeding demand and there are no water charges. Since power costs are directly proportional to the water supplied, the present low irrigation efficiency increases O&M costs through additional energy costs.

6.3 Prior to December 1987, some wells operated on diesel but, apart from some Government farms, these wells never provided a reliable irrigation service because of unpredictable fuel shortages and lack of other inputs. Consequently, agricultural production data collected up to about 1990 has been at best indicative, with considerable unexplainable variations in yields between wells. The project agricultural impact at full development still cannot be estimated with certainty since the last wells were energized early in 1991. However, the operational wells are generally performing as designed with the irrigated area building up as farmers except the risks of changing from rainfed to irrigated agriculture. As would be expected, this transition is being undertaken cautiously given the magnitude of the change involved, but still is taking place at about the same rate anticipated at appraisal. One problem, as yet unresolved, is that project monitoring has not been carefully designed to include all variables affecting irrigated agricultural impact. Thus, variations in crop production cannot be compared to the quality and quantity of irrigation service.

6.4 Results. The ERR for the project reestimated for the PCR is about 8 percent compared to about 22 percent at appraisal as detailed in Annex 2. The shortfall in ERR compared to that calculated at appraisal reflects: (a) serious delays in project implementation; (b) slower than expected response by farmers to irrigation; and (c) shortcomings in the planning and design (para 5.4). However, the PCR analysis is considered to be conservative since it assumes that: (a) the irrigation intensity at full development will be only about 125 percent compared to 150 percent predicted at appraisal; (b) some 7 percent of the tubewells will fail because of poor water quality and soils, or for other technical reasons; and (c) farmers will initially put about 40 percent of the irrigated area to irrigated sesame, giving low returns at low risk. Under more optimistic assumptions, the ERR may increase to about 10 percent, if the PCR analysis was to reflect a continuation of farmers' response to the incentives created by the recent opening of free markets for agricultural produce (Case C in annex 2). There is strong evidence that the project has now provided farmers with a substantial financial incentive to more fully utilize the irrigation service.

6.5 Other Project Results. The main project objective of regional development in a dry zone area has been achieved, but strengthening of the agencies involved has been only partly successful. Many shortcomings in institutional performance were due to sector issues and government-wide bureaucratic constraints which could not be effectively addressed at the project level. The formal and on-the-job training through technical assistance appears to have had only a marginal impact. However, the project has provided GOM with substantial experience which will be useful if further groundwater development programs are implemented.

6.6 Main Lessons Learned. The World Bank had good reason to assume that the project would be successful given the four year "pilot phase" sub-project under UNDP (para 2.3). With hindsight, although the "pilot phase" produced some useful data for the project, the result was a feasibility study and should have been treated as such with the project area identified to little more than reconnaissance level. Shortcomings, which emerged as the project moved to the implementation stage, included: (a) insufficient detail on physical resources (soils, groundwater topography, etc.); (b) unproven assumptions on irrigation and water management efficiency; and (c) an assumed developmental impact in groundwater irrigated areas which had not been demonstrated. Furthermore, project performance depended on GOM taking hard policy decisions on sensitive issues related to institutional strengthening and staffing, budget provision for non-planned expenditures and basic improvements in procurement and bureaucratic procedures. The rapid appraisal following the "pilot phase" subproject indicates that the World Bank did not fully identify the potential risks in the first 'project' scale operation to develop groundwater.

7. Project Sustainability

7.1 The project will only be sustainable if full staffing and resources for O&M activities are routinely provided and the WUGs provided with technical support. One long term problem will be to repair and replace the equipment which was procured from a wide variety of sources using foreign exchange. To the extent possible under the Credit, the project has taken preventive maintenance action by procuring about five years worth of spare parts, particularly for mechanical and electrical equipment of the tubewells. Nonetheless, a water charge system will have to be designed and introduced to cover at least the full O&M costs and the extension effort strengthened to encourage farmers to more fully utilize the irrigation service. The project should be closely monitored to quantify the many lessons learned to date and to enable remedial action to be taken as required. The procedures and processes for land and agricultural development should continue to be tested and demonstrated and action taken to ensure that all the inputs are available for irrigated agriculture (including fertilizers and improved seed varieties) and that all farmers can receive an reliable and equitable irrigation service. The electrical power supply should be sustainable. If necessary, there is considerable flexibility to accommodate power shortages by extending the daily running hours to include night irrigation.

8. IDA Performance

8.1 The project concept to support groundwater irrigation development was, and continues to be, a sound proposition and given the four year "pilot phase" sub-project, it is easy to see why the appraisal was optimistic - particularly with respect to procurement, the electrification program, the role of technical assistance, and the limited priority given to O&M. Nonetheless, there is evidence that if the irrigation

subsector had been more fully evaluated at the time of appraisal, the risks (which soon turned into problems) could have been better identified. As a result of the optimistic appraisal, the implementation phase was only partly successful in fulfilling the project objectives and considerable effort was spent correcting problems which may have been avoided. The "pilot phase" sub-project prior to appraisal produced only a feasibility study and did not fully identify the technical and institutional risks of developing a large scale groundwater irrigation investment. The siting criteria and procedures describe in the SAR were not followed because of start-up delays. Another risk, not fully evaluated at appraisal, was the assumption that GOM agencies would have the procedural flexibility, authority and incentive to coordinate their project programs.

8.2 Supervision. The supervision performance was varied but, on average, was sufficient to identify the causes of the shortcomings and make appropriate recommendations for curative action. However, it is clear that the project was under-supervised during the critical start-up period particularly as problems related to procurement developed. Lack of focus on the key issues earlier in the project cycle allowed many problems to develop unchecked, such that the project substantially deviated from the plan envisaged at appraisal. However, actions required to overcome the problems as they developed were generally beyond the power of the project staff to address. One reason for weak supervision was that most missions were split between two or more operations resulting in a superficial reviews which did not thoroughly address the key issues (i.e., the causes of the delays and technical shortcomings). In fact, it is fully understandable that many basic problems and constraints developed unchecked and the project deviated from the plan envisaged at appraisal. During this period, considerable resources were used on preparing the proposed Groundwater Irrigation II project while the first project was making negligible progress. More focused supervision may have resulted in better value from the consultant services (by revising their terms of reference) and agricultural support activities.

8.3 Once the project finally got underway in about 1987, the World Bank review process became easier and the comprehensive aide memoires and detailed recommendations for improvements helped to improve the situation. In particular, the World Bank supervisions during the Credit extension period (1989 - 1992) helped to secure potential benefits and perhaps, more importantly, record the many lessons which were learned from the implementation phase.

9. Borrower Performance

9.1 The project performance appears to be typical of a country undertaking groundwater irrigation development on a large scale for the first time. Under difficult country circumstances, the agencies involved managed to overcome a wide range of problems and, in the end, were able to exceed the project scope with a saving in cost, even though the project took three years longer to implement than expected. In fact, with the first three years primarily devoted to resolving start-up problems and constraints, the effective implementation period was about that envisaged at appraisal.

9.2 Clearly the project could have gone better in that the best way to resolve a problem is to avoid it. However, most of the causes of the problems were generic, sectoral or country-wide in nature and could not be addressed through a specific project. Furthermore, it was understandable that the Borrower should be less than enthusiastic with the numerous problems during the start-up period. The Borrower's institutions managed to resolve most of the problems, albeit at some cost to the quality of the planning and design. Nonetheless, the agencies now have the capability to successfully implement groundwater development should GOM decided to continue with the program in other areas.

9.3 Throughout the implementation period, the administrative resources were insufficient for the staff to perform effectively. One consequence was the persistent lack of reliable reporting and monitoring of performance. Most reporting related to information available in the offices or from construction sites. Thus, data tended to be limited to physical and financial progress; and, without performance data and related diagnostic analysis, was not sufficient for effective management. The field data collected by each agency was seldom made available outside the respective project office for serious review or analysis. As a result , the project status could not be consolidated since each agency seemed to have a different format, time base and procedure for processing data. Reporting and monitoring could and should have been given more attention. An important lesson for the Borrower should be the need for reliable performance data for both irrigation service and agricultural production. Without reliable data, it is not

possible to have effective management or institutional accountability or evaluate whether Myanmar should continue with public sector groundwater development.

9.4 The main lessons to be learned by the Borrower and agencies involved relate to improvements in: (a) procurement procedures; (b) local funding and the budgetary process; (c) institutional capability, responsibility, accountability and coordination; (d) the use of technical assistance; (e) quality control of planning and design and appropriateness of the technology; (f) O&M of completed tubewell schemes; and (g) monitoring and reporting. A fundamental lesson to be learnt by the GOM is that diagnostic analysis of project planning, design and implementation must be undertaken if similar new investments are to benefit from the lessons to be learned.

9.5 The Borrower complied with most of the project specific covenants to standards that generally prevail throughout the irrigation subsector. The financial statements and audit reports were satisfactory but submission was generally delayed, reflecting the slow and complex procedures related to fiscal control in Myanmar. However, the Credit Agreement would have been improved with specific conditionalities related to project coordination, well siting criteria and site selection, quality control and O&M standards. Stronger provisions could also have been made related to cost recovery, reporting and monitoring, institutional strengthening and full provision of qualified staffing. Compliance with these project activities were generally beyond the control of the project authorities.

9.6 Borrower's Strengths. The agencies involved performed remarkably well under extremely difficult circumstances and have substantially succeeded in saving the project after a disastrous start.. Perhaps the most encouraging outcome has been that once a lesson was learned or problems were identified, GOM and the agencies involved, in particular ID, have shown willingness to take whatever action was feasible. In fact, the project was implemented almost entirely by the national staff since the technical assistance made only a marginal contribution.

10. Project Relationships

10.1 Throughout its implementation, the project was marked by the most cordial relationship between IDA and GOM, although there were differences on the issues related to, inter alia, procurement delays, the role of EPC in the project and availability of diesel fuel and lubricants until GOM took appropriate action to address these shortcomings.

11. Consultant Services

11.1 There was about 15 months delay in the employment of the consultants compared to the timetable set at appraisal. Even with the slow start-up of project, the timing of the consultant services limited their impact. Their main activity was to assist in irrigation agronomy and on-farm water management on the assumption that the project work program would be completed as scheduled at appraisal. Unfortunately, the first electrified tubewell systems were not operational until the last few months of the consultancy which was completed in December 1988. Thus, even though the consultants provided the agreed staff resources, their impact was severely limited. Much of the consultants' efforts had to be focused on production of general guidelines and on the research farms with little opportunity to apply lessons learned on the farmers' fields. Some useful work was initiated on water losses and irrigation efficiency, water and soil quality considerations, land levelling, cropping patterns and irrigation practices. However, most analyses were incomplete because the consultants did not sufficiently monitor the quantity or quality of the irrigation service, or train national staff in water measurement. Lack of reliable data on irrigation performance did not enable a diagnostic analysis of the consultant's preliminary conclusions and recommendations to be made.

12. Project Documentation and Data

12.1 The SAR and legal documents provided a useful (but insufficiently detailed) framework for IDA and GOM during implementation. If the details in the supervision reports had been fully endorsed and understood at the working level by all project agencies, many implementation problems may have been tackled earlier. The IDA implementation documentation was comprehensive and many of the supervision reports (and aide memoires) were persuasive.

PART II. PROJECT REVIEW FROM THE BORROWER'S PERSPECTIVE

(The Borrower has cooperated actively in the preparation of Parts I & III, but has not provided any additional inputs for Part II).

PART III

STATISTICAL INFORMATION

Table I. Related IDA Credits

Credit Number and Title	Purpose	Year of Approval	Status
483-BA Irrigation I	Rehabilitate and extend flood protection embankments, repair construction equipment, supply irrigation pumps to farmers, and construct jute baling facilities.	1974	Completed in 1978.
642-BA Lower Myanmar Paddyland Development	Construct new and rehabilitate existing flood protection embankments, excavate drainage channels, and reclaim abandoned land.	1975	Completed in 1985.
745 -BA Seeds Development	Improve research capability of six central farms, develop seed program for rice and cotton, create processing facilities for seed and storage, pilot project for groundnut seed storage in Lower Myanmar, overseas training, and consultants.	1977	Completed in 1984.
835-BA Paddyland Development II	Flood protection and drainage of 175, 000 acres, including reclamation of 50,000 acres abandoned lands, procurement of construction and agricultural equipment, and establishing workshops in the project area.	1978	Completed 1990.
1031-BA Kinda (Nyaunggyat) Multipurpose	Construct 235 ft. high dam, hydropower station, rehabilitate existing irrigation system for 88,000 ac, construct new system for irrigation, drainage and flood protection for 113,000 ac, and strengthen MAS for trails on new crops, and procurement of fertilizer.	1980	Dam and power station completed and power generation started in 1985. Irrigation commenced in entire new area in June 1990. Project completed March 31, 1991.
1092-BA Grain Storage	Improve storage facilities at selected locations within the country.	1981	Completed 1986.
1245-BA Power	Provide essential transmission facilities for the generating stations in operation and under construction; institutional development for operations; planning; and financial performance including level and structure of electricity tariff.	1982	Completed in 1990.
1315-BA Tank Irrigation	Construct an 82 ft. high dam, rehabilitate and extend existing irrigation system for 5,000 acres. Construct another dam, 92 ft. high for supplying water to 850 acres of orchards, 2,000 acres of paddy, and Mudon town of 40,000 inhabitants. Also strengthen ID for design and planning and MAS for extension.	1982	Works completed, irrigation and town water supply already commenced. Project closed in June 1990.
1616-BA Seeds Development II	Strengthen seed production and management capability of MAS, and establish efficient seed multiplication program.	1985	Project expected to be completed in 1994.
1707-BA Grain Storage II	Improve efficiency of rice milling through rehabilitation of existing facilities and construction of new mills.	1986	Project expected to be completed in 1994.
1731-BA Ye-U Irrigation Rehabilitation	Rehabilitate and modernize irrigation system for 121,000 acres to stabilize paddy production, strengthen ID mechanical wing for repairs and inventory control of construction equipment, and prepare a Master Plan for rehabilitation of irrigation systems in Central Myanmar.	1986	Project had delayed start due to political disturbances. Implementation is catching up.

Note: The most recent and relevant Project Performance Audit Reports (PPARs) are Nos. 3845 and 6810.

Table 2. Project Timetable

Item	Date Planned	Date Actual	
- Identification a/	-	March 1981	
- Preparation/Preappraisal b/	-		
- Appraisal Mission	October 1983	9/28/83	c/
- Credit Negotiations	4/11/83	4/18/83	
- Board Approval	5/17/83	6/7/83	
- Credit Signature	-	7/18/83	
- Credit Effectiveness	-	10/7/83	d/
- Credit Completion	9/30/88	6/30/92	
- Credit Closing	6/30/89	6/30/92	e/

Comments:

a/ The project identification resulted from recommendations of a World Bank Agricultural Sector Mission which visited Myanmar in 1977.

b/ The project was prepared through the Groundwater Exploitation and Pilot Development Subproject under the UNDP (Myanmar) Umbrella Project. The Subproject produced a Feasibility Report from countrywide reconnaisance level studies of groundwater resoruces.

c/ The appriasal mission arived in Myanmar one month after the submission of the UNDP feasibility report.

d/ There was one condition of effectivenesss which was fully complied with (Table 7).

e/ The Credit Closing date was extended three times to June 30, 1992.

Table 3. Credit Disbursements

Fiscal Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
	----------US$ Million----------									
Appraisal Estimate a/	1.3	5.7	10.2	12.5	13.7	14.0	14.0	14.0	14.0	14.0
Actual b/	0.0	0.2	2.1	6.2	7.6	10.4	12.7	14.5	16.0	16.4
Actual as % of Appraisal Estimate c/	0.0	3.5	20.6	49.6	55.5	74.3	90.7	103.5	114.3	117.1

Date of Final Disbursement: June 11, 1993 d/

Notes:

a/ Original Credit closing date - June 30, 1989; revised Credit closing date - June 30, 1992 (see note e/ below).

b/ The disbursement percentage for civil works was increased from 50% to 100% from August 17, 1990. This was done to reflect that costs of civil works compared to other project components was larger than anticipated at appraisal. If the disbursement percentages had not been revised IDA would only have been able to fund about 65% of total costs, compared to 75% agreed when the Credit was approved.

c/ In current value dollar terms, the percentage disbursement was lower than shown because of the change in exchange rate between the dollar and SDR. The increased disbursements in US dollar equivalent terms is due to depreciation in value of the US dollar.

d/ The Credit was closed on January 13, 1993 and then re-opened, as provided for in Operational Disbursement Procedures (ODP) 6.06 of February 1993, to honor part of a withdrawal claim related to an eligible expenditure of US$ 531, 573.42 for a contract to purchase spares for tubewells. The payment against this claim fully disbursed the Credit.

Table 4. - Project Implementation

A. Project Components

Ref No	Components	Indicators	Units	Appraisal Estimate	Actual	Comments
A	IRRIGATION					
1	Tubewells					
		Construction of New Tubewells	No.	106	120	
		Completion of Exisiting Tubewells	No.	25	25	
2	Power Facilities					
		33/11kV Substations	No.	4	4	
		33kV Power Line	Mile	16	16	
		11kV Power Line	Mile	115	119	
		Electrification (New Tubewells)	No.	106	120	
		Electrification (Existing Tubewells)	No.	25	22	
3	Irrigation Networks					
		Excavation of Main Canals	Mile	50	59	
		Lining of Main Canals	Mile	50	59	
		Construction of Unlined Laterals	No	430	512	approx 4 miles per TW
		Construction of Drains	Mile	100	113	
4	Equipment					
		Well Components	Sets	106	120	sufficient for all wells
		Drilling Rig Spare Parts	Sum	-	100%	sufficient for drilling program
		Drilling Equipment & Materials	Sum	-	100%	sufficient for drilling program
		Workshop Equipment	Sum	-	100%	
		Survey Equipment	Sets	7	7	
		Office Equipment	Sets	1	1	
		Vehicles and Plant	No.	61	67	
		Tubewell Spares	%	20	30	% of items procured for works
		Power Supply Spares	%	20	20	% of items procured for works
5	Misc					
		Setting up Water User Groups	No.	131	145	
B	AGRICULTURE					
6	Construction					
		Research Farm Facilities	No.	1	1	
		Production Camps	No.	6	6	
		Office for Demonstration Farm	No.	1	1	
7	Equipment					
		Various Agricultural Plant	No.	7	7	
		Tubewell Components (for farms)	Sets	3	3	
		4-wheeled drive vehicles	No.	4	4	
		Motorcycles	No.	4	4	
		Bicycles	No.	26	26	
8	Fertilizer /Chemicals					
		Urea	M/Ton	2321	2321	
		TSP	M/Ton	2063	2063	
		MOP	M/Ton	799	799	
		Misc Chemicals	M/Ton	2719	2719	

Table 4. Project Implementation

B. Present Status of Tubewells in Project Area a/

Ring No.	No. of Tubewells Type	No.	Present Irrigated Tubewells Type	No.	Remaining Non-irrigated Tubewells b/ Type	No.
Part A. Original Project Tubewells						
1	A = 9) B = 22)	31	A = 9) B = 21)	30	A = 1) B = 1)	2
2	A = 11) B = 21)	32	A = 11) B = 20)	31	A) B = 1)	1
3	A = 2) B = 35)	37	A = 2) B = 33)		B = 2)	2
4	A = 11) B = 20)	31	A = 11) B = 18)	29	A = 1) B = 1)	2
Subtotal		**131**		**125**		**6**
Part B. Additional 14 Project Tubewells						
2	A = 1) B = 4)	5	A = 1) B = 4)	5	A =) B =)	
3	A = 1)	1	A 1)	1	A =)	
4	A = 1) B = 7)	8	A 1) B = 7)	8	A =) B =)	0
Subtotal		**14**		**14**		**0**
Total		**145**		**139**		**6**

a/. A = 1 cusec tubewells; B. = 2 cusec tubewells. There are four electrcial power rings each controlled by a substation. Status of tubewell construction as of March , 1993.

b/ Causes of Low Utilization by Wells are as follows (March 1993):

Ref.	Cause of Low Utilization	No. of Well Affected
1	Low irrigation efficiency due to sandy soil type	7
2	Low well discharge	3
3	Irrigation cannot all tubewell command area	8
4	Low demand by farmers	6
5	Electrical breakdowns	6
6	Water quality	7

7 tubewell are cosidered to serious problems which are unlikely to be resolved without major remedial works.

Table 4. Project Implementation

C. Additional Equipment and Spares Procured a/

Ref.	Description	Unit	Quantity
Part A. Pump Set Spares b/			
a.	Johnston Turbine Pumps (1 cusec)	No.of Sets	9
b.	Johnston Turbine Pumps (1 cusec)	No of Sets	16
c.	Audoli Turbine Pumps (1 cusec)	No of Sets	26
c.	Audoli Turbine Pumps (2 cusec)	No of Sets	106
c.	Audoli Turbine Pumps (1 cusec)	No of Sets	26
Part B. Motor Control Switchboard			
1.	Circuit Breaker	No.	176
2.	Transformer	No.	60
3.	Misc small items		
Part C. Electrical Power Line Material			
1.	11 KV Lightning Arrestor (Single phase)	No.	25
2.	33 KV Lightning Arrestor (Single phase)	No.	10
Part D. Office Equipment			
1.	Electronic Teleprinter	No.	1
2.	Facsimile machine	No.	1

Notes:

a/ Procured in 1991/92 to ensure that there would be sufficient inported spare parts to sustain the project tubewells for about five years after project completion.

b/ Spares for each type of pump set include, inter alia: discharge head; bearing spider; rubber bearing; shaft sleeve; shaft coupling; top column shaft; pump bowl; impeller; pump shaft; and tools and tool box. Number of spare reflect predicted annual maintenance requirements.

Table 5. Project Costs and Financing

A. Project Costs a/
(US$ million equivalent)

Ref.	Project Component	Appraisal Local	Appraisal Foreign	Appraisal Total	Actual Local	Actual Foreign	Actual Total
A	Well Construction	0.82	1.94	2.75	1.85	1.92	3.77
B	Irrigation Distribution and Drainage	4.79	1.77	6.56	4.82	0.95	5.77
C	Engineering & Administration	0.74		0.74	1.62		1.62
D	Power Supply	1.39	3.02	4.42	1.32	2.12	3.44
E	O&M	0.58	0.42	1.00	1.53		1.53
F	Agricultural Ext'n & Applied Research	0.28	0.17	0.44	0.30	0.12	0.42
G	Fertilizer & Chemicals		1.87	1.87		1.28	1.28
H	Technical Assistance and Training	0.07	0.98	1.05		0.95	0.95
	Project Evaluation	0.01	0.02	0.03	0.02	0.05	0.07
	Phase II Preparation				0.61		0.61
	Petroleum Products					0.46	0.46
	Subtotal	8.68	10.20	18.88	12.06	7.85	19.90
	Taxes and Duties	3.12		3.12	1.42		1.42
	Total	11.80	10.20	22.00	13.47	7.85	21.32

a/ The Actual Costs are as recorded in the audited accounts of the ID and AC converted at the exchange rate used at appraisal (7.786 Kyats = 1.0 US Dollar).
The savings at closure are partly due to favorable exchange rate between the US dollar and SDR.

Table 5. Project Costs and Financing

B. Project Financing a/

Financing Source			Credit Agreement		Revised b/		Actual c/ a/	
			(SDR Million)					
(a) IDA	Category							
	1	Civil Works d/	2.78	(3.0)	5.67	(7.09)	6.14	(8.08)
	2	Equipment, Materials & Spares	8.99	(9.7)	6.13	(7.66)	5.55	(6.96)
	3	Consultant Services & Training	0.93	(1.0)	0.77	(0.96)	0.74	(0.94)
	4	Petroleum Products	-		0.43	(0.53)	0.44	(0.58)
	5	Unallocated	0.3	(0.3)	-	-	-	
		Subtotal	13.0	(14.0)	13.0	(16.24)	13.0	(16.56)
(b) Domestic			7.4	(8.0)	N/A	N/A	4.4	(5.58)
		Total Financing	20.4	(22.0)	N/A	N/A	17.4	(22.14)

Comments:

a/ US Dollar equivalent given in parenthesis.
b/ The Credit Agreement was amended on April 15, 1987 to support purchase of petroleum products not included at appraisal.
c/ As of June 11, 1993 when Credit was fully disbursed.
d/ Percentage of expenditures financed for civil works was increased from 50% to 100% for Category 1 on August 17, 1990.

Abbreviation: N/A. - Not available.

Table 6. - Project Benefits

A. Direct Benefits a/

Ref.	Indicators	Appraisal "Future Without" Project Area (ac)	Appraisal "Future Without" Project Production (Tons)	Appraisal "Future With" Project Area (ac)	Appraisal "Future With" Project Production (Tons)	Actual in Closing Year Area (ac)	Actual in Closing Year Production (Tons)	PCR Estimate at full Development (2003 on) Area (ac)	PCR Estimate at full Development (2003 on) Production (Tons)
A.	Irrigated Crops								
	Paddy HYV (Monsoon)					1131	2149	2332	4431
	Cotton	1075	366	10000	6530	1015	599	1779	1050
	Wheat	717	430	10000	14700	7052	10579	11610	17414
	Mung Bean			10000	6530				
	Sesame	1075	263			6901	621	11360	1022
	Subtotal	**2867**	**1059**	**30000**	**27760**	**14968**	**11799**	**24749**	**19486**
	Cropping Intensity	123% b/		150%		67%		124%	
B.	Rainfed Crops								
	Sesame	26083	2113	21322	1727	4373	262	1584	95
	Cotton					1060	138	384	50
	Chickpea	23330	7303	20014	6264	1855	445	672	175
	Wheat	11898	3891			2120	657	768	238
	Mung Bean	11486	574	9986	499				
	Fodder/Sorghum	5949	779			3843	346	1392	125
	Irrigation Right-of-Way c/	215		2000					
	Subtotal	**78961** d/	**14660**	**53322** d/	**8490**	**12191**	**1710**	**4416**	**633**

a/ See Annex 1, Part I for PCR assumptions used in re-calculating project impact.
b/ Irrigation intensity on existing "pilot phase" tubewells as reported at appraisal. IDA supervision reports about 75% irrigation intensity on existing wells in 1983/84 with shortfall due to deisel fuel shortages.
c/ The pre-project cultivated area lost for infrastructure right-of-way.
d/ Including about 46,700 acres assumed to be affected by the development of the irrigated area (see Annex 1 for explanation).

Table 6. Project Benefits

B. Economic Impact a/

Ref.	Indicator	Unit	Appraisal Estimate	Estimated at Closing Date	Estimated at Full a/
A.	Economic Rate of Return b/		22%	10%	11%
B.	Basic Assumptions				
	Project Life b/	years	20	15/35/50	15/35/50
	Constant Prices used for Analysis	year	1983	1990	1990
	Official Rate of Exchange	Kyat/US$	7.8	7.5	7.5
	Standard Conversion Factor	No.	0.8	0.2	0.2
	Wage Rate	Kyat/day	8	18	18
	Economic Price Farm Labor	Kyat/day	6.4	3.6	3.6
C.	Economic Farmgate Prices				
	Paddy	Kyat/ton	-	3793 c/	3793 c/
	Cotton	Kyat/ton	6852	5605	5605
	Wheat	Kyat/ton	2138	1503	1503
	Mung Bean	Kyat/ton	2699	-	-
	Sesame	Kyat/ton	5390	4047	4047
	Pluses and Misc. Crops	Kyat/ton	-	3892	3892
	Chickpea (Kalape)	Kyat/ton	1614	-	-
	Fodder Sorghum	Kyat/ton	1577	-	-
	Onions	Kyat/ton	-	2695	2695
	Chillies	Kyat/ton	-	12535	12535
	Urea	Kyat/ton	3330	1568	1568
	TSP	Kyat/ton	2557	1605	1605
	MOP	Kyat/ton	1608	1350	1350
D.	Annual Incremental Crop Production c/				
	Paddy	Tons	-	4310	4310
	Cotton	Tons	5385	655	655
	Wheat	Tons	10379	15387	15387
	Mung Bean	Tons	6530	-	-
	Sesame	Tons	-650	540	540
	Sunflower	Tons	-	-12	-12
	Chickpea	Tons	-1038	-205	-205
	Fodder Sorghum	Tons	-75	-376	-376
	Onions	Tons	-	1087	1087
	Chillies	Tons	-	60	60
E.	Other Impact a/ d/				
	Farm Families served e/	No.	6000	4365	4365
	Incremental Farm Labor	M/man/days	0.3	N/A	N/A
	Increase in Family Income	percent	160%	250%	250%
	Foreign Exchange Savings	US$M	8.7	N/A	N/A

a/ See Annex I, Part I for details.
b/ The ERR at full development reflects the impact of the new farmer's incentives to increase crop production.
c/ The exchange rate used in calculating the economic price of paddy is US$1.0 = Kyats 30 based on the official exchange rate for paddy exported through joint ventures.
d/ Assuming that the average irrigated holdings is about 5.2 acres (Project Baseline Survey, October 1986).
e/ Excluding 715 families on holdings irrigated by the existing 25 tubewells (i.e., some 3.0 acre per family).

Table 6. Project Benefits

C. - Financial Impact a/
(1990 constant Kyats)

With Project Net Farm Income from	Appraisal Estimate	Actual at Full Development
5 ha. farm, partly irrigated	13150	32700

a/ See Annex I, Part I for details.

D. - Technical Assistance and Training

Ref.		Item	Unit	Appraisal Estimate Quantity	Appraisal Estimate Cost Local (US$'000)	Appraisal Estimate Cost Foreign (US$'000)	PCR Estimate Quantity	PCR Estimate Cost Local (US$'000)	PCR Estimate Cost Foreign (US$'000)
A		Technical Assistance a/			38.00	500.00		223.90	789.8
	a	Irrigation Agronomist	MM	36.0			31.6		
	b	Groundwater Engineer	MM	1.0			1.4		
	c	Electrical Engineer	MM	1.0			2.0		
	d	Mechancial Engineer	MM	8.0			1.0		
	e	Unspecified b/	MM	4.0			13.0		
		Total		50.0					
B		Training			0.19	2.48		n/a	0.42
	1	Irrigation Department							
	(i)	Overseas Tour	months	12.0			2.0		
	(ii)	Groundwater Engineer	months	15.0			12.0		
	(iii)	Hydrologist	months	15.0			12.0		
	(iv)	Irrigation Agronomist	months	15.0					
		Geophysics	months				12.0		
	2	Agricultural Corporation c/							
	(i)	Subject Matter Sp. (cotton)	months	12.0			-		
	(ii)	Subject Matter Sp. (wheat)	months	12.0			-		
	(iii)	Subject Matter Sp. (beans)	months	12.0			-		

Notes:

a/ Mobilized on 14 November 1985 and departed from Myanmar on 9 December 1988.
b/ Including: Computor Model specialist; Senior Agronomist; Drainage Specialist; Geophysicist; and Research Agronomi
c/ The ID overseas tours did not materialize.
d/ The AC did not utilize the training component.

Table 7. Status of Covenants

DCA Section	Subject	Deadline for Compliance 1/	Status a/
3.02(a(	To establish/maintain Project Steering Committee.	N/A	2
3.02(b)	Cause ID to appoint a Project Director and 3 Executive Engineers for civil, electrical and mechanical divisions.	October 7, 1983	2 b/
3.03	To employ consultants under agreed TOR.	N/A	2
3.04(a)	Goods procures overseas to be insured.	N/A	2
3.04(b)	Goods and services financed out of the Credit to be used exclusively for the project.	N/A	2/7
3.05(a)	Furnish plans, specifications, reports, contract documents, etc. as the IDA shall reasonably request.	N/A	3
3.05(b)	Maintain records and monitor project progress.	N/A	3 c/
3.06	Identify and survey at least 30 new tubewell locations and CCAs.	June 30, 1984	2
3.07(a)	Cause water user groups to be established on each new tubewell being/are commissioning	N/A	2
3.07(b)	Cause water user groups to be established on the 25 existing tubewells.	March 31, 1984	2
4.01(d)	Audit reports on accounts to be submitted to IDA not later than 9 months after the end of each fiscal year.	N/A	2
4.03	EPC to charge the ID for power supply to project wells and O&M cost of power distribution system.	N/A	2
4.04	To review periodically crop pricing system to provide incentives to the farmers.	N/A	2/7 d/
4.05	To establish and maintain recovery of O&M and capital cost, when procurement is modified or abolished, in consultation with the Bank.	N/A	3 e/

a/ 1 = unavailable; 2 = in compliance; 3 = partially in compliance; 4 = not in compliance; 5 = to be waived/deleted; 6 = no longer relevant; 7 = to be amended; 8 = not yet done.

b/ Condition of Credit effectiveness.

c/ Project performance records were generally incomplete.

d/ Agriculture policy was revised in August 1987, limiting Government procurement to industrial crops only. Private dealers started to trade in grains. Free market for cash crops.

e/ Recovery is being partially effected through land and irrigation tax.

Table 8. Use of Bank Resources

A. Staff Inputs a/

Stage of Project Cycle	Planned	Actual
	(Staff Weeks)	
Through to Appraisal	N/A	4.5
Appraisal through Board Approval	N/A	56.3
Board Approval through Effectiveness	N/A	0.9
Supervision b/	N/A	95.1
Project Completion Report	(6.0)	(6.0)
TOTAL	N/A	162.8

Comments.

a/ Staff inputs as of May 18, 1993; figures in brackets are PCR estimates; no details of planned inputs are available.
b/ Planned staff inputs for supervision have been taken as about 7.0 staff weeks for typical specific investment project.

Table 8. Use of Staff Resources

B. IDA Missions [a/] [b/]

Stage of Project Cycle	Month/Year	No of Persons	Days in Field [c/]	Specialization Represented [d/]	Performance Rating Status [e/]	Type of Problem [f/]
I. Project Appraisal:	10/82	3	22	(2)IE; E		-
II. Appraisal to Board:	(10/82 to 3/83)	1	15	E		-
III. Board Appraisal to Effectiveness:	(3/83 to10/83)					-
						-
IV. Supervision:						
	11/83	2	(3)	E, IE(GW)	-	P, M, TA
	5/84	2	(15)	E, IE(GW)	2/2	P, M, T(I)
	10/84	1	(3)	E	2/1	P, O
	4/85	3	(9)	E, IE, AE	2/1	P, TA
	11/85	3	(7)	E, IE, AE	3/2	P, TA
	5/86	3	(8)	E, IE, A	3/2	T, TA, D
	11/86	2	(10)	IE, IE(GW)	3/2	M, T(I & A)
	6/87	1	(15)	IE(GW)	2/2	T, O
	10/87	1	(6)	A	-	M, T(A)
	5/88	1	12	IE	2/1	D, T(A)
	5/89	1	8	IE	2/2	D, M, T(I)
	2/90	1	(4)	D	-	T(I & A)
	3/91	1	16	IE	2/1	M, T
	1/92	2	14	IE, S	2/2	T(I & A), M
V. PCR	4/93	1	12	IE	-	D, O

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a/ Expected and actual staff inputs not available for the project through the MIS.
b/ Figures in brackets are PCR estimate of project field days during multi project missions.
c/ Number of days from start to finish of mission in field.
d/ Key to Specialization: IE = Irrigation Engineer; A = Agriculturalist; E = Economist; S = Sociologist; D = Disbursement Specialist
e/ Key to Status: Development Impact/Overall Status.
f/ Key to Problems: M = Management; T = Technical; F = Financial; P = Procurement; TA = Technical Assistance; O = Other (Project coordination and general project problems).

PROJECT COMPLETION REPORT

MYANMAR

GROUNDWATER IRRIGATION PROJECT I

CREDIT 1381 - BA

Project Irrigation Performance

1. Background. The Supplementary Volume to the Appraisal Report (dated May 16, 1983) included a working paper No. 2 on "Design and Operation Criteria for Tubewell Irrigation Systems". The project design assumed that: (a) absolute maximum daily operation would be 20 hours while about 14 hours/day would be preferred (so that wells were not operated during peak demand hours to 18.00 to 22.00 hours). Overall conveyance efficiency was assumed at 0.9 with a field application efficiency of 0.66. Field water requirements were calculated at about 5 inches per (monthly) application, assuming that each holding was irrigated twice a month. The calculations concluded that there would be a shortage of about 20 percent at peak demand periods if daily pumping was restricted to 14 hours/day.

2. It was also assumed that the tubewell irrigation systems would be operated on a rotational basis and, as power supply could be assured, the rotation period would be 7 or 14 days depending on the cropping pattern. Field turn-outs were to be provided for half acre or one acre plots and the farmers were expected to subdivide their plots into small irrigation basins. On level fields, at least two basins per acre were recommended for heavy soils, 4 to 9 basins for medium soils and up to 20 basins on coarse textured soils. The TA component was supposed to finalize the most appropriate operational principles for typical project wells. It was even contemplated that night storage reservoirs might be constructed to avoid the need for night irrigation.

3. Consultant's Work. The Consultant's Final Report was submitted in October 1988 before the first wells were electrified. It was therefore not possible for the Consultants to test and demonstrate their ideas on irrigation system and 'on-farm' water management, or to demonstrate their recommendations for land preparation. More importantly, planning and design assumptions (summarized in para 1 above) were never confirmed by site measurements or monitoring of operational wells. The Final Report simply re-stated (and expanded) the assumptions made at appraisal, again assuming (not measured) that system conveyance efficiency would be 60 per cent. The operational recommendations were analyzed theoretically by the Consultants who concluded that the systems could not be operated to respond to likely variations in the dominant design parameters, particularly those related to operational principles. Thus, the Consultants recommended that " the water delivery organization must be simple, assuring that each plot gets sufficient water for its crops." This would be achieved by rotation on a three or four weekly period with gross water application of not less than 4 inches. It is concluded that this recommended operation practice would result in a system efficiency substantially less than that assumed in the design. On the other hand, the irrigation requirements calculated for the project using Penman and an average seasonal cropping pattern are likely to be conservative for most farmers.

PCR Project Performance Evaluation

4. Irrigation Performance. The rate of build up of irrigated area is about that assumed at appraisal and as yet, with few exceptions, all tubewell systems are underutilized, enabling an 'on-demand' operation. The few tubewells with high irrigated crop intensity do appear to be managed on a rotational basis with the arrangement acceptable to (and manageable by) the water user

groups. There are large differences in performance of tubewells on the same electrical network (i.e. the same power supply) which cannot be explained, given that irrigation supplies are free at present. Under such circumstances, it would be expected that farmers would over-use the irrigation service, if for nothing else to reduce the risk on crops grown under rainfed conditions on part of their holdings 1/.

5. To evaluate farmer's response to the project, the irrigated area for all individual tubewells (on an electric network ring basis) was compared to the tubewell running hours (as measured from the solid state hour meter installed at each tubewell). For both the wet and dry seasons in 1990/91 and 1991/92, this enabled the hours of irrigation per unit area irrigated to be calculated (Tables 1 and 2 of this Annex). Since the wet season in 1990/91 was the first time that two of the four power network rings were operational , the analysis enabled the farmers' response to irrigation to be assessed over four sequential crop seasons for a large number of wells. For all tubewell systems, the equivalent hours to irrigate one acre (assuming a one cusec source) has substantially decreased over the two year period, until it is now about the magnitude assumed in the project design (i.e., about 4 to 8 inches per irrigation per unit area). This means that at present, farmers are irrigated reasonably efficiently since the average crop yields are about that assumed for irrigated crops at appraisal and compare favorably with other part of Myanmar. This may indicate that the tubewell irrigation systems are distributing water supplies at about the conveyance efficiency assumed at appraisal (or that system efficiency and irrigation use are both lower than expected).

6. As yet the ID and AC have not produced additional data to compare irrigation and agricultural performance. The data does indicate that farmers are making the recommended number of irrigations which means that on-farm water management practices are reasonable. It also indicates that most fields, presently being irrigated, must have been reasonably prepared for irrigation.

7. Agricultural Performance. The irrigated cropping patterns at the time of the PCR indicate that farmers are still risk adverse and reluctant to invest in what they perceive to be speculative crops requiring a high level of inputs (compared to rainfed agriculture). However, an encouraging sign is the substantial increase in irrigated area in 1992/93 which may reflect to greater incentives to farmers with the open market for all farm produce (detailed in Annex 1). One problem is that local authorities have not been able to stop farmers growing paddy which has high water demand. As demand for irrigation increases, the value (and scarcity) of water will increase and paddy will have to be banned. Introduction of water charges (in the near future) should encourage farmers to take into consideration the marginal value of water.

8. It is concluded that, even with some start-up problems still to be resolved, the project impact predicted at appraisal will be achieved at full development. However, there is a risk that farmers incentives may change in Myanmar. Consequently, this PCR makes conservative assumptions on the average impact of the project which, inter alia, take into account: (a) the variation in soil and water quality which have, as yet, not been fully evaluated; (b) average O&M of wells which can be expected with farmer management; and (c) the fact the most farmers are risk adverse and thus unlikely to maximize irrigated agricultural production.

1/. The consultant's report (confirmed by the PCR mission) that the maturity rate of rainfed crops is about 40% for early monsoon crops, some 80% for wheat and 90% for cotton. The main reason for failure is lack of moisture and pest damage.

MYANMAR

GROUNDWATER IRRIGATION I PROJECT

IRRIGATION PERFORMANCE

AREA IRRIGATED (acres) (1990-91 Wet Season)[1/]

Ring No.	Sesame			Paddy				Cotton			Greengram			Other Crops			Total Area Irrigated	IRRIGATION SERVICE			
																		Tubewell Running Hours		Hours of Irrigation per area irrigated	
	I	II	T	I	II	III	T	I	II	T	I	II	T	I	II	T		Actual[4/]	Equivalent one cusec hours[5/]	By well hours[6/]	Equivalent one cusec hours[7/]
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	362	147	509	37	32	-	69				(5)		5	(5)		5	583	10831	16120	18.6	27.7
3	(81)	(55)	136														136	2596	5192	19.1	38.2
4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	443	202	645	37	32		69				5		5	5		5	719	13427	21312	18.7	29.6

AREA IRRIGATED (acres) (1991-92 Wet Season)[1/]

Ring No.	Sesame			Paddy				Cotton			Greengram			Other Crops			Total Area Irrigated	IRRIGATION SERVICE			
																		Tubewell Running Hours		Hours of Irrigation per area irrigated	
	I	II	T	I	II	III	T	I	II	T	I	II	T	I	II	T		Actual[4/]	Equivalent one cusec hours[5/]	By well hours[6/]	Equivalent one cusec hours[7/]
1	(277)	(128)	405	(2)	(2)		4	(1)	(1)	2	(4)		4	(16)	(16)	32	447	4428	7025	10.0	15.7
2	424	176	600	256	249	96	601	(10)	(10)	20	(25)		25	(68)	(68)	136	1388	11087	17581	7.9	12.7
3	414	97	511	30	19		49	(81)	(80)	161	(44)		44	(203)	(203)	406	1171	6295	12405	5.4	10.6
4	340	81	421	35	34		69	(160)	(159)	319			-	(81)	(80)	161	970	9239	13795	9.5	14.2
Total	1455	482	1937	323	304	96	723	252	250	502	(73)		73	368	365	735	3976	31049	50806	7.8	12.8

1/ Wet season is taken as pre-monsoon (January to April) and monsoon (May to August).
2/ Numbers in brackets are assumed breakdown of total area irrigated to reflect likely number of irrigation of crops.
3/ I = first irrigation; II = second irrigation; III = third irrigation; T = total of area irrigated (i.e., I + II + II = T or I + II = T).
4/ Number of running hours of tubewells.
5/ Number of running hours of equivalent one cusec (i.e., two cusec tubewell counted double since two lateral are served at a time).
6/ Tubewell total running hours divided by area irrigated.
7/ Equivalent one cusec tubewell houring hours divided by area irrigated.

Annex 1
Table 1

MYANMAR

GROUNDWATER IRRIGATION I PROJECT

IRRIGATION PERFORMANCE

AREA IRRIGATED (acres) (1990-91 Dry Season)1/

Ring No.	Wheat I	Wheat II	Wheat T	Cotton I	Cotton II	Cotton T	Vegetables I	Vegetables II	Vegetables T	Other Crops I	Other Crops II	Other Crops T	Total Area Irrigated	IRRIGATION SERVICE: Tubewell Running Hours Actual4/	Tubewell Running Hours Equivalent one cusec hours5/	Hours of Irrigation per area irrigated By well hours6/	Hours of Irrigation per area irrigated Equivalent one cusec hours7/
1	(99)	(64)	163										163	1293	1921	7.9	11.8
2	1319	863	2182	(10)	(9)	19				(59)	(59)	118	2319	10371	16516	4.4	7.1
3	(578)	(379)	957							(375)	(374)	749	1706	10205	20372	6.0	11.9
4	(109)	(71)	180										180	2365	3085	13.1	17.1
Total	2105	1377	3482	(10)	(9)	19				434	433	867	4368	24234	41894	5.4	9.6

AREA IRRIGATED (acres) (1991-92 Dry Season)1/

Ring No.	Wheat I	Wheat II	Wheat T	Cotton I	Cotton II	Cotton T	Vegetables I	Vegetables II	Vegetables T	Other Crops I	Other Crops II	Other Crops T	Total Area Irrigated	IRRIGATION SERVICE: Tubewell Running Hours Actual4/	Tubewell Running Hours Equivalent one cusec hours5/	Hours of Irrigation per area irrigated By well hours6/	Hours of Irrigation per area irrigated Equivalent one cusec hours7/
1	(505)	(39)	544	(16)	(6)	22				(3)	(1)	4	570	1508	2644	2.6	4.6
2	911	76	998	13		13				(40)	(28)	68	1079	3872	6036	3.6	5.6
3	788	75	813	197	28	225				(77)	(30)	107	1145	2375	4529	2.0	4.0
4	346	47	393	114	8	122	(8)		8	(10)	(4)	14	537	2930	4280	5.5	7.8
Total	2550	188	2748	340	42	382	8		8			193	3331	10685	17489	3.2	5.2

1/ Dry season is taken as September to December.
2/ Number in brackets are assumed breakdown of total area irrigated to reflect likely number of irrigations of crops.
3/ I = First irrigation; II = Second irrigation; T = Total of area irrigated (i.e., I + II = T).
4/ Number of running hours of tubewells.
5/ Number of running hours of equivalent one cusec (i.e., two cusec tubewell counted double since two laterals are served at a time).
6/ Tubewell total running hours divided by area irrigated.
7/ Equivalent one cusec tubewell running hours divided by area irrigated.

Annex 1
Table 2

PROJECT COMPLETION REPORT

MYANMAR

GROUNDWATER IRRIGATION PROJECT I

CREDIT 1381 - BA

Details of PCR Financial and Economic Results

1. Background. The project impact predicted at appraisal assumed an increase in agricultural production and farm incomes through irrigation where no other economical water source would be available. It was implicitly assumed that, under the project, farmers would substantially increase their use of agricultural inputs and also go for higher return (but greater risk) crops. The cropping pattern would be 'controlled' crops - including cotton, wheat and mung beans- which would be procured by Government at below the crop export or import prices.

2. It was also assumed that some 6,000 families would benefit from the project, each with a holding of about 10 acres of which some 3 acres would be irrigated and 7 acres rainfed. In this respect, the appraisal analysis assumed that all farmers would have similar size and type of holdings. Thus, it was assumed that: (a) the project would directly impact on some 66,700 acres (i.e., about 20,000 irrigated acres to served by the new and existing wells and a surrounding rainfed area of some 46,700 acres); and (b) farmers would devote less time to their rainfed area once the irrigation service was provided and thus there would be a small loss of rainfed production to be offset against the increase in irrigated agricultural production.

3. In addition, the appraisal analysis assumed that 2,150 acres were being (fully) irrigated from the 25 existing diesel tubewells with a cropping intensity of some 120 percent. The main change in farming practice in this existing irrigated area would be a substitution of irrigated mugbeans for irrigated sesame on some 30 percent of the tubewell command areas. It was also assumed that about 10 percent of the cultivable (rainfed) land would be used as right-of-way for irrigation infrastructure and thus go out of production after the project works were completed.

4. PCR Findings. Most of the socio-economic assumptions at appraisal (summarized above) were not based on field surveys, but appear to simply repeat the analysis assumptions used in the 'pilot phase' feasibility report. Subsequent project supervision reports indicate that the existing wells never provided a reliable irrigation service because of unpredictable fuel shortages and crop yields were much lower than predicted because of shortages of other agricultural inputs. Furthermore, agricultural production data collected through the project period (up to about 1990) has been at best indicative, with considerable unexplainable variations in yields between wells and was substantially less than that reported at appraisal. The performance records do show that farmers tried (encouraged by the project) but never adopted mugbeans as an irrigated crop because of the low financial returns. The various appraisal assumptions on land use and farmers' response under the 'present' situation have not been confirmed by data collected during implementation.

5. The PCR analysis has therefore been based on 'actual' performance data as recorded by the ID and AC (mainly during the period 1990 to 1993). One problem, as yet unresolved, is the lack of reliable performance data because project monitoring has not been carefully designed to measure all variables affecting irrigated agricultural impact. Thus, variations in crop production cannot be compared to the quality and quantity of irrigation service. It is not possible to predict whether the irrigation service could limit the project impact.

6. The PCR analysis has assumed that the operational wells (some 7 percent of the wells have technical problems) will continue to perform as designed with the area irrigated and the

irrigation intensity building up to full development level over a five year period (i.e., about 1998/99) as farmers incentives exceed the risks of changing from rainfed to irrigated agriculture. As would be expected given the risks involved, farmers will make the transition from rainfed to (high value) irrigated agriculture cautiously.

Results

7. Impact at Full Development. The project agricultural impact at full development still cannot be estimated with certainty since the last wells were energized early in 1991 and farmers' response to irrigation is changing rapidly due to the new incentives created by free crop markets. In addition, farmers are not yet being charged for water and thus it is not possible with certainty to assess how they will react once water ceases to be a free in terms of use of irrigation and crops grown.

9. Financial Impact. Table 2 of this Annex indicates that the 'free market' crop prices should continue to provide a strong incentive to farmers to maximize production, reflecting the rapid expansion in irrigated area since 1991. The net income should also enable farmers to purchase the full package of inputs necessary to optimize crop production (i.e., the level of inputs assumed in the PCR analysis).

10. Economic Impact. Table 3 of this Annex details the cost and benefit stream assumptions used in calculating the ERR and NPV for the PCR. Five cases were considered reflecting a range of assumptions on future O&M costs and the level and rate of build up of benefits. The base case (Case A of Table 3) gives an ERR of about 8 percent and assumes that the caution shown by farmers up to now will continue into the future. However, Case A is considered to be overly conservative since it assumes that: (a) the irrigation intensity at full development will only reach about 140 percent compared to 150 percent predicted at appraisal; (b) some 7 percent of the tubewells will continue to be non-operational because of poor water quality and soils, or for technical reasons; and (c) farmers will continue to put about 40 percent of the irrigated area to irrigated sesame, giving low returns at low risk.

9. Sensitivity Analysis. A sensitivity analysis was undertaken to test what would happen if farmers reacted to the project irrigation service is a less conservative way. These tests show that the project is not very sensitive to either variations in future O&M costs or moderate (but achievable) increases in benefits. Three tests (Cases C, D and E) were designed to more fully reflect the farmers' response to recent incentives created by the 'free market' for agricultural produce which should encourage farmers to more fully utilize the irrigation service. Under these circumstances, the most likely future scenario would be Case C, giving an ERR of about 10 percent. This case assume that farmers will: (a) substantially decrease their area to irrigated sesame with a corresponding increase the area to irrigated wheat; and (b) also reduce the amount of irrigation provided (once water charges are introduced) to less than that assumed at appraisal (and used to estimate the base case O&M costs). Not tested but technically possible, is the assumption that the project irrigated command area can be increased by expanding the irrigated commands of individual tubewells beyond that fixed at the design stage. This has happened on some tubewells and if repeated through the project area, it is estimated that the total project irrigated command area could expanded by at least 10 percent without any detrimental effect on the existing irrigated area. This action, if taken over the next five years, would increase the ERR by a further two percentage points.

Annex 2
Table 1

PROJECT COMPLETION REPORT

MYANMAR

GROUNDWATER IRRIGATION PROJECT 1

1990 Financial and Economic Prices

	Unit	Financial Prices				Economic Prices	
		Weight (lb)	K/Unit	K/long ton	K/lb	K/long ton	K/lb
Crop							
Paddy	Basket	46.0	64.29	3,131	1.4	3,793	1.7
Wheat	Basket	72.0	147.3	4,583	2.0	1529	0.68
Cotton	Viss	3.6	10.00	6,222	2.8	5,605	2.5
Chillies (Dry)	Viss	3.6	40.29	25,070	11.2	12,535	5.6
Sesame	Basket	54.0	313.18	12,991	5.84	4,047	1.8
Pulses	Basket	69.0	240.00	7,792	3.5	3,892	1.7
Onion	Viss	3.6	8.66	5,389	2.4	2,695	1.2
Groundnut	Basket	25.0	108.64	9,734	4.4	2,829	1.3
Fertilizers							
Urea	Ton			2,160	0.96	1,568	0.70
TSP	Ton			1,900	0.85	1,605	0.72
Potash	Ton			1,000	0.45	1,350	0.60
Manure (Kyat/load)			40.00				8.00
Other Inputs							
Seeds 1/							
Paddy	Basket	46.0	100.00	4,870	2.2		2.00
Cotton	Viss	3.6	10.00	6,222	2.8		3.00
Chillies	Viss	3.6	50.00	31,111	13.9		6.70
Sesame	Basket	54.0	350.00	14,519	6.5		2.20
Pulses	Basket	69.0	250.00	8,115	3.6		2.00
Onion	Viss	3.6	10.00	6,222	2.8		1.50
Groundnut	Basket	25.0	120.00	10,752	4.8		1.50
Wheat	Basket	72.0	177.0	5500	2.5		0.08
Labor							
Human Labor (Kyat/day		18.0					3.6
Animal Labor (Kyat/day)		45.0					9.0

1/ Seed prices have a 20% premium in economic analysis.

PROJECT COMPLETION REPORT

MYANMAR

GROUNDWATER IRRIGATION PROJECT I

Financial Farm Budgets at Full Development a/ b/

Ref.	Item	Unit	Amount	Irrigated Crops								Rainfed Crops									Total
				Paddy	Cotton	Chillies	Sesame	Pulses	Onions	Ground-nut	Wheat	Local Paddy	Cotton	Chillies	Sesame	Pulses	Onions	Ground-nut	Rainfed Wheat	Irrigated Wheat	
	Yield	ton/acre		1.51	0.69	0.15	0.16	0.31	2.72	1.29	1.50	0.62	0.19	0.13	0.05	0.17	2.07	0 72	0.30	0.60	
	Production	tons		1.51	0.69	0.15	0.16	0.31	2.72	1.29	1.50	0.62	0.19	0.13	0.05	0.17	2.07	0.72	0.30	0.60	
	Price	Kyat		3131	6222	25070	12991	7792	5389	9734	4583	3131	6222	25070	12991	7792	5389	9734	4583	4583	
	Gross Value	**Kyat**		**4728**	**4293**	**3761**	**2079**	**2416**	**14658**	**12557**	**6875**	**1941**	**1182**	**3259**	**650**	**1325**	**11155**	**7008**	**1375**	**2750**	
	Costs	Kyat		1973	2054	2389	1225	1061	1902	2769	1675	1786	1088	1792	545	886	1921	2322	1158	1374	
	Net Income	**Kyat**		**2755**	**2239**	**1371**	**853**	**1354**	**12756**	**9788**	**5200**	**156**	**94**	**1467**	**105**	**439**	**9234**	**4687**	**217**	**1376**	
	Cropped Area	Acre		2332	1779	444	11360	357	444	774	11610		280	90	2070	310	90		460		
	With Project																				
	Irrigated Area	Acre	29000																		
	Cropped Area	Acre	20700																		
	C.I.	%	140.1	3267	2492	622	15915	500	622	1084	16265										
	Rainfed Area	Acre	3500																		
	Cropped Area	Acre	20700																		
	Cropping Intensity	%	16.9									0	47	15	350	52	15	0	78	0	
	5Ha Farm			0.79	0.60	0.15	3.84	0.12	0.15	0.26	3.93	0.00	0.01	0.00	0.08	0.01	0.00	0.00	0.02	0.00	
	Adjusted C.P.			0.79	0.60	0.15	3.84	0.12	0.15	0.26	3.93				1.02						
	Farm Income	**Kyats**		**2174**	**1348**	**206**	**3280**	**164**	**1917**	**2564**	**20428**	**0**	**0**	**0**	**107**	**0**	**0**	**0**	**0**	**0**	32187
	Without Project																				
	Rainfed Area	Acre	20700																		
	Cropped Area	Acre	20700																		
	Cropping Intensity	%	100.0									0	1656	532	12243	1833	532	0	2721	0	
	5Ha Farm			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.13	2.96	0.44	0.13	0.00	0.66	0.00	
	Adjusted C.P.																				
	Farm Income	**Kyats**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	38	189	311	194	1187	**0**	143	**0**	2061

a/ See Annex I, Table 1 for financial prices and assumptions.
b/ For a typical 5 ha. irrigated farm.

PROJECT COMPLETION REPORT

MYANMAR

GROUNDWATER IRRIGATION PROJECT I

Project ERR and NPV a/

Year	Case A					Case B					Case C					Case D					Case E				
	Costs	Net Benefits	Benefit Stream	ERR	NPV	Costs	Net Benefits	Benefit Stream	ERR	NPV	Costs	Incr Benefits	Benefit Stream	ERR	NPV	Costs	Incr Benefits	Benefit Stream	ERR	NPV	Costs	Incr Benefits	Benefit Stream	ERR	NPV
	$ M	$ M	$ M	%	$ M	$ M	$ M	$ M	%	$ M	$ M	$ M	$ M	%	$ M	$ M	$ M	$ M	%	$ M	$ M	$ M	$ M	%	$ M
1983	0.89	-0.39	-1.28	0.08	-20.42	0.89	0.00	-0.89	0.09	-13.02	0.89	0.00	-0.89	0.095	-0.21	0.89	0.00	-0.89	0.099	7.01	0.9	0.00	-0.89	0.110	25.96
1984	12.45	-0.24	-12.69			12.45	0.00	-12.45			12.45	0.00	-12.45			12.45	0.00	-12.45			12.5	0.65	-11.80		
1985	43.62	0.40	-43.22			43.62	0.65	-42.97			43.62	0.65	-42.97			43.62	0.65	-42.97			43.6	1.83	-41.79		
1986	41.34	1.57	-39.77			41.34	1.83	-39.51			41.34	1.83	-39.51			41.34	1.83	-39.51			41.3	1.76	-39.58		
1987	39.07	1.51	-37.56			39.07	1.76	-37.31			39.07	1.76	-37.31			39.07	1.76	-37.31			39.1	1.94	-37.13		
1988	30.59	1.54	-29.05			30.59	1.94	-28.65			29.59	1.94	-27.65			29.59	1.94	-27.65			29.6	1.86	-27.73		
1989	31.09	1.86	-29.23			31.09	1.86	-29.23			30.09	1.86	-28.23			30.09	1.86	-28.23			30.1	2.58	-27.51		
1990	16.35	2.58	-13.77			16.35	2.58	-13.77			15.35	2.58	-12.77			15.35	2.58	-12.77			15.4	4.77	-10.58		
1991	7.50	4.77	-2.73			7.50	4.77	-2.73			6.5	4.77	-1.73			6.5	4.77	-1.73			6.5	16.31	9.81		
1992	9.42	16.31	6.89			9.42	16.31	6.89			8.42	16.31	7.89			8.42	16.31	7.89			8.4	23.02	14.60		
1993	6.00	23.02	17.02			5.00	23.02	17.02			5.00	23.02	18.02			5.00	23.02	18.02			4.0	27.05	23.05		
1994	6.20	27.05	20.85			5.00	27.05	20.85			5.00	27.05	22.05			5.00	27.05	22.05			4.2	35.71	31.51		
1995	6.30	32.46	26.16			5.10	34.08	27.78			5.10	35.71	30.61			5.10	35.71	30.61			4.3	37.49	33.19		
1996	6.40	36.63	30.23			5.10	38.46	32.06			5.10	40.29	35.19			5.10	40.29	35.19			4.5	45.50	41.00		
1997	8.80	38.64	29.84			7.80	40.57	31.77			7.80	42.50	34.70			7.80	45.50	37.70			7.8	46.60	38.80		
1998	8.80	38.54	29.74			7.80	40.47	31.67			7.80	42.39	34.59			7.80	46.60	38.80			7.8	47.60	39.80		
1999	8.80	38.87	30.07			7.80	40.81	32.01			7.80	42.76	34.96			7.80	47.60	39.80			7.8	48.60	40.80		
2000	8.80	40.27	31.47			7.80	42.28	33.48			7.80	44.30	36.50			7.80	48.60	40.80			7.8	48.60	40.80		
2001	6.4	41.27	34.87			5.2	43.33	36.93			5.2	45.40	40.20			5.2	48.60	43.40			5.0	48.60	43.60		
2002	6.4	41.77	35.37			5.2	43.86	37.46			5.2	45.95	40.75			5.2	48.60	43.40			5.1	48.60	43.50		
2003	6.4	42.27	35.87			5.2	44.38	37.98			5.2	46.50	41.30			5.2	48.60	43.40			5.2	48.60	43.40		
2004	6.4	42.27	35.87			5.2	44.38	37.98			5.2	46.50	41.30			5.2	48.60	43.40			5.2	48.60	43.40		
2005	6.4	42.27	35.87			5.2	44.38	37.98			5.2	46.50	41.30			5.2	48.60	43.40			5.2	48.60	43.40		
2006	6.4	42.27	35.87			5.2	44.38	37.98			5.2	46.50	41.30			5.2	48.60	43.40			5.2	48.60	43.40		
2007	6.4	42.27	35.87			5.2	44.38	37.98			5.2	46.50	41.30			5.2	48.60	43.40			5.2	48.60	43.40		
2008	6.4	42.27	35.87			5.2	44.38	37.98			5.2	46.50	41.30			5.2	48.60	43.40			5.2	48.60	43.40		
2009	6.4	42.27	35.87			5.2	44.38	37.98			5.2	46.50	41.30			5.2	48.60	43.40			5.2	48.60	43.40		
2010	6.4	42.27	35.87			5.2	44.38	37.98			5.2	46.50	41.30			5.2	48.60	43.40			5.2	48.60	43.40		
2011	6.4	42.27	35.87			5.2	44.38	37.98			5.2	46.50	41.30			5.2	48.60	43.40			5.2	48.60	43.40		
2012	6.4	42.27	35.87			5.2	44.38	37.98			5.2	46.50	41.30			5.2	48.60	43.40			5.2	48.60	43.40		
2013	6.4	42.27	35.87			5.2	44.38	37.98			5.2	46.50	41.30			5.2	48.60	43.40			5.2	48.60	43.40		
2014	6.4	42.27	35.87			5.2	44.38	37.98			5.2	46.50	41.30			5.2	48.60	43.40			5.2	48.60	43.40		
2015	6.4	42.27	35.87			5.2	44.38	37.98			5.2	46.50	41.30			5.2	48.60	43.40			5.2	48.60	43.40		
2016 on	6.4	42.27	35.87			5.2	44.38	37.98			5.2	46.50	41.30			5.2	48.60	43.40			5.2	48.60	43.40		

Case A: Base Case

Case B: 5 percent increase in benefit stream (increase in yields); 20 percent reduction in O&M costs to reflect actual lower irrigation rates.

Case C: 10 percent increase in benefit stream (decrease in area to sesame and increase in wheat - higher income crop); 20 percent reduction in O&M costs.

Case D: 15 percent increase in benefit stream (decrease in area to sesame and increase in wheat - higher income crop); 20 percent reduction in O&M costs.

Case E: As in Case D above, but full benefits achieved one year earlier.

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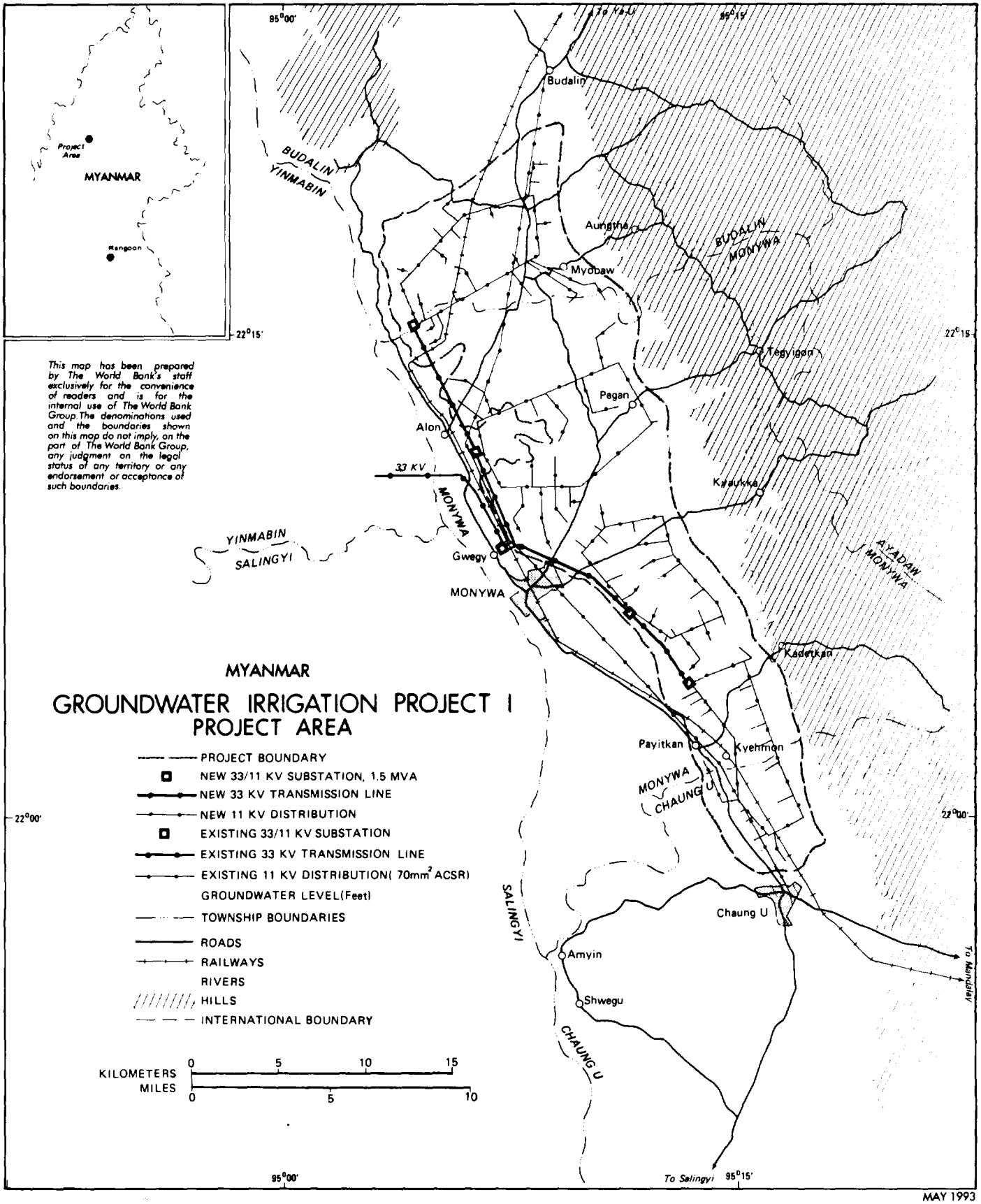

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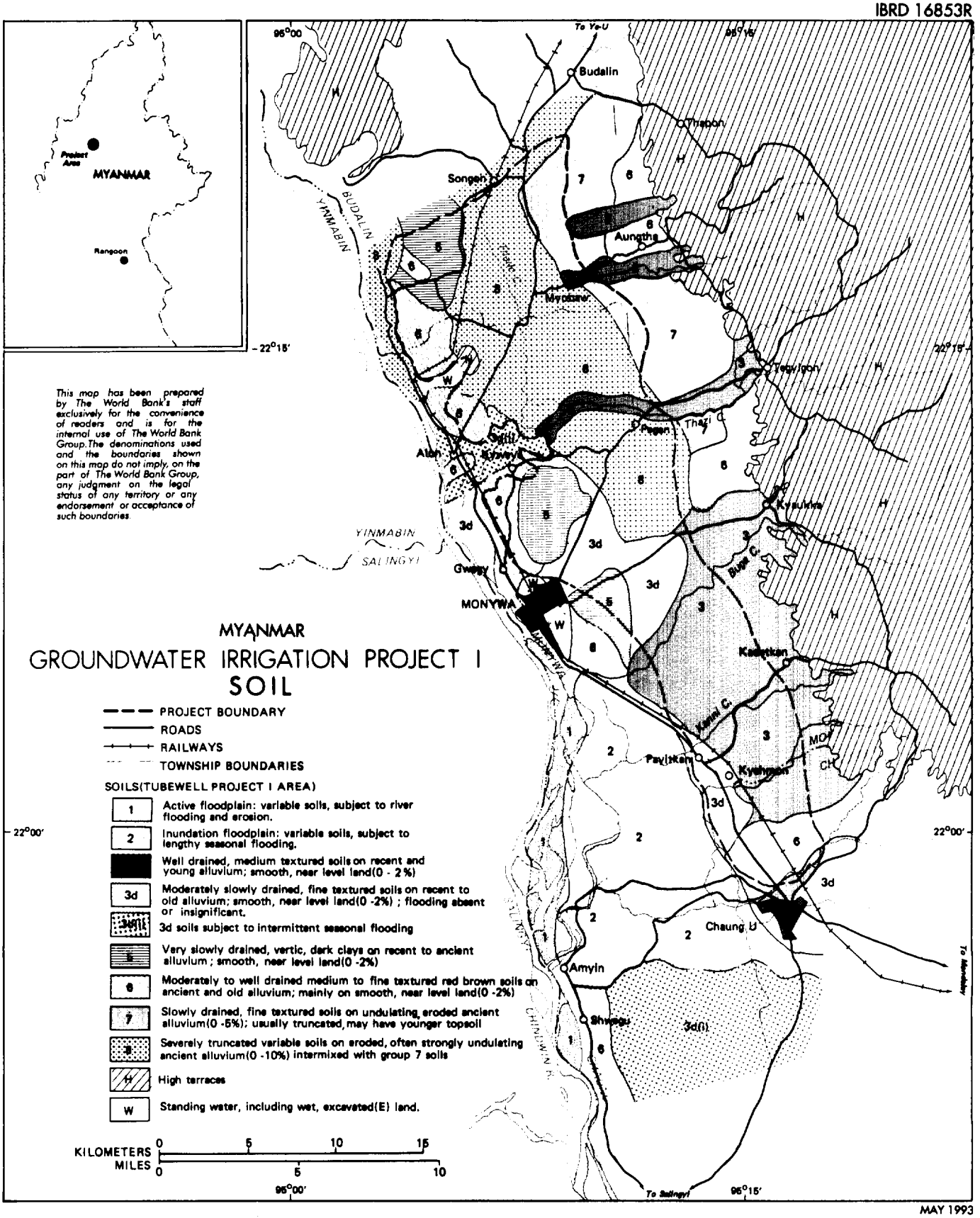

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MYANMAR
GROUNDWATER IRRIGATION PROJECT I
SOIL

PROJECT BOUNDARY
ROADS
RAILWAYS
TOWNSHIP BOUNDARIES

SOILS(TUBEWELL PROJECT I AREA)

1	Active floodplain: variable soils, subject to river flooding and erosion.
2	Inundation floodplain: variable soils, subject to lengthy seasonal flooding.
	Well drained, medium textured soils on recent and young alluvium; smooth, near level land(0 - 2%)
3d	Moderately slowly drained, fine textured soils on recent to old alluvium; smooth, near level land(0 -2%) ; flooding absent or insignificant.
3d(i)	3d soils subject to intermittent seasonal flooding
5	Very slowly drained, vertic, dark clays on recent to ancient alluvium ; smooth, near level land(0 -2%)
6	Moderately to well drained medium to fine textured red brown soils on ancient and old alluvium; mainly on smooth, near level land(0 -2%)
7	Slowly drained, fine textured soils on undulating, eroded ancient alluvium(0 -5%); usually truncated, may have younger topsoil
8	Severely truncated variable soils on eroded, often strongly undulating ancient alluvium(0 -10%) intermixed with group 7 soils
H	High terraces
W	Standing water, including wet, excavated(E) land.

KILOMETERS 0 5 10 15
MILES 0 5 10

MAY 1993