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**Report No.** 9980

PROJECT COMPLETION REPORT

INDIA

MAHANADI BARRAGES PROJET
(CREDIT 1078-IN)

OCTOBER 7, 1991

Agricluture Operations Division
India Department
Asia Regional Office

## CURRENCY EQUIVALENT

Name of Currency: Rupee (Rs.)

| Rate of Exchange: | | | |
|---|---|---|---|
| | Appraisal (July 1980) | US$ 1.00 | = Rs. 8.40 |
| | Intervening years (average) | US$ 1.00 | = Rs.12.25 |
| | Completion year | US$ 1.00 | = Rs.15.50 |

Fiscal Year of Borrower: GOI and GOO: April 1 to March 31
Weights and Measures: Metric System

## GLOSSARY

| | | |
|---|---|---|
| Anicut | - | Diversion weir |
| Chak | - | Watercourse Cultivable Command Area |
| cm | - | centimeters |
| cumecs | - | cubic meters per second |
| kg | - | kilogram |
| $kg/cm^2$ | - | kilogram per square centimeter |
| Kharif | - | Wet season: June-October |
| m | - | meters |
| mm | - | millimeters |
| Rabi | - | Dry season: November - April |
| $t/m^2$ | - | tons per square meter |
| Watercourse | - | Small channel below outlet serving a chak |
| Warabandi | - | A rotational water supply system (RWS) of allocating water along farmers by fixed turns and time periods; flow rate is constant, and time periods are proportional to land holding size. |

## ABBREVIATIONS

| | | |
|---|---|---|
| CWC | - | Central Water Commission |
| CWPRS | - | Central Water and Power Research Station (at Pune) |
| DMP | - | Drainage Master Plan |
| ERR | - | Economic Rate of Return |
| GOO | - | Government of Orissa |
| GOI | - | Government of India |
| IPD | - | Irrigation and Power Department (within GOO) |
| NDP | - | Net Domestic Product |
| O&M | - | Operation and Maintenance |
| PCR | - | Project Completion Report |
| RL | - | Reservoir Level |
| RWS | - | Rotational Water Supply |

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

Office of Director-General
Operations Evaluation

October 7, 1991

MEMORANDUM TO THE EXECUTIVE DIRECTORS AND THE PRESIDENT

SUBJECT: Project Completion Report on India
Mahanadi Barrages Project (Credit 1078-IN)

Attached, for information, is a copy of a report entitled "Project Completion Report on India - Mahanadi Barrages Project (Credit 1078-IN)" prepared by the Asia Regional Office with Part II of the report contributed by the Borrower. No audit of this project has been made by the Operations Evaluation Department at this time.

Attachment

# PROJECT COMPLETION REPORT

## INDIA

## MAHANADI BARRAGES PROJECT
## (Credit 1078-IN)

### Table of Contents

# PROJECT COMPLETION REPORT

## INDIA

## MAHANADI BARRAGES PROJECT
## (Credit 1078-IN)

## PREFACE

This is the Project Completion Report (PCR) for Mahanadi Barrages Project in the State of Orissa, India, for which Credit 1078-IN in the amount of SDR 63.3 million (US$83 million) was approved on December 2, 1980. The Credit closed on March 31, 1989, two years behind schedule, and by September 8, 1989 the Credit was fully disbursed.

The PCR was prepared by the New Delhi Agriculture Unit of the Agriculture Operations Division of the India Department, Asia Regional Office (Preface, Evaluation Summary, Parts I and III), and the Borrower (Part II).

Preparation of this PCR was initiated during the Bank's final supervision mission of the project in December 1988, and is based, inter alia, on the Staff Appraisal Report, the Legal Documents, supervision reports, correspondence between the Bank and the Borrower, and internal Bank memoranda.

# PROJECT COMPLETION REPORT

## INDIA

## MAHANADI BARRAGES PROJECT
(Credit 1078-IN)

### Evaluation Summary

#### Objectives

1. The main objective of the project was to construct new barrages in place of the existing weirs in order to ensure continuity of the irrigation system in the old delta and to create the necessary conditions for improvements in the water distribution system and for increased production.

#### Implementation Experience

2. The project made a promising start and attained reasonably good progress on civil works. However, the momentum slowed down soon thereafter and persisted throughout, particularly on the construction of right under-sluice bays, right head regulator, and divide walls of Mahanadi Barrage. The reasons contributing to slippages and shortfalls are listed in para 11, Part I. Unreliable performance of the construction agencies also constituted a major bottleneck. The critical works remained more or less bogged down during the 1985 to 1987 working seasons requiring two one-year extensions of closing date from March 31, 1987 to March 31, 1989. Generally, late rains and consequent flooding in the river during the month of November also delayed the resumption of works. The speed of construction on the critical components of Mahanadi Barrage Complex picked up significantly from May 1988 after a new construction agency was appointed by the Government of Orissa (GOO) along with the deployment of additional financial and equipment inputs. The erection of gates was also accelerated by utilization of a 90-ton capacity crane made available by GOO. The Credit of US$83 million was fully disbursed by September 8, 1990.

#### Results

3. Notwithstanding an implementation delay of over two years, the new Mahanadi and Birupa barrages were successfully constructed without the failure of the existing old weirs during the construction period. The principal objective of the project in ensuring the continuity of irrigation of 167,000 ha in the Delta was thus fulfilled. In addition, another objective of saving 30 to 40 cumecs water (which would have been lost from leakages through the shutters of old weirs) for irrigation purposes had also been achieved through the completion of new barrages fitted with the state-of-the-art gates and related operating equipment (para 19, Part I).

4. The analysis shown in Table 6B of Part III reflects the Economic Rate of Return (ERR) for the project as 14.1% and 15.6% under the existing irrigation conditions and improved irrigation standards, respectively. This compares to 21.0% and 41.0% at appraisal. The general shortfall in ERR compared to that evaluated at appraisal was due to: (i) project cost escalation; (ii) decline in world market price for rice; and (iii) delay in accrual of benefits. Because of incomplete implementation, an important objective of the study envisaged at appraisal to introduce warabandi type rotational water supply (RWS) (mainly during rabi) to improve the equity and reliability of

water supply, has not been fulfilled. Accordingly. as brought out in para 13, Part I, GOO will have to make sustained efforts over the next 3 to 4 years to attain this project objective.

5. Preparation of a Master Plan for Drainage and Flood Control (DMP) is a notable achievement of the project, particularly so in the context of immensity and complexity of the task.

Sustainability

6. With a good Operation and Maintenance (O&M) back-up system, there is no doubt that the project, incorporating updated designs, provision of under-sluice bays, and state-of-the-art gates, will be sustainable over the normally accepted long-range life expectancy for projects of this type.

Findings and Lessons Learnt

7. The Bank's technical advice during project implementation had a positive impact on the project, including valuable guidance provided to GOO in the preparation of DMP. However, there were a number of deficiencies and lessons to be learnt for future projects. These have been highlighted in paras 9 and 10 (a) and (b), Part I. The 5-year implementation period estimated at appraisal was far too optimistic, particularly so when, during appraisal, no serious thought was given to the need to specify mechanized construction methodologies and corollary support, including a full range of matching state-of-the-art equipment. Construction methods outlined in the Staff Appraisal Report were too sketchy and tended to favor labor-intensive techniques. This was not conducive to achievements of optimum progress and high quality construction. Furthermore, the implementation schedule should have provided at least one working season for geological exploration, mapping foundation profiles, and data collection needed by the Central Water Commission (CWC) to complete design. Another major finding relates to the enforcement of contract provisions by GOO. As is common on most Indian projects, contract provisions are seldom strictly enforced, and there is a general hesitation in terminating contracts despite continuous slow progress. Such delays also occurred on this project, though the situation was substantially improved towards the end by terminating the contractor engaged in the critical works of Mahanadi Barrage. GOO should have scheduled period-wise milestones, and in the event of failure of any construction agency in achieving those, the contract should have been terminated promptly and a new agency appointed.

# PROJECT COMPLETION REPORT

# INDIA

# MAHANADI BARRAGES PROJECT
# (Credit 1078-IN)

## PART I: PROJECT REVIEW FROM BANK'S PERSPECTIVE

### Project Identity

| | | |
|---|---|---|
| Project Name | : | Mahanadi Barrages Project |
| Credit No. | : | 1078-IN |
| RVP Unit | : | Asia |
| Country | : | India |
| Sector | : | Agriculture |
| Subsector | : | Irrigation |

### Background

1. The State of Orissa, located in eastern India, had a population of about 26 million in 1980. Predominantly rural (92%), some 39% of the population belonged to scheduled tribes and backward classes, the highest in India. Though rich in forest and mineral resources, the average per capita income in the State was among the lowest in India.

2. The agriculture sector provided employment to 79% of the working population and accounted for 69% of Net Domestic Product (NDP). Being highly vulnerable to weather that typically varies from the extremes of severe floods and droughts, the economic growth lagged behind the rest of India. Between 1960/61 and 1977/78, the NDP grew at an annual rate of 2.3% compared with an all-India figure of 3%.

3. Development of the canal systems in the Mahanadi Delta started in the 1860's with the construction of weirs on the Mahanadi, Birupa and Kathjori rivers, and included three main canals and related distribution systems. Irrigation was limited to kharif season and covered about 80,000 ha under the old delta system. Construction of the Hirakud Dam upstream on Mahanadi river was undertaken and completed in 1957 which helped in increasing the cultivable command area in the old Delta to 167,000 ha and allowed the introduction of rabi irrigation as well.

4. The condition of weirs on Mahanadi river and its Birupa branch had deteriorated over the period since their construction in 1863 and 1868, respectively. Frequent damage by heavy floods and extensive scouring of downstream protective aprons continued to cause weakening of these structures. A critical stage of deterioration had been reached which threatened a major breach of the weirs with the consequence of reverting the entire project area back to rainfed conditions.

Project Objectives and Description

5. The principal objectives of the project were:

(a) To finance over five years, the construction of two new barrages in place of the existing weirs and replacement of the existing three head regulators, in order to:

(i) ensure continuity of the irrigation system in the 167,000 ha being already irrigated;

(ii) save the estimated 30 to 40 $m^3$/sec of water losses, resulting from excessive seepage underneath and through the crest and sluice shutters of the old weirs, and use this reclaimed water for irrigating 16,700 ha during the rabi season;

(iii) prevent accumulation of silt through the provision of under-sluice bays in the new barrages; and

(iv) create necessary conditions for improvements in the water distribution and drainage system as needed for increased production.

(b) To finance the preparation of a Master Plan for Drainage and Flood Control (DMP) for the whole Mahanadi delta area (about 300,000 ha) covering the main and intermediate level drainage systems.

(c) To finance a program of water management pilot operations to include construction of water courses and field drains and introduction of RWS over an area of about 1000 ha in order to update and improve the water management.

6. Project physical indicators are given in Table 4 and project cost estimates in Table 5A, Part III. Project cost estimate at appraisal was Rs.926.5 million(US$ 110.3 million). An IDA Credit of SDR 63.3 million (US$ 83 million) to finance about 75% of the total project cost was signed on December 5, 1980 and was effective on February 11, 1981. Closing was scheduled for March 31, 1987. Two one-year extensions were subsequently approved. Financing details are shown in Table 5B, Part III, which indicate the actual cost of the project as Rs.1135.78 million at project closing (March 1989). Table 6D lists a number of studies financed under the project.

Project Design and Organization

7. The appraisal was fairly thorough and covered all the key features and requirements for rehabilitating existing weirs, site selection of new barrages, foundation investigations, and structural design aspects, including contingencies. It also covered institutional aspects in general, including quality control, and O&M criteria and procedures. Throughout preparation and appraisal, GOO gave full cooperation and support.

8. The project was to be executed entirely by the Irrigation and Power Department (IPD) of Orissa, under the Chief Engineer, Irrigation. Designs of the Mahanadi and Birupa barrages, except the prestressed concrete bridge component of Mahanadi barrage, were the responsibility of the CWC who was required to conduct periodic inspections to ensure that the work was carried out in accordance with its designs and specifications. GOO's Command Area Development Department was responsible for the water management program. IPD was responsible for improving the main

conveyance and drainage systems serving the pilot water management area as well as for the preparation of the drainage master plan (DMP).

9. A notable deficiency pertains to shortcomings in the framing of the construction method outlined in the Staff Appraisal Report. Since construction of Mahanadi Barrage and related head regulators was the biggest component of the project, constituting about 70% of the total cost, the report should have emphasized to a much greater extent the critically important plant and equipment planning needed to obtain optimum progress and high quality construction. The acceptance of manual placement of concrete did not conform to good construction practice either quantitatively or qualitatively for such a large and important barrage. The report also mentions that 'if necessary, buckets operated by crane can be used for placing the concrete', but mechanization of concrete delivery and placement should have been mandatory. The methodology prescribed in the report of handling of concrete encourages aggregate segregation and often results in a porous concrete. In retrospect, concrete delivery from batching plant by transit concrete mixers and placement by long boom cranes with skip/bucket combinations should have been suggested and outlined in the report. In addition, deployment of hydraulic pumpcrete machines and beltcrete system should have been included. The construction methods outlined in the report were too sketchy to adequately cover the job requirements. They do not cover formwork, height of lifts, treatment of construction joints etc. as would have been needed to guide efficient implementation. The report also made no mention of the methodology and equipment needed for dismantling massive ancient structure. It is clear that slippage was due to inadequate construction and equipment planning at appraisal.

10. The description and specification of each project component as provided in the Staff Appraisal Report are generally adequate. Viewed in retrospect, the analysis and optimal timing depicted in the report for initiating construction of two barrages starting in 1980/81 has proven to be realistic. In addition, the emergency plan to repair any breach caused by the failure of either of the existing weirs during flood seasons and during the construction of new barrages, had been well conceived in the report, as well as the broad methodology for accomplishing repairs and the carrying out of functions of the responsible engineers. However, the five-year implementation schedule for the completion of Mahanadi Barrage was too optimistic. The characteristics of actual foundation material which were required to complete designs were not fully provided. The preliminary design, based on only 18 foundation borings as evolved by CWC was vulnerable to substantial changes upon actual excavation of the foundations. Accordingly, the critical path schedule in the Staff Appraisal Report should have provided at least one initial working season for completion of geological exploration, foundation profiles including field work and data collection .

Project Implementation

11. GOO at the very outset made encouraging efforts to address the start-up problems. Construction on Birupa barrage made a promising start and proceeded at a good pace for a couple of years, exceeding the physical targets agreed at appraisal but slipped thereafter. However, the Mahanadi barrage complex not only experienced a delayed start but continued to experience shortfalls througnout project implementation particularly on the construction of right under-sluice bays, right head regulator and divide walls due to unreliable performance of the construction agencies. These works remained more or less bogged down during the 1985 to 1987 working seasons. Late rains and consequent flooding in the river during the month of November also delayed resumption of works. Generally, the implementation delays were due to the following reasons:

a) Clay strata was unexpectedly encountered during excavation of foundations which necessitated the review of CWC's earlier designs;

b) Site investigations involved a time-consuming process and GOO had to entrust the work of preparing the foundation profile of barrage bays 49 to 68 to a consultancy firm, and until the receipt of the final profile, completion of the designs by CWC for the barrage floor and piers in these bays was held up. The implementation schedule had not made any specific provision for this activity;

c) Poor management and operational performance of the original construction agency in the mobilization of labor and the required skills/trades, as well as the deployment of needed equipment ;

d) Poor mobilization, inadequate equipment deployment and unsatisfactory by the replacement construction agency;

e) Serious power shortages in the State resulting in frequent disruption of work requiring power supplies at the construction site;

f) Work by the contractor was limited mostly to the day shift instead of mobilizing the crew and organizing work on a round-the-clock basis; and

g) Financial limitations constrained progress more frequently than should have been necessary.

As a result of the above factors, the implementation schedule for the Mahanadi Barrage component was revised a number of times by the Project Management, necessitating two one-year extensions of the Credit Closing Date to March 31, 1989. The speed of construction on the critical components of Mahanadi Barrage Complex picked up significantly from May 1988 after a new construction agency was appointed by GOO along with the deployment of additional funds and equipment. The erection of gates was also accelerated by utilization of a 90-ton capacity crane, made available by GOO. The project was expected to be fully commissioned by March 1990[1]. However, the DMP-created computer-based drainage evaluation model will be useful in continuing analyses of improved irrigation and flood drainage potential for many years to come.

12. GOO initiated preparation of a Master Plan for Drainage and Flood Control (DMP) by establishing a special cell under a Superintending Engineer. A Bank specialist was made available for technical review during various supervision missions. The Central Water and Power Research Station (CWPRS) at Pune was enlisted to develop a mathematical model of the Delta to analyze Delta river and drain hydraulics as a means of assisting in the project design. A realistic critical path-type schedule for accomplishment of DMP was prepared by the Bank consultant resulting in an agreed completion of plan by March 1989. However, completion of the DMP was delayed for the following reasons: (i) shortage of engineering cadre staff in IPD caused by diversion of staff engaged on DMP to the repairs of flood damages following unprecedented floods in the State in September 1982; (ii) delay in filling up the needed complement of positions and deputation to the team of engineers as required to undergo basic computer training; and (iii) inordinate amount of time taken by the Special Cell to review and revise the draft reports to conform to the agreed new design criteria. Out of a total of ten volumes of the proposed DMP report, eight had been

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[1] Chief Engineer, Mahanadi Barrages Project, GOO, intimated the completion of project in June 1990 except for the installation of mechanism of the operation of gates through remote control system.

completed and the other two are being printed. The final version of the DMP Report, including review by CWC, was expected to be completed by December 31, 1990.

13. In respect of the Water Management Pilot Operation Study undertaken in the pilot blocks covering a total of 1094 ha under Distributary No.6, the physical systems (land consolidation, essential control and measurement structures on Distributary No.6 and its offtaking channels, etc.) were completed and made operational, but the study is still in progress under the Joint Director of Agriculture. Nevertheless, the important objective of the study envisaged at appraisal has not been fulfilled. Because of the delayed implementation and the need for additional operational experience, it will still require a continuing effort of three to four years to develop required farmer-village level organizations, improve cropping patterns, increase extension and physical inputs, and obtain useful monitoring results on all aspects. Sustained efforts by GOO through the Command Area Development Authority and the Irrigation Department would be needed to obtain a meaningful result of the proposed RWS schemes.

14. Unlike the Mahanadi Barrage works complex, the construction of civil works on Birupa barrage and its head regulator did not present any serious difficulty, though actual performance has belied earlier expectations that the physical targets would be completed ahead of the appraisal schedule.

15. Construction quality throughout implementation was generally variable. The Bank supervision missions helped instill quality-consciousness among project engineers and construction staff. Quality control was good on the implementation of the prestressed concrete girder bridge over Mahanadi Barrage. However, construction quality was not satisfactory in a number of piers which suffered from inadequate inspection and testing as evidenced by concrete honey-combing, poor concrete finish, improper construction joints and, partial embedment of gunny bags and burlap pieces in concrete at construction joints. Poor formwork, slow manual placement of concrete, lack of vibration, and inadequate quality control, contributed to this situation. However, rectification of defective construction was satisfactorily carried out.

16. Inordinate delays in the release of encroached lands coming in the alignment of Taladanda Link Canal (in its head reach) offtaking from the right head regulator of Mahanadi Barrage caused the delay in the construction of this important link channel. Completion was achieved by March 31, 1990 except in about 300 meters reach where construction to full section, including lining, was not done for want of clearance from encroachments. GOO has sought court intervention for removing the encroachments.

17. The schedule of disbursements under the Credit is shown in Table 3, Part III. This demonstrates that whereas the actual disbursements were more than the appraisal projections during Fiscal Years 1982 and 1983, they declined thereafter in the subsequent years and increased relatively only during Fiscal Years 1988 and 1989. The Status of Covenants is shown in Table 7, Part III. In general, except for Section 2.04 of Development Credit Agreement which relates to the two-year delay in project closing, other covenants were in compliance. In respect of this covenant, GOO initiated positive result-oriented steps to address the critical components of Mahanadi Barrage Complex and completed them in accordance with subsequent agreed revised implementation schedules albeit with considerable delays.

Project Results

18. Project implementation by component is shown in Table 4, Part III. The Birupa barrage civil and mechanical works have been completed. The Mahanadi barrage complex is also practically

complete and only a very small fraction remains to be done. These incomplete works include concretion of the right head regulator and erection of the gates, lining of Taladanda link channel, completion of the balance portion of the left upstream divide wall and completion of the dismantling of old anicut structure.

19. Project direct benefits in Table 6A, Part III show encouraging results. Successful completion of the construction of the new Mahanadi and Birupa barrages, without the failure of existing old weirs (during the period when the new barrages were being constructed), has fulfilled the project objectives and prevented the return of project command areas even temporarily to the rainfed conditions, thereby maintaining the crop outputs and farm incomes. Completion of the project has successfully accomplished the principal objective of ensuring the continuity of irrigation in the Delta of 167,000 ha already being irrigated. Furthermore, the new barrages fitted with the state-of-the-art gates and related operating equipment and having under-sluice bays, have eliminated all the structural and operational defects associated with the old weirs. As such, the new barrages are expected to prevent at least 85 to 90% of water losses which were otherwise seeping underneath and leaking through the old weir structures and shutters. The exact quantum of such savings will, however, be known later during actual sustained operations. The appraisal objective of irrigating an additional area of 16,700 ha during rabi, through saving of the estimated 30 to 40 $m^3$/sec of leakage occurring from the old weirs, is optimistically expected to be achieved at the full development stage.

20. Revised economic rates of return have been calculated for the project as a whole using the actual costs for a 1000 ha pilot area and based on (i) the proposed cropping pattern throughout the project life, and (ii) predominantly paddy cultivation (60% of the rabi area), both under existing and improved irrigation standards. Based on these assumptions, the economic rates of return are: under existing standards, 14.1% under proposed cropping pattern, and 6% with paddy as the predominant crop; and under improved standards, 15.6% under proposed cropping pattern, and 9.7% with paddy as the predominant crop. These compare with appraisal estimates of 21% under existing irrigation standards and 41% under improved irrigation. Decline in rates of return was attributed to project cost escalation, to the decline in world market price for rice, and to the delay in accrual of benefits. Details of economic re-evaluation are in Table 6-B.

Project Sustainability

21. Following completion of the new barrages, incorporating updated designs, provision of under-sluice bays, installation of state-of-the-art gates and stop logs and given the overall good quality of construction, there is little doubt that the functional aspects of the new work and facilities will be sustainable over the normally accepted long-range life expectancy for projects of this type. The sustainability and reliability would depend on the adequacy of future O&M performance but, in any case, even with their inherent operational and structural deficiencies, the new works and facilities are superior to that of the old weirs which have been in operation for over 100 years. It will, however, be important and desirable for GOO to continue the water management pilot operation study and bring it to a successful conclusion through sustained efforts to develop required farmer-village level organizations, improved cropping pattern, efficient agriculture extension and better water management. As such it will be an indispensable tool with which GOO will be able to properly analyze future modernization and rehabilitation development prospects for the entire Delta area.

Bank's Performance

22. The Bank, in the course of project supervision, provided useful technical assistance

throughout the project implementation cycle. Table 8, Part III demonstrates that from project start-up Bank missions provided result-oriented assistance to GOO and its Project Management in all aspects of project implementation, including procurement, and planning and finance, organization and management, pilot water management study, and technical assistance in the preparation of Master Plan for Drainage and Flood Control of the Mahanadi Delta. In addition the Bank provided overall assistance and guidance in the identification and deployment of proper construction equipment and required infrastructure for improving progress and achieving quality construction.

Borrower 's Performance

23. The IPD extended its full cooperation to the Bank and exhibited positive responses to the various suggestions and recommendations throughout the project implementation cycle. Various constraints inherent in the State-wide system and set-up, including financial stringencies, power shortage, shortage of required technical expertise, unreliable construction agencies, to name a few, resulted in over two years delay in completing the project. Notwithstanding the delay, GOO's overall performance was satisfactory. Non-performing contractors were replaced to speed up critical and lagging components of Mahanadi barrage complex. The Irrigation Department demonstrated strong management at the State level and made earnest efforts to implement Bank recommendations and suggestions. Of course, there have been shortcomings too. Preparation of Barrage Operation Rules have been abnormally and unnecessarily delayed. GOO realized quite late during implementation that in-house expertise was not adequate to prepare a comprehensive O&M manual. Private consultants were eventually employed. The O&M Manual had been completed and approved by the Chief Engineer.[2]

Project Relationships

24. Throughout the project cycle, GOO, its implementing agencies, and the Bank maintained very cordial relationships, which enabled frank discussions, presentations and understanding of each other's view points. On technical aspects, the Irrigation Department invariably considered Bank observations with an open mind and ensured that their project staff took appropriate actions. Such a strong link of professional association between the Bank, GOO, and the Project Management helped in resolving numerous issues, leading to the successful completion of the project.

Consultancy and Contracting Services

25. Consultants were engaged by GOO for site investigation and preparation of the foundation profile for the required Mahanadi barrage bays which were furnished to CWC to complete the design of barrage floor and piers. GOO also engaged CWPRS, Pune, in the development of a mathematical model of Mahanadi Delta river flow hydraulics.

26. Contractors were engaged for all project works except on a part of Mahanadi barrage right side head regulator which was undertaken by the Irrigation Department pending the appointment of a construction agency. Two construction agencies had to be replaced over time because of their unsatisfactory performance.

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[2] This takes into account Government comments.

Project Documentation and Data

27. In general the legal documents were appropriate and adequate. The Staff Appraisal Report provided a good framework for project execution except for a shortcoming listed in paras. 9 and 10.

## PART II: PROJECT REVIEW FROM BORROWER'S PERSPECTIVE

Confirmation of Adequacy and Accuracy of Information in Parts I and III

28. Paras 11 and 22 of Part I have been revised to take account of Governments' comments. GOO had no comments on Part III.

Project Objecives

29. Mahanadi Barrages Project which became effective in February, 1981 and operational in June 1989 is programmed for completion by March 31, 1990. The project contemplated and achieved the following broad objectives.

i. Construction of Mahanadi and Birupa Barrages as replacement of old anicuts to ensure continuity of irrigation with assured supply to a cultivable command area of 167,000 ha.

ii. Drainage Master Plan covering the irrigated area of 303,000 in Mahanadi Delta.

iii. Water Management Pilot Project covering an area of 1094 ha under Distributary No.6 of Kendrapara Canal.

30. The main components of Mahanadi Barrage of length 1928 meters ± between abutments are:

i. 95 bays of 18 meters clear span of which 79 are spillway bays and 8 under-sluice bays each on left and right.

ii. One fish pass bay 2 meters wide between right divide wall and right under-sluice bays.

iii. Head regulator of Kendrapara Canal of 4 bays of 10 meters each on the left bank with discharge capacity of 142 cumecs.

iv. A two-lane bridge over the Barrage adjacent to hoist bridge.

v. Guide bundh in the upstream and downstream on the left bank and in the downstream on right bank and two long spurs in the upstream on the right bank.

31. Similarly main components of Birupa Barrage of length 180 meters between abutments are:

i. 15 bays of 10 meters clear span of which three are under--sluice bays on the left and 12 are spillway bays on the right.

ii. Head regulator of High Level Canal Range I of three bays of 10 meters each on the left bank with discharging capacity of 142 cumecs.

iii. A two-lane bridge over the Barrage adjacent to the hoist bridge.

iv. Guide Bundh both upstream and downstream on both left and right banks.

Project Design

32. For Mahanadi and Birupa Barrages, the Central Water Commission was the design consultant. The hydraulic model studies were entrusted to the Central Water and Power Research Station (CWPRS), Pune. Results of the model studies formed the basis of hydraulic design and structural design so far as they were relevant. Exploration of foundation of the barrages was conducted by the project authorities through their own organization at the earlier stage. Subsequently foundation exploration of Mahanadi Barrage was entrusted to M/s Duban Project Engineering (P) Ltd., Bombay. The exploration results formed the basis of structural design of the two Barrages.

33. After analysis of flood data, design flood of Mahanadi at Naraj was fixed at 42,475 cumecs. Equivalent design discharge of Mahanadi and Birupa arms were taken as 15,300 and 2,070 cumecs respectively. In the Staff Appraisal Report, the higher flood recorded at Naraj was 43,100 cumecs in 1972. That was exceeded and the highest flood of 44,749 cumecs passed during 1982 at Naraj. Frequency analysis was conducted at CWPRS, Pune which revealed mean value of 100 years flood as 50,260 cumecs and 95% Upper Confidence Limit 59,832 cumecs at Naraj. Corresponding to 50,260 cumecs at Naraj, discharges in Mahanadi and Birupa are 18,000 and 2,500 respectively. The model has been tested for these discharges. Model was not run for the discharges of 59,832 cumecs at Naraj as, such high flood is not likely to reach Naraj because of low embankment capacity in the upper reaches.

34. The shape and alignment of upstream and downstream guide bundhs of Birupa Barrage, left upstream and downstream and right downstream guide bundh of Mahanadi Barrage were fixed as per model study recommendation. Looseness factor of 3.27 and existing shoal formation upstream of right under-sluice posed a problem for river training Mahanadi right. As the best alternative, two long spurs of length 706 meters and 966 meters have been constructed in the upstream of Mahanadi Barrage to develop adequate velocity preventing reformation of shoal and silt entry into Head Regulator of Taladanda Canal. Model study recommended removal of shoal in specified area upstream of the right under-sluice of Mahanadi Barrage and the same was taken up accordingly. Excessive sediment deposit was observed on the right upstream bank of the Birupa river in the model and therefore the Head Regulator of Kendrapara Canal was shifted to the left side of Mahanadi Barrage. Width between abutments of the new Mahanadi Barrage has been kept 1928 meters against 1935.50 meters of the old anicut keeping in view the water-way of existing railway bridge near the downstream in spite of a looseness factor of 3.27. Width of 180 meters between abutments has been kept of Birupa Barrage against 635 meters in old anicut and the present water-way has been found satisfactory in the model test, the looseness factor remaining as 0.83. The reservoir level (RL) of 21.2 meters of old Mahanadi anicut has been retained for the new Barrages. Capacity of each of the three Head Regulators is kept at 142 cumecs against 84.90, 90.19 and 18.62 cumecs of old Head Regulators of Taladanda, Kendrapara and High Level Canals respectively to utilize additional regulated releases due to future reservoirs.

35. Foundation exploration was taken up by M/s Duban Project Engineering (P) Ltd., Bombay for Mahanadi Barrage and Birupa Barrage during the period from 4/82 to May 1986. These show that left under-sluice bays of Mahanadi Barrage are located on stiff grey clay below which are layers of sand and loam which are further underlain by very stiff yellow clay. The thickness of the grey and yellow clays and of the sandwiched sandy layers vary both in longitudinal and transverse directions. The gray clay of 8.0 meters depth under left abutment disappears at the left divide wall. Clay thickness of 8.0 meters below bottom of raft in the upstream vanishes below downstream raft. The subsoil between bays 9 to 48 mostly consists of thick alluvium deposit of thickness from 16 meters to 30 meters underlain with a stiff yellow clay stratum. Between bays 49 to 63, there is

a top sand layer extending up to RL 0.00 in bay 49 and up to RL + 8.0 m in bay 63. Between bays 64 to 78, there is a top sand layer extending up to RL + 11.0 meters in bay 64, up to +6.0 meters in bay 73 and up to RL + 11.0 meters in bay 78. Within bays 79 to 88, there is a top sand layer with elevation ranging from RL + 11.0 meters to +9.0 meters, stiff black clay layer between RL + 10.0 meters and + 7.0 meters , gray medium stiff clay below, RL 6.0 meters with thin sandy clay/clays sand between two clay layers. In right under-sluice bays from 88 to 95, the subsoil mainly consists of stiff black clay within intermediate layers of clayey sand. The raft rests on clay throughout its length, against subgrade reaction of 2.10 kg/cm$^2$ for sand foundation and 2.80 kg/cm$^2$ for grey clay estimated by design consultant, 0.9 kg/cm$^2$ has been adopted for actual design of raft. The raft abutment is resting on stiff black clay of about 8.2 meters depth underlain by sandy strata of about 6 meters depth below which stiff yellow clay of about 1.5 meters depth exists. Preconsolidation pressure for black clay and yellow are 22 t/m$^2$ and 24 t/m$^2$ respectively under design pressure of 20 t/m$^2$ which is less than the above values. The differential settlement expected is negligible. On analysis, settlement is found to be about 2.39 cm. Ultimate bearing capacity with over-burden estimated is 40 t/m$^2$. The left abutment was constructed to its full height leaving an expansion joint between the toe of the abutment and raft of first bay. Without constructing the portion of the raft, the abutment was back-filled up to its full height and some surcharge load on backfill and on toe was placed and settlement observations were made for about one year. Practically no settlement of left abutment was noticed. The black stiff clay encountered in the foundation of right abutment is almost identical. In the foundation of right abutment, the stiff clay continues to a large depth and there are also thin layers of clayey sand. The heave estimated is about 25 mm and ultimate bearing capacity is 45 t/m$^2$. Total settlement calculated is 145 mm which is the sum total of consolidation settlement of 120 mm and heave of 25 mm. In order to keep the estimated total settlement within permissible limit of about 90 mm, several alternatives such a providing the sand drain below right abutment and adjoining under-sluice bays, combining the abutment with some under-sluice bays and founding the right abutment on reamed pile etc. were studied in detail. Finally, to reduce the intensity of base pressure, it was decided that the last bay (bay No.95) would be constructed monolithically on the right abutment with a double pier between bay 94 and 95. Thus maximum intensity was reduced from 20 t/m$^2$ to 15 t/m$^2$ and settlement was reduced to the permissible limits.

36. The Birupa Barrage is founded on hard laterite rock underlain by stiff yellow clay. Safe bearing capacity is found to be 38 t/m$^2$ against maximum abutment pressure of 20 t/m$^2$. Settlement corresponding to load intensity of 96.8 t/m$^2$ is about 0.8 mm for 300 mm plate. Therefore, settlement and differential settlement of abutment would be marginal and no settlement is expected in barrage bay. The modulous of subgrade reaction estimated is 61.5 kg/cm$^3$ for laterite rock and the same value has been used for design of raft.

37. For Mahanadi Barrage, double pier has been provided generally after 10 days. However, where the foundation strata is changing this has not been adhered to. Care has been taken in making separate unit of raft having the same type of foundation. Double piers have been provided between bays numbered 3-4, 8-9, 18-19, 28-29, 38,39, 48-49, 58-59, 70-71, 75-76, 78-79, 83-84, 87-88 and 94-95. The raft is designed as a reinforced concrete beam on elastic foundation spanning between piers. Keeping in view the uncertainties, a 'conservative value of co-efficient of subgrade reaction (0.9 kg/cm$^2$)' has been adopted. The raft is stiffened by extra transverse reinforcement to withstand any settlement. The raft is divided into various zones depending on the intensity of loads/forces coming. The raft is analyzed for various conditions such as flood, pond, hydraulic jump and construction etc. And also for normal and seismic conditions. Seismic coefficients of 0.12 kg for horizontal and 0.06 kg for vertical acceleration acting simultaneously have been considered. The critical condition which has given maximum loads and moments in

various zones has been finally considered in the design. Two meters wide piers have been extended to full length of raft. Over the piers, hoisting equipment for gates operation and a road bridge have been accommodated. Loads dispersion angle of 45 degrees has been adopted. According to the height of piers and loads coming, piers have been divided into various zones. The condition of live loads of bridges which cause maximum vertical loads and corresponding horizontal force has been analyzed. Both normal and seismic conditions were considered and the one causing maximum eccentricity is the critical one for which reinforcement has been provided. Pier has been designed as a column subjected to combined bending and direct load. Abutment has been designed as a reinforced concrete retaining wall in three parts i.e. stem, heel and toe. Each member is acting as a cantilever fixed at the junction of the member and subjected to vertical forces in case of heal and toe slab and horizontal forces due to earth pressure, water pressure and bridge live load in case of vertical stem. The structural design for Head Regulator of Taladanda Canal and Kendrapara Canal have been done in the same manner as various components of barrage structure. Prestressed Girder bridge has been designed for Mahanadi Barrage and bridge over Head Regulator of Kendrapara Canal and reinforced concrete slab bridge has been designed for Head Regulator of Taladanda Canal.

38. For design of raft of Birupa Barrage, the modulous of subgrade reaction of 61.5 kg/cm$^2$ has been used. The three left under-sluice bays have been isolated from 12 spillway bays on the right side with provision of expansion joint and double pier between bay No.3-4. A divide wall separates under-sluice bays and spillway bays. The highly stressed abutments are isolated from the main raft with provision of an expansion joint between two of abutment and main raft. The procedure of design of raft, pier and abutment adopted for Mahanadi has been followed for Birupa Barrage. Structural design for Head Regulator of High Level Canal Range-I has been done in the same manner as various components of Birupa Barrage. Reinforced concrete beams with slabs have been designed for bridge over Birupa Barrage and Head Regulator of High Level Canal Range-I.

Project Implementation

39. In Mahanadi Barrage clay was encountered in the foundation of the left and right under-sluice bays and open dewatering by pumps of various capacities was resorted to. Spillway bays were founded on bed of sand. Dewatering of foundation was accomplished with well-point dewatering system with 50/70 horsepower Electric/Diesel Pumps in combination with one submersible pump of 8 to 10 horsepower capacity in each bay. Concrete was supplied from batching plants installed on the banks and was transported to worksite by Tippers and finally placed in position manually. To a limited extent, concrete mixers were used near worksites to feed concrete mostly for cement concrete blocks for upstream and downstream protection works. Birupa Barrage was founded on laterite rock requiring open dewatering by small capacity pumps. Concreting was done by concrete mixers. Progress on Birupa Barrage, although heartening during earlier period, lagged behind construction schedule during later period. However, being a small work in comparison with Mahanadi Barrage, it was completed ahead of Mahanadi Barrage. Progress of Mahanadi Barrage could not keep pace with the implementation schedule and following reasons in addition to those listed in Part-I of the PCR contributed to the time over-run:

i. River diversion posed a great problem throughout construction period. Mahanadi Barrage was constructed 60 meters downstream of the old anicut keeping the old irrigation system operational. Water diversion through canals and escapes of Delta Stage-I and Stage-II mostly did not succeed due to resistance of the people growing crops in the land along the drainage channels. Water level in the pond of the old anicut remained high and submerged the working area and construction machinery

several times by over-topping or breaching masonry coffer dam during monsoon cyclones resulting in considerable loss of working period and life and efficiency of construction machinery.

ii. There was occasional dislocation in work due to non-availability of cement during working season 1984-85.

iii. Foundation including concrete raft was the major and difficult component of work requiring sustained lowering of water level in construction area by four to seven meters. Disruption in power supply led to more of idle pumping and considerable loss of progress in items of work. In view of uncertain electric supply position, four of 250 kilovolt amperes diesel generating sets were procured and put to work from working season of 1986-87. Had these sets been procured from the beginning, delay on this account could have been avoided.

40. In the foundation of bays 44 to 53 of Mahanadi Barrage (downstream of the central sluice area) laterite masonry, laterite dry masonry, crates made of palm tree sown into four pieces lengthwise and filled with granite stones and concrete blocks of nearly 2 m depth were encountered. Due to presence of sand underneath, dewatering took a long period, involving time over-run and blocking of dewatering pumping units. Four to five small rigs worked to make holes to insert 1/2 inch diameter well-points. One high capacity rig had to be procured to make holes to insert 4 inches diameter well points. Two open pumping pits were dug by crane grabs and provided with inverted filter arrangements. An indication of this problem in the Staff Appraisal Report would have led to better preparedness to prevent seepage in construction schedule on this account.

41. The Mahanadi Delta Development plan envisages an integrated development of Mahanadi Delta Command with Gross Command Area and cultivable command area of 5.20 and 3.03 lakh hectares in the following sectors.: (i) Drainage Development; (ii) Flood Control Works; (iii) Modernization of Irrigation System; (iv) Command Area Development and land consolidation works; and (v) Conjunction use of ground water along with the surface irrigation system. For this purpose comprehensive project report in 10 volumes has been prepared taking into consideration (i) Topographical survey, geology, and Delta formation, (ii) Climatic study; (iii) Soil Survey; (iv) Socio Economic Benchmark study; (v) Position of groundwater table, its fluctuation and quality; (vi) existing canal system and its efficiency; (vii) existing drainage channels and their efficiency and other relevant topics. Mathematical model study for determination of water movement in the Delta have been undertaken at CWPRS, Pune. Several specific notes have been received from CWPRS and these have been incorporated in designing the drainage system and flood control works. All the ten volumes of the project report have been completed and the dialogue with Central Water Commission is continuing.

42. Modernization of the Distributary No.6 Ex-Kendrapara Canal was selected as a pilot project. 1026 hectares in 21 villages in three patches were identified for agricultural demonstration. A project implementation committee was formed under Chairmanship of Chief Engineer, Mahanadi Birupa Barrage Project to coordinate amongst Land Consolidation Department, Agriculture Department, Command Area Development Authority and review the program and progress of the project. The sole motto of implementing the project was to expose the advancement in cultivation methods and water management to the agricultural community. The Agriculture University, Orissa carried out studies over pre-stage and post-stage socio-economic development in the said area.

43. The program consisted of the following: (i) Modernization of Distributary 6, (ii) on-farm development in the pilot patches, (iii) To regulate pre-determined discharge through outlets, (iv) To educate the cultivators regarding the program, and (v) benefit evaluation through economic surveys. The 110 year old existing canal which has lost the shape and the structures being either broken or insufficient for full discharge in tail reaches are to be remodelled to avoid periodical drought and unnecessary flooding. The canals have been developed to the required design shape to supply required quantity of water in time. Beyond the outlets the on-farm development is done by command area development.

44. In the full modernization program a summary of the structures included 26 head regulators, 17 cross regulators, 22 drainage syphons, 59 intervening bridges, 3 falls, 407 outlets, and one aqueduct. Also, a total of 79.19 kilometers of earthwork on the canal were executed. Significant development in providing effective irrigation in the pilot area was achieved with the help of modernization. Valuable guidelines provided by the missions during their visits to the project site were of much help in implementating the project.

45. A well equipped quality control unit was established for the project. Project Engineers desired to maintain quality of construction. Bank supervision missions insisted on quality with constructive suggestions. There were occasions when Bank missions became harsh on the quality of work but these were taken in the stride as the observations were meant to improve the quality of work. Pressure was all the time exerted to complete the project within the original target date and after that date was over, to complete with least time over-run. Targets set were ambitious considering cumulative effect of reasons contributing to shortfall in progress. Hurrying tendency to make good slippage in program was one of the contributing factors for the deficiency on finishing quality. However, remedial measures were taken giving due weightage to observations of Bank missions and rectification was satisfactory achieved.

46. Work of link channel of Taladanda Canal could not be started before the stipulated date of project completion (i.e. March 31, 1987). Taking possession of land under unauthorized occupation of individuals posed a great problem. After acquisition of land in the head reach, it was possible to demolish the dwelling houses towards middle of 1988-89 working season and take up the work. Vacation of some land in the tail reach has not yet been possible. However, efforts are being made for taking possession of land and to complete the work by March 31, 1990 as per program.

Development Impact of the Project

47. Saving of 30 to 40 cumecs of water which was earlier being lost as leakage through shutters of old anicuts and elimination of fluctuation in pond level due to deficiencies of shutters of old anicuts, have assured supply in canals up to full supply level as per requirement throughout irrigation season. This has been achieved in practice during Kharif season of 1988-89. Because of this project, GOO is already executing Birupa Genguti Island Irrigation Project at estimated cost of Rs.4.63 crores contemplating irrigation to 3830 ha during Kharif and 3095 ha during Rabi drawing design discharge of 4.41 cumecs from Nattamundai Branch of Kendrapara Canal. GOO has also set up organization to execute Mahanadi Chitrotpala, contemplating irrigation to 16.612 ha during Kharif and 15,438 ha during rabi, drawing design discharge of 26.47 cubic meters per second from Kendrapara Canal. With assured supply of water due to this project and Drainage Master Plan ready, GOO cannot afford any delay except to arrange resources for taking up the execution of Mahanadi Delta Development Plan.

# PART III: STATISTICAL TABLES

TABLE 1

RELATED BANK CREDITS

| Loan/Credit Title | Purpose | Year of Approval | Status | Comments |
|---|---|---|---|---|
| Credit 682-IN Orissa Agricultural Development Credit (US$ 20 M) | To reorganise and improve extension & research services. | 1977 | Project closed on June 30, 1984. | The project acheived most of targets and overall physical performance was good. Quality of extension in the State improved and made a positive effect on agricultural production. |
| Credit 1523-IN National Agricultural Extension Project I (US$ 39.1 M) (or SDR 38.6 M) | To provide 1984 assistance for achieving continued strengthening of agriculture extension services and the research-extension linkages. | 1984 | Project implementation is severely behind schedule with respect to SAR completion date of March 1989. Credit Closing Date had been extended to March 31, 1992. | Notwithstanding the fact that sound professional extension services are now well established, deficiencies exist in the extension quality and coverage besides serious planning and financial constraints. |

TABLE 2

## PROJECT TIME TABLE

| Item | Date Planned | Actual (A)/Estimated at Closing (E) |
|---|---|---|
| Identification (Executive Project Summary) | Not available | |
| Preparation | Not available | |
| Appraisal Mission | | July '80 (A) |
| Loan/Credit Negotiations | | October '80 (A) |
| Board Approval | | Dec. 2,'80 (A) |
| Credit Signatures | | Dec. 5, '80 (A) |
| Credit Effectiveness | | Feb. 11, '81 (A) |
| Project Completion | Mar. 31, '86 | March '90 (E) 1/ |
| Credit Closing | Mar. 31, '87 | Mar. 31, '90 (A) |

1/ The Chief Engineer of the Project intimated that estimated project completion was June 1990, except for the installation of mechanism of the operation of gates through remote control system.

TABLE 3

## SCHEDULE OF DISBURSEMENTS

| BANK/FY/ Semester | | Appraisal Projection | Cumulative Disbursements Revised Projection (3/88) | Revised Projection (12/88) | Actual | % Actual to SAR or Revised Projection |
|---|---|---|---|---|---|---|
| | | (US$ M) | | | | |
| 1982 | 1st | 0.2 | | | | |
| | 2nd | 2.2 | | | 3.7 | 168 |
| 1983 | 1st | 5.2 | | | 5.5 | 106 |
| | 2nd | 11.0 | | | 9.3 | 84 |
| 1984 | 1st | 19.0 | | | 13.1 | |
| | 2nd | 30.0 | | | 22.20 | 74 |
| 1985 | 1st | 43.0 | | | 24.20 | |
| | 2nd | 55.0 | | | 35.90 | 65 |
| 1986 | 1st | 65.0 | | | 40.22 | 69 |
| | 2nd | 74.0 | | | 49.86 | 67 |
| 1987 | 1st | 80.0 | | | 52.70 | 66 |
| | 2nd | 83.0 | | | 56.18 | 67 |
| 1988 | 1st | | | | 69.30 | |
| | 2nd | | 74.0 | | 73.80 | 99 |
| 1989 | 1st (Sept.'88) | | 76.0 | | 76.70 | 101 |
| | 2nd (Dec.'88) | | 80.0 | | 77.10 | 96 |
| | 3rd (Mar.'89) 1/ | | 82.0 | 81.3 | 81.30 3/ | 100 |
| | 4th (June 89) | | 83.0 | 83.0 | | |
| 1990 | 1st (Sept 89) 2/ | | | | | |

1/ Credit Closing date.
2/ End of grace period (9/89).
3/ US$ 81.30 M is equivalent to SDR 62 M against Credit amount of SDR 63.3 M.

## PROJECT IMPLEMENTATION

| Indicator | Unit | Appraisal Estimate | Reformulated Estimate (1/89) | Actual Achievement (3/89) | Remarks |
|---|---|---|---|---|---|
| 1. Mahanadi Barrage (Civil Works) | | | | | |
| Foundation excavation | m3 | 946700 | 657,000 | 609057 | Completed in 5/89 (619557 m3) |
| Formation of sheet piles | m2 | 39800 | 35,000 | 33,428 | Completed in 5/89 (33688 m2) |
| Concrete in substructure | m3 | 241632 | 184,820 | 181,488 | |
| Concrete in super-structure | m3 | 100347 | 83,830 | 74,898 | |
| Concrete blocks | m3 | 39680 | 63,000 | 49,742 | |
| Prestress girder | Nos. | 380/1429 m3 | 428 | 396 | |
| Mild steel reinforcement | mt | 21600 | 19,000 | 18,244 | |
| Loose stone apron | m3 | 144,930 | 126,000 | 106,852 | |

| Indicator | Unit | Appraisal Estimate | Reformulated Estimate (1/89) | Actual Achievement (3/89) | Remarks |
|---|---|---|---|---|---|
| 2. Mahanadi Barrage Mech. Works | | | | | |
| Manufacture and supply of embedded parts | mt | 609.60 | 521.29 | 521.29 | Completed |
| Erection of embedded parts | mt | 609.60 | 521.29 | 505.23 | |
| | Completed 5/89 | | | | |
| Manufacture and supply of gate stoplog | mt | 2938 | 2202.49 | 2202.49 | Completed |
| Erection of gate and stoplog | mt | 2938 | 2202.49 | 1934.20 | |
| 3. Birupa Barrage Civil Works | | | | | |
| Foundation excavation | m3 | 45,618 | 99,700 | 99,700 | Completed |
| Laterite excavation | m3 | 362.97 | 47,700 | 47,700 | Completed |
| Concrete in sub-structure | m3 | 33,277 | 29,000 | 26,506 | Completed |
| Concrete in super-structure | m3 | 17,563 | 12,000 | 13,867 | Completed |
| Concrete blocks | m3 | 2,863 | 14,000 | 13,469 | Completed in 5/89 (13737 m3) |
| Steel reinforcement | mt | 3,380 | 2,280 | 2,177 | Completed |
| Loose stone apron | m3 | 21,693 | 22,000 | 12,000 | |

| Indicator | Unit | Appraisal Estimate | Reformulated Estimate (1/89) | Actual Achievement (3/89) | Remarks |
|---|---|---|---|---|---|
| 4. Birupa Barrage Mech. Works | | | | | |
| Manufacture and supply of embedded parts | mt | 70.50 | 92.07 | 92.07 | Completed |
| Erection of embedded parts | mt | 70.50 | 92.07 | 92.07 | Completed |
| Manufacture and supply of gates and stoplogs | mt | 379.60 | 332.31 | 332.31 | Completed |
| Erection of gate and stoplog | mt | 379.60 | 332.31 | 332.31 | |
| | Completed | | | | |
| Manufacture and supply of hoist | nos. | 15 | 15+3 (H/R) | 15+3 (H/R) | Completed |
| Erection of hoists | nos. | 15 | 15+3 (H/R) | 15+3 (H/R) | Completed |
| Supply and erection of Gantry Crane | nos. | 1 | 1 | NIL | 1 |
| 5. Head regulators (H/R) and link channel | Rs.M | 17.7 | 55.0 | 41.0 | |
| 6. Camps and buildings | Rs.M | 17.0 | 141.7 | 141.0 | Completed in 5/89 (146.0) |
| 7. Roads | Rs.M | 5.0 | 9.0 | 9.0 | Completed |
| 8. Master Drainage Plan | Rs.M | 12.0 | 40.2 | 39.8 | Completed in 5/89 (40.2) |
| 9. Water Management | Rs.M | 3.0 | 8.0 | 9.04 | Completed |

TABLE 5-A

## PROJECT COSTS

| | Appraisal Estimate | | | Appraisal Estimate | | | Revised Estimate (3/87) | Actual at 3/89 (Credit Closing) | Balance Estimated Expenditure at 3/89 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Local Costs | Foreign Exchange Costs | Total | Local Costs | Foreign Exchange Costs | Total | | | | |
| | -------- (US$ M) 1/ ------- | | | ---------- (Rs. M) -------- | | | (Rs. M) | (Rs. M) | (Rs.M) | (US$M) 3/ |
| 1. Civil Works | 38.1 | 9.5 | 47.6 | 320.2 | 80.0 | 400.2 | 858.60 | 768.18 | 37.02 | 2.38 |
| 2. Mechanical Engineering | 4.8 | 7.1 | 11.9 | 40.3 | 60.0 | 100.3 | 159.40 | 153.53 | 10.00 | 0.64 |
| 3. Engineering Supervision and Administration | 9.0 | 0.5 | 9.5 | 75.4 | 4.0 | 79.4 | 141.70 | 166.47 | 12.00 | 0.77 |
| 4. Drainage Master Plan | 1.2 | 0.2 | 1.4 | 10.0 | 2.0 | 12.0 | 28.70 | 39.20 | 2.00 | 0.13 |
| 5. Water Management Program | 0.3 | 0.1 | 0.4 | 2.4 | 0.6 | 3.0 | 8.40 | 8.40 | - | - |
| 6. Base Cost | 53.4 | 17.4 | 70.8 | 448.3 | 146.6 | 594.9 | - | - | - | - |
| 7. Physical Contingencies (18.5%) | 9.9 | 3.2 | 13.1 | 83.0 | 27.1 | 110.1 | - | - | | |
| 8. Price Contingencies (31.4%) | 19.9 | 6.5 | 26.4 | 167.0 | 54.5 | 221.5 | - | - | | |
| Total Project cost | 83.2 | 27.1 | 110.3 (US$M) | 698.3 | 228.2 | 926.5 (Rs.M) | 1196.80 (Rs. M) | 1135.78 (Rs M) | 61.02 (Rs M) | 3.92 US$ M |

Notes:

1/ Exchange rate US$ 1 = Rs. 8.40.

2/ It includes the cost of buildings and equipment (pages 25 and 26 of SAR, October 31, 1980).

3/ 1 US$ = Rs. 15.50.

## PROJECT FINANCING

| Source | Planned in Credit Agreement (SDR '000) | Revised (Reallo-cation (SDR '000) (8/87) | Actual as on 3/31/89 (SDR '000) | Final Actual 2/ (SDR '000) |
|---|---|---|---|---|
| IBRD Expenditure Categories | | | | |
| A. Original Credit Agreement | | | | |
| 1. Civil works, gate manufacture and erection thereof. | 52,590 | 59,030 | 57156.13 | 58317.48 |
| 2. Equipment, materials and vehicles | 1,540 | 1,400 | 1428.04 | 1428.04 |
| 3. Drainage and water Management. | 1,540 | 2,870 | 3,440.48 | 3,554.48 |
| 4. Unallocated | 7,630 | 0 | 0 | 0 |
| Total SDR '000 | 63,300 1/ | 63,300 | 62,024.65 | 63,300.00 |
| or US$ '000 | 83,000 | 83,000 | 81,300 | 83,000.00 |
| B. Co-financing Institutions | 0 | 0 | 0 | 0 |
| C. Other External Sources | 0 | 0 | 0 | 0 |
| D. Domestic (GOO) US$ '000 | 27,300 | 48,090 | 42,930 6/ | 44,740 6/ |
| Total (US$ '000) | 110,300 | 131,090 4/ | 123,810 5/ | 127,730 |
| Total (Rs. M) | 926.500 | 1196.80 3/ | 1135.78 7/ | 1196.80 |

1/ SDR 63.3 M Credit or US$ 83 M equivalent; US$ = Rs.8.4 and 1SDR= US$1.31.
2/ Disbursements taken at the end of grace period (9/89).

3/ Revised Project Cost (3/87).
4/ 1 US$ = 13.00 on 3/87
5/ 1 US$ = 15.50 on 3/89
6./ This does not reflect true expenditure as the disbursements were made at different exchange rates through respective periods of project execution.
7/ Additional Rs.61.02 M (US$ 3.92 M) shall have to be expended to complete prescribed works as per revised cost estimate of works (Rs.1196.80 M)
(US$ 000) 127,730 - 123,810 = US$ 3.920 M.

## DIRECT BENEFITS

| Indicator<br>1 | Appraisal estimate<br>2 | Closing date estimate<br>3 | Full development estimate<br>4 |
|---|---|---|---|
| 1. Continuity of irrigation. | Ensuring continuity of irrigation in 167000 ha being already irrigated. | Completion of the project has accomplished the primary objective of the continuity of irrigation as envisaged at appraisal. | Same as in column 3. |
| 2. Preventing the return of project area to rainfed conditions with the consequent reduction in crops output. | Failure of existing weirs and non-implementation of the Project would revert the project to rainfed conditions with the consequent annual reduction of crops output to an estimated US$ 30M in financial 1980 prices, besides severely affecting farm incomes and employment. | Successful project implementation without any failure of existing weirs has fulfilled the project objectives and prevented the return of project areas even temporarily to the rainfed conditions, thereby maintaining the crop outputs and farm incomes and employment. | Same as in column 3. |
| 3. Eliminating emergency repairs of old weirs. | Eliminating the need for emergency repairs of existing old weirs involving an expenditure of US$2.0M. | Successful construction of new barrages has accomplished the project objective through elimination of the need for emergency repairs. | Same as in column 3. |

| Indicator<br>1 | Appraisal estimate<br>2 | Closing date estimate<br>3 | Full development estimate<br>4 |
|---|---|---|---|
| 4. Preventing existing leakage of water through the construction of new barrages. | Prevention of 544 M $m^3$ leakage and its utilization in rabi season for achieving additional benefits of Rs.40 M annually. | Prevention of 400 M $m^3$ estimated to be achieved. | 1/ |

1/ Realistic evaluation of the quantum of leakage saved shall be determined through actual operation of gates of new barrages in the next few years.

TABLE 6-B


## ECONOMIC IMPACT

A. Economic Rates of Return

| Particulars | Appraisal Estimate 1/ | | PCR Estimate | |
|---|---|---|---|---|
| | Existing Irrigation Standard | Improved Irrigation Standard | Existing Irrigation Standard | Improved Irrigation Standard |
| Economic Rate of Return (%) | 21.0 | 41.0 | 14.1<br>6.0 2/ | 15.6<br>9.7 2/ |
| Major Assumptions | | | | |
| 1. Project Costs (nominal) | Rs. 926.5 M | | Rs. 1196.8 3/ | |
| 2. Water Management cost for improved irrigation in the pilot area (1000 ha) | | Rs. 3.0 M | | Rs. 8.4 M 4/ |

1/ Refer to Staff Appraisal Report, Annex 5, paras. 5 and 6.

2/ Decline in ERR if the farmers start cultivating paddy predominantly in the rabi season.

3/ Real cost escalation for the total project costs plus the extended water management program to cover the full 167,000 ha was 23%.

4/ At appraisal, the cost of construction works for attaining improved irrigation system was estimated at Rs. 3 M for 1000 ha pilot area, which, if projected to cover full command area of 167,000 ha, works to Rs. 501 M. The actual incurred cost of Rs. 8.4 M for the same pilot area, when projected to cater to improved irrigation management for the full command, is estimated to Rs. 1402.8 M. This increase in cost makes ERR fall from 41% to 15.6%.

B. Irrigation Potential Utilized for a Total Command Area of 167,000 ha ('000 ha)

| Year | Kharif | Rabi | Remarks on Rabi Irrigation |
|---|---|---|---|
| 1978-79 | 153 | 92 | Heavy 1/ and light2/ rabi irrigation |
| 1979-80 | 154 | 87 | Ditto |
| 1980-81 | 154 | 67 | Ditto |
| 1981-82 | 156 | 89 | Ditto |
| 1982-83 | 156 | 82 | Only light2/ rabi irrigation |
| 1983-84 | 156 | 115 | Ditto |
| 1984-85 | 156 | 109 | Ditto |
| 1985-86 | 156 | 109 | Ditto |
| 1986-87 | 156 | 111 | Ditto |
| 1987-88 | 156 | 111 | Ditto |
| 1988-89 | 156 | 111 | Ditto |
| 1989-90 | 156 | 94 | Heavy1/ and light2/ rabi irrigation |
| 1990-91 3/ | 159 | 96 | Ditto |
| 1991 onwards | 159 | 96 | Ditto |

C. Economic Prices of Commodities

| | Rs. per Kg. |
|---|---|
| N | 8.85 |
| P | 8.36 |
| K | 4.43 |
| Paddy | 1.54 |
| Jute | 2.53 |
| Groundnut | 3.98 |
| Potato | 1.6 |
| Pulses | 6.4 |
| | Rs. per md |
| Wage Rate | 9.6 |

Footnotes:

1/ Heavy irrigation pertains to paddy crop; light irrigation to pulses, groundnut and other gardenland crops.
2/ From 1982/83 to 1988/89, there was a disruption in rabi irrigation due to construction of barrages under the project. Only pulses and groundnuts were irrigated.
3/ Full irrigation potential will be utilized from 1990-91 onwards.

D. Assumptions

1. General. For traded commodities like paddy, groundnut and jute, the economic prices were derived from the Bank's commodity forecasts 1995 (projected expressed in 1988 constant values with appropriate adjustments for freight, handling and processing). A standard exchange rate of US$1 to Rs. 14.7 was used for 1988 period. For non-traded commodities, market prices were multiplied by a standard conversion factor of 0.8.

2. Agricultural Wages. The wage rate is Rs.12 per manday for unskilled labor. The shadow wage rate of labor is taken as Rs.9.60 per manday (80% of Rs.12).

3. Inorganic Fertilizers have been valued at world market prices which on an average is 40% higher (1995 projected) than the domestic retail prices. The border prices for nutrients per kilogram were estimated as Rs.8.85 for N (Nitrogen), Rs.8.36 for P205 (Phosphate), and Rs.4.43 for K20 (Potash) in 1995 at 1988 constant values.

4. Crops. Paddy is the principal crop in the project area. Rice is, on the margin, a traded good for India, and Bank projections indicate that in the 1990s India is likely to be a net exporter of foodgrains. Consequently economic price of paddy was based on the assumption that production would be exported out of India. Groundnut was considered as an import commodity since edible oils are imported by India. India exports jute and accordingly the economic price was calculated.

5. Seeds, By-products and Farm Yard Manure. The economic prices for seeds, by-products and farm yard manure were calculated by multiplying the market prices by the standard conversion factor of 0.8.

6. Project Costs. The economic value of the project cost was calculated by multiplying the actual cost with the standard conversion factor of 0.8. The real economic cost (1988 constant) was computed by using wholesale price index.

7. Yield assumptions with and without project are very similar to that used in the Staff Appraisal Report.

E. Cost and Benefit Streams for a Total Command Area 167,000 ha (in Rs. million)

| | Incremental Costs | Incremental Benefits | Net Increm. Benefits | Incremental Costs | Incremental Benefits | Net Increm. Benefits |
|---|---|---|---|---|---|---|
| I. Under Proposed Cropping Pattern | | | | II. With Paddy as Predominant Crop | | |
| A. Under Existing Water Management System | | | | A. Under Existing Water Management | | |
| 1978-79 | 2.22 | 0 | -2.22 | 2.22 | 0 | -2.22 |
| 1979-80 | 7.87 | 0 | -7.87 | 7.87 | 0 | -7.87 |
| 1980-81 | 12.51 | 0 | -12.51 | 12.51 | 0 | -12.51 |
| 1981-82 | 46.62 | 0 | -46.62 | 46.62 | 0 | -46.62 |
| 1982-83 | 88.02 | 0 | -88.02 | 88.02 | 0 | -88.02 |
| 1983-84 | 168.42 | 0 | -168.42 | 168.42 | 0 | -168.42 |
| 1984-85 | 146.65 | 0 | -146.65 | 146.65 | 0 | -146.65 |
| 1985-86 | 164.88 | 0 | -164.88 | 164.88 | 0 | -164.88 |
| 1986-87 | 195.44 | 0 | -195.44 | 195.44 | 0 | -195.44 |
| 1987-88 | 129.29 | 0 | -129.29 | 129.29 | 0 | -129.29 |
| 1988-89 | 98.42 | 0 | -98.42 | 98.42 | 0 | -98.42 |
| 1989-90 | 45.26 | 144.63 | 99.37 | 45.26 | 45.43 | 0.17 |
| 1990-91 2/ | 12.2 | 156.19 | 143.99 | 12.2 | 49.1 | 36.9 |
| 1991-92 | 12.2 | 164.63 | 152.43 | 12.2 | 51.75 | 39.55 |
| 1992-93 | 12.2 | 173.07 | 160.87 | 12.2 | 54.41 | 42.21 |
| 1993-94 | 12.2 | 181.51 | 169.31 | 12.2 | 57.06 | 44.86 |
| 1994-95 | 12.2 | 189.95 | 177.75 | 12.2 | 59.72 | 47.52 |
| 1995-96 | 12.2 | 198.4 | 186.2 | 12.2 | 62.37 | 50.17 |
| 1996-97 | 12.2 | 206.84 | 194.64 | 12.2 | 65.02 | 52.82 |
| 1997-98 | 12.2 | 422.12 | 409.92 | 12.2 | 132.7 | 120.5 |
| 1998-99 | 12.2 | 422.12 | 409.92 | 12.2 | 132.7 | 120.5 |
| 1999-20 | 12.2 | 422.12 | 409.92 | 12.2 | 132.7 | 120.5 |
| 2000-29 | 12.2 | 422.12 | 409.92 | 12.2 | 132.7 | 120.5 |
| ERR | | | 14.10% | | | 6.00% |
| B. Under Improved Water Management System | | | | B. Under Improved Water Management System | | |
| 1978-79 | 2.22 | 0 | -2.22 | 2.22 | 0 | -2.22 |
| 1979-80 | 7.87 | 0 | -7.87 | 7.87 | 0 | -7.87 |
| 1980-81 | 12.51 | 0 | -12.51 | 12.51 | 0 | -12.51 |
| 1981-82 | 46.62 | 0 | -46.62 | 46.62 | 0 | -46.62 |
| 1982-83 | 88.02 | 0 | -88.02 | 88.02 | 0 | -88.02 |
| 1983-84 | 168.42 | 0 | -168.42 | 168.42 | 0 | -168.42 |
| 1984-85 | 146.65 | 0 | -146.65 | 146.65 | 0 | -146.65 |
| 1985-86 | 164.88 | 0 | -164.88 | 164.88 | 0 | -164.88 |
| 1986-87 | 195.44 | 0 | -195.44 | 195.44 | 0 | -195.44 |
| 1987-88 | 129.29 | 0 | -129.29 | 129.29 | 0 | -129.29 |
| 1988-89 | 98.42 | 0 | -98.42 | 98.42 | 0 | -98.42 |
| 1989-90 | 45.26 | 144.63 | 99.37 | 45.26 | 112.77 | 67.51 |
| 1990-91 | 138.73 | 156.19 | 17.46 | 138.73 | 121.88 | -16.85 |
| 1991-92 | 214.09 | 164.63 | -49.46 | 214.09 | 128.47 | -85.62 |
| 1992-93 | 297.35 | 173.07 | -124.28 | 297.35 | 135.05 | -162.3 |
| 1993-94 | 201.9 | 181.51 | -20.39 | 201.9 | 141.64 | -60.26 |
| 1994-95 1/ | 21.4 | 335.5 | 314.1 | 21.4 | 148.23 | 126.83 |
| 1995-96 | 21.4 | 350.41 | 329.01 | 21.4 | 154.82 | 133.42 |
| 1996-97 | 21.4 | 365.32 | 343.92 | 21.4 | 161.41 | 140.01 |
| 1997-98 | 21.4 | 745.56 | 724.16 | 21.4 | 329.4 | 308 |
| 1998-99 | 21.4 | 745.56 | 724.16 | 21.4 | 329.4 | 308 |
| 1999-20 | 21.4 | 745.56 | 724.16 | 21.4 | 329.4 | 308 |
| 2000-29 | 21.4 | 745.56 | 724.16 | 21.4 | 329.4 | 308 |
| ERR | | | 15.60% | | | 9.70% |

1/ From hereon costs represent maintenance costs.

TABLE 6-C

STUDIES

| Title of Study | Purpose as Defined at Appraisal | By Whom Carried Out | Reference in SAR | Status | Impact of Study |
|---|---|---|---|---|---|
| 1. Water Management Pilot Operations | To carry out water management pilot operations, including the construction of water courses and drains, and the introduction of Rotational Water Supply System (RWS) in a pilot area of about 1,000 ha. | Irrigation and Power Department (IPD); Command Area Development (CAD) and State Evaluation Organization (SED) of GOO. | Annex 3 Pages 1&2 | Physical systems are completed and the study is in progress. However, it would require a continuing long range effort of 4 to 6 years to accomplish the study objectives. | It has not so far made the desired impact. |
| 2. Drainage Master Plan (DMP) | To formulate a Drainage Master Plan for the whole of Mahanadi Delta area (30,000 ha) in order to prepare comprehensive solutions to the existing poor drainage situation in most parts of the project area. | Irrigation and Power Department (IPD); Bank Consultant Mr. B. Barber and Central Water and Power Research Station, Pune (CWPRS). | # 4.05 | Out of ten volumes of the Project Report for DMP, eight have been completed and sent to CWC. Final DMP duly reviewed by CWC was expected to be ready by Dec.31,1989. | The Study when completed and actually implemented in field should solve drainage of low lying areas; prevent breaches of river embankments; increase the CCA; raise the value of crop production; increase the crop intensity and have a great impact on the agriculture and socio-economic aspects of the Command. |

TABLE 7

## STATUS OF COVENANTS

| Covenants Reference | Subject | Status |
|---|---|---|
| Section 2.01 | GOO to carry out project with diligence and efficiency and in conformity with appropriate engineering practices & provide funds, facilities, services and other resources required. | Except for off and on financial constraints, GOO, in general, tried to allocate the needed finances for the project. Implementation of Mahanadi Barrage Complex had slippages due to poor performance of construction agencies. Prompted by the low performance of such agencies, the project management did initiate positive and result-oriented steps to complete the critical activities. |

Note: GOO is in compliance of all other Covenants.

TABLE 8-A

## STAFF INPUTS

| Stage of Project Cycle | Pre FY78 | FY78 | FY79 | FY80 | FY81 | FY82 | FY83 | FY84 | FY85 | FY86 | FY87 | FY88 | FY89 | FY90 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Preappraisal | 6.40 | | 5.20 | 22.10 | | | | | | | | | | | 33.70 |
| Appraisal | | | | 4.00 | 29.10 | | | | | | | | | | 33.10 |
| Negotiations | | | | | 2.60 | | | | | | | | | | 2.60 |
| Supervision | | | | | 7.20 | 18.90 | 9.50 | 12.70 | 14.70 | 11.60 | 15.80 | 14.80 | 2.10 | | 107.30 |
| Project Completion | | | | | | | | | | | | | 0.50 | 1.10 | 1.60 |
| Totals | 6.40 | 0.00 | 5.20 | 26.10 | 38.90 | 18.90 | 9.50 | 12.70 | 14.70 | 11.60 | 15.80 | 14.80 | 2.60 | 1.10 | 178.30 |

## BANK MISSIONS

| State of Project Cycle | Month/Year | No. of Persons | Days in Field | Specializations Represented 1/ | Performance Rating 2/ | Types of Problems | Comments |
|---|---|---|---|---|---|---|---|
| 1. Before Appraisal | | NOT AVAILABLE | | | | | |
| 2. Appraisal to Board Approval | | NOT AVAILABLE | | | | | |
| 3. Board Approval through Effectiveness | | NOT AVAILABLE | | | | | |
| 4. Supervision | 01/81 | 2 | 2 | EN | | | (Progress review of start-up activities |
| | 02/81 | 2 | 3 | EN | | | (on Mahanadi Barrages. |
| | 09/81 | 3 | 3 | EN | | PR | |
| | 12/81 | 2 | 3 | FIN/PROC | | | Proc. & Financial Review Mission. |
| | 02/82 | 4 | 7 | EN/EN/EC/EC | | T | Review & Assistance Mission for implementation of Pilot Water Management Project. |
| | 04/82 | 2 | 2 | EN/EC | | AG | Progress Review Mission |
| | 08/82 | 2 | 3 | EN/EC | | F/T | Progress Review Mission |
| | 11/82 | 4 | 8 | EN/EN/EC/EC | | M/T AG | Water Management Pilot Project Review Mission |
| | 12/82 | 2 | 2 | EN/EC | 2/1 | T | Supervision Mission |
| | 01/83 | 2 | 3 | EN/EC | | F/AG | Progress Review Mission |
| | 03/83 | 2 | 1 for 3 days 1 for 5 days | EN/EN | | T/AG | Mahanadi Pilot Project Progress Review Mission |
| | 06/83 | 3 | 3 | EN | 2/3 | | Periodic Supervision Mission |
| | 02/84 | 3 | 3 | EN/EC/EN | 2/1 | M/T | Periodic Supervision Mission |
| | 11/84 | 3 | 3 | EN | 3/2 | M/PR | Progress Review Mission |

| State of Project Cycle | Month/Year | No. of Persons | Days in Field | Specializations Represented 1/ | Performance Rating 2/ | Types of Problems | Comments |
|---|---|---|---|---|---|---|---|
| | 06/85 | 4 | 5 | EN | 3/2 | M/PR | Periodic Supervision Mission |
| | 11/85 | 4 | 5 | EN/EN/EN/PROC | 3/2 | M/PR/OR | Periodic Supervision Mission |
| | 12/85 | 1 | 3 | FIN | | | Financial Review Mission |
| | 05/86 | 4 | 8 | EN/EN/EN/AG | 3/1 | PR/OR | Periodic Supervision Mission |
| | 10/86 | 4 | 10 | EN/EN/EC/AG | 2/1 | M | Periodic Supervision Mission |
| | 04/87 | 1 | 2 | FIN | | | Financial Review Mission |
| | 05/87 | 4 | 8 | EN/EN/AG/EC | 2/2 | OR/M/T | Progress Review Mission |
| | 09/87 | 3 | 4 | EN/EN/AG | 2/2 | M/PR/AG | Periodic Supervision Mission |
| | 02-03/88 | 2 | 4 | EN | 2/2 | M/OR/T/PR | Periodic Supervision Mission |
| | 12/88 | 1 | 4 | EN | 2/1 | AG | Periodic Supervision Mission |

Notes: 1/ Abbreviations used: EN - Engineer; EC - Economist; AG - Agriculturist; PROC - Procurement Specialist; FIN - Financial Analyst; TRG - Training Specialist; OP - System Operation Specialist; HYD - Hydrologist.

2/ Performance ratings: 1st indicator; 1 - minor problems; 2 - moderate problems; 3 - major problems;
2nd indicator; 1 - improving; 2 - static; 3 - deteriorating.

3/ Abbreviations used: M - Management Problems; F - Financial Problems; OR - Organisational Deficiencies; T - Technical (Engineering) Deficiencies; OP - Incorrect Operation; P - Political Interference; LEG - Serious Covenant Non-compliance; AG - Deficiencies in Agricultural Support Services; PR - Procurement Infringement.