ASIAN DEVELOPMENT BANK **RES: INO XXX**

REEVALUATION

OF THE

BALI IRRIGATION SECTOR PROJECT
(Loan No. 522-INO)

IN

INDONESIA

December 1997

EXECUTIVE SUMMARY

A loan of $33.6 million was approved for the Bali Irrigation Sector Project on 17 September 1981. The Project was intended to increase food production, provide employment, reduce poverty, and strengthen institutional capability. The Project focused on the rehabilitation and expansion of 51 irrigation facilities (including a dam) covering 19,000 hectares (ha) and 5,000 ha, respectively. The Project was completed in November 1989. The Project Completion Report was circulated in June 1990 and the Project Performance Audit Report in June 1992. The latter stated that the designer's limited understanding of farmer-managed hill irrigation and of key physical and sociocultural traits resulted in shortcomings in the Project. Equitable sharing of water, competing claims on water, and watershed concerns were overlooked in the design of schemes under the Project. *Subak*[1] capabilities for operation and maintenance (O&M) were weakened due to the Project; a complex and uncertain situation had emerged. None of the beneficiaries reported a perceptible gain in output from the Project. Overall, the Project was rated as a partial success. The Project was reevaluated in July 1997.

The Reevaluation Mission (REM) found that the Project improved 31,900 ha of existing subak water systems and developed 1,850 ha of mostly new irrigation in the Palasari Dam and Air Sanih schemes. The Project's projections for irrigation expansion did not take into account realities on the ground. The principle of equity in water distribution was substituted for that of technical efficiency in Project design, with adverse consequences for water rights, subak ownership of the facilities created, and O&M responsibility essential for sustainable management. The Project attempted, unsuccessfully, to introduce irrigation scheduling, which is a complex and labor-intensive undertaking suitable for large plantations. This approach had to be modified in 1986 due to subak opposition and the inability of the Provincial Irrigation Department to handle irrigation scheduling due to shortage of staff. The special maintenance program restored a number of the subak-designed dividing weirs; subak members were responsible for making some of the other changes and repairs. However such structures still remain.

Farmers find improved weirs and canal lining provided by the Project very convenient. However, weir site selection and design were not always appropriate for mountain torrents, resulting in some failures. In several cases, the design of structures for sharing low flow conditions among subaks along the river were not properly designed, causing conflicts with downstream subaks. Where water sharing agreements had been negotiated with the subaks, the results were highly satisfactory. The Project should have fielded community organizers to facilitate formation of federations of subaks for water-sharing arrangements for entire watersheds.

The substitution of traditional fixed proportional dividers by gated structures that continually modified irrigation delivery resulted in deviations in water distribution from each member's irrigation allocation and led to complaints. Similarly, creation of common weirs for

[1] Subaks are traditional irrigation associations in Bali, which have existed for centuries, and are responsible for the construction, operation, and maintenance of local irrigation schemes.

different subaks without their consultation and without regard to long-standing water rights resulted in conflicts among subaks which were unresolved for a long time.

Upgraded weirs did not significantly increase water availability. However, system operation became more reliable at reduced O&M costs to farmers. The Project has resulted in increased cropping intensities, planned cropping patterns, and increased yields. It has augmented incomes. Some farmers are now able to get up to five crops of rice and one non-rice (*palawija*) crop every two years. The time saved from O&M allows them to engage in off-farm employment.

Upgrading subaks to technical standard required the Government to take over system operation. Thus, the Government now subsidizes the O&M undertaken earlier by the subaks on their own. This is against declared national policy. Subaks are unwilling to take over O&M without rebuilding key structures that would restore proportional water distribution.

The introduction of irrigation scheduling disrupted the relationship between subak members' rights and responsibilities. It contributed to the ongoing process of Government intervention in subak irrigation, undermining subak autonomy and water management capabilities. Reduction of O&M requirements has also helped enhance the sustainability of the subaks below 500 ha. Subaks over 500 ha are dependent on periodic maintenance by the Government, and neglect of such maintenance could have adverse consequences for the sustainability of Project benefits.

The Project has had no significant adverse environmental impact, but competing use of land, water, and forests from the agriculture, tourism, industry, and domestic sectors could lead to pressures on the environment.

The Project improved the reliability of water availability, made O&M easier for the subaks, and contributed to changes in cropping patterns and in increased crop intensities, paddy yields, and farmer incomes. The Project, however, had shortcomings in design, implementation, O&M responsibility, cost recovery, and sustainability, and contributed to the continuing erosion of the subaks' management capabilities. The REM's estimate of the economic internal rate of return (EIRR) for the Project as a whole is about 5.6 percent. Overall, postevaluation classification of the Project as partly successful is maintained.

Key issues for dealing with Bali subaks in the future are (i) thorough investigation of sustainable local resources management practices before consideration of institutional changes; (ii) provision for conflict resolutions through federations of subaks, and through apex associations of such federations; (iii) retention/return of Project ownership and O&M responsibilities by/to subaks; and (iv) enforcement of cost recovery, subject to restoration of physical facilities to subaks' specifications.

Lessons learned from the Project include the need to (i) investigate local institutions that Project interventions expect to modify, and support and strengthen local resources management systems; (ii) examine water use efficiency on a watershed basis rather than on the basis of individual systems; and (iii) involve beneficiaries in all stages of the planning, design, and implementation of projects and their subprojects, and consider beneficiary ownership an option for sustainable operation and maintenance.

It is recommended that a comprehensive study be undertaken to determine the suitability of different types of water distribution structures acceptable to subaks, for the formation of subak federations for watershed level water management and allied matters and for the apex assocations of such federations, and for improving subak systems with subaks retaining ownership. It is also recommended that all subaks below 500 ha have O&M responsibility turned over to them. The bigger subaks should be given the option to take over management of their system, or pay the irrigation service fees established by the Government. Regular periodic maintenance of weirs should be undertaken. A comprehensive plan should be prepared to allocate water among different uses over a period of time.

I. INTRODUCTION

A. The Island of Bali

1. Bali Province has a land area of 5,561 square kilometer (km^2)and a population of about 3 million, with a density of 540 persons per km^2. The economy of the island is predominantly rural and dependent on agriculture. The intense population pressure on Bali's natural resources has forced farmers to develop marginal lands. There is a significant and a growing tourist and associated handicraft industry, thanks to Bali's scenic beauty and distinct culture.

2. A volcanic mountain range, including several active volcanoes and four crater lakes, extends east to west along the center of the island. The island is heavily vegetated, particularly in the higher areas, except in the eastern parts. There are 162 named rivers with their origin in the mountain range. The flow of many of the rivers is augmented by springs. The rivers have cut deep ravines into the volcanic soils.

3. The soil in the Island is suitable for rice and nonrice (*palawija*) crops. About 80 percent of the rainfall is received during the rainy season between October and April; the rest of the year is relatively dry. The climate is ideally suited for year-round cultivation of rice, provided irrigation facilities are available.

B. Subak Irrigation in Bali

4. The more than 17,000 *subaks*[1] in Bali were formed as socioreligious, agriculture communities to develop and sustain irrigated rice production. Each subak is characterized by a common source of water with the subak's water temple in close proximity, one or more rice field temples, written or unwritten rules, and full autonomy for managing its own affairs. Subaks range in size from a few hectares (ha) to over 700 ha. A subak, with its carefully crafted rules, roles, rights, and responsibilities, is one of the world's best examples of a long-enduring, local resource management system.

5. The owner of land with a right to receive water from the subak is a subak member. The allocation of water from the system to subak members is quantified as a fixed proportion, or share, of the flow delivered to the first distribution structure. Shares are generally based on the contribution made to the construction of the system and unrelated to the size of the member's land holding or to the crop being grown. Shares are handed down from generation, to generation and in some cases traded. The right to receive water carries with it the responsibility to contribute to all subak activities, including system operation and maintenance (O&M). The level of responsibility is determined in the same way as it is for water allocation.

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[1] Subaks are traditional irrigation associations in Bali, which have existed for centuries, and are responsible for the construction, operation, and maintenance of local irrigation schemes.

6. Most subaks divert water from streams and rivers. A traditional weir consists of boulders and bamboo-strip gabions filled with stone. During periods of low flow, brush and leaves are used to reduce leakage through the weir. Since most streams serve many subaks, each with a weir, negotiated agreements have established arrangements for sharing water among subaks. Sharing arrangements in effect establish a watershed basis for water management that incorporates reuse of return flow and helps determine cropping patterns of the entire basin. These arrangements are continually confirmed through rituals that include passing holy water down through a hierarchy of water temples.[1] The supreme water temple is located at the uppermost water source in the watershed.

7. Many subaks have constructed tunnels to lead their canal safely out of the ravine to stable ground where an open, unlined canal continues to the first block of fields. Water distribution from the main canal to smaller canals and eventually to each member's field is generally done using weirs with rectangular openings, each at a uniform crest elevation.[2] The width of the opening to each offtake canal, relative to the width of other openings, determines the share of water it delivers. This proportional share of the irrigation supply is delivered regardless of fluctuations in canal discharge. By using these easy to monitor structures, subak members are assured of receiving their share of the available canal discharge at all times.

8. Given the unusual nature of the subak arrangements and the high profile of the area, it was inevitable that they would attract intervention from aid agencies.

II. BACKGROUND

A. Project Objectives, Scope, and History

9. A loan of $33.6 million was approved for the Bali Irrigation Sector Project (BISP) on 17 September 1981. Appendix 3 gives a brief history of Bank assistance to Bali's subaks. The Project was intended to increase food production, provide employment, reduce poverty, and strengthen institutional capability. The Project scope included (i) rehabilitation and expansion of 51 irrigation facilities (including a dam) covering 19,000 and 5,000 ha, respectively; (ii) establishment of water management centers and strengthening of the hydro-meteorological network; (iii) groundwater studies; and (iv) consultancy services for detailed design and construction supervision. The subprojects were to be planned, implemented, and operated with the subaks. The Executing Agency of the Project was the Directorate General of Water Resources Development (DGWRD).

10. Implementation of the Project was completed in November 1989. The Project Completion Report (PCR) was circulated in June 1990, and the Project Performance Audit Report (PPAR) was circulated in June 1992.

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[1] See Appendix 1 for details about water temples and the significance of holy water in the coordination of subak in a watershed.

[2] See Appendix 2 for a sketch and details about the subaks' proportional flow dividers.

B. The Project as Implemented

11. At Project completion, it was found that during implementation, the number of subprojects upgraded under the Project was increased to 76, covering 169 irrigation schemes over 33,800 ha, an increase of 41 percent. Irrigation was extended to 406 ha of paddy land. The length of rural roads upgraded increased from 103 km to 245 km. Some additional groundwater studies were carried out. Resulting from this, the Air Sanih spring development scheme was included and implemented. Inadequacies in the system facilities resulted in a special maintenance program under the Project for 34 subprojects[1] at a cost of $2.5 million. Training was ineffective. The hydro-meteorological facilities have not been used effectively. The low cut-off criterion in the Appraisal Report (AR) of 150 ha for the eligibility of schemes was inappropriate[2] and was not followed; several small schemes were lumped together into one subproject. Project coordination was insufficient, specially with regard to formation of system-wide *subak gedes* or federations of subaks. Design deficiencies included (i) substitution of the principle of equity in water sharing by hydraulic efficiency; (ii) inappropriate design for hill conditions; (iii) selection of subprojects on the basis of spreading development throughout the island rather than on the basis of streams, with potential conflicts resulting; and (iv) overestimation of dry-season flows. Participation of water users' associations (WUAs) was limited. About 30,500 ha, or 90 percent, of the total irrigable area under the Project was irrigated with an average cropping intensity of 233 percent. Average paddy yields were marginally higher than projected at appraisal: 4.3 tons per hectare (t/ha) versus 4.1 t/ha, but the appraised without-Project yields were too low, so that with- Project incremental benefits were overestimated at appraisal, and were actually lower. Farm incomes were lower than appraised. The PCR did not calculate the estimates of the economic internal rate of return (EIRR) of the whole Project, but its estimates of EIRRs for four out of five subprojects were substantially lower than appraisal estimates.[3] O&M did not proceed as planned as allocation of funds for it was inadequate. A total of $25.5 million was used out of the Bank's loan, which was closed on 19 April 1990.

C. Postevaluation Findings

12. The PPAR states that the Bank had limited experience with mountainous irrigation schemes. The experience of DGWRD was insufficient for a sector loan. The designer's limited understanding of farmer-managed hill irrigation and key physical and sociocultural traits resulted in shortcomings in the Project. Equitable sharing of irrigation water and competing claims on water were overlooked. The Project did not provide adequate beneficiary participation. The irrigated rice yields of about 2.4-2.6 t/ha for the before-Project and the 2.6-2.9 t/ha for the without-Project situation quoted in the AR were too low. Appraisal costs were substantially overestimated. Traditional flow dividers were replaced by structures that resulted in gates being blocked by silt and debris and in the gate openings being submerged by water, which in turn prevented visual monitoring of water sharing. Canals overflowed, breached, and destroyed terraced rice fields.

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1 Two of these were from Loan No. 352-INO: *Bali Irrigation Project (BIP)*, approved for a loan amount of $18 million on 7 September 1978.

2 The Project Performance Audit Report (PPAR) commented that this resulted in the initial exclusion of one-fifth of the potential area that comprised most of the poorest farmers' schemes.

3 The PCR recalculated the EIRRs for five of the seven sample subprojects evaluated at appraisal.

13. According to the PPAR, the staff of DGWRD accepted without question the data and results from consultants for appraisal of subprojects. The criteria for selection of schemes overlooked watershed concerns. Also partially neglected were water availability, traditional rights, and aspects of hill irrigation ecosystems. Compliance with O&M covenants was partial because of inadequate funding and subaks' resistance. The program for collection of irrigation service fees was not in place, and it was not clear whether the shift of O&M responsibilities from subaks to the irrigation agency should be enforced.

14. In the PPAR's assessment, the Project contributed to strengthening the Provincial Water Resources Service (PWRS), but subak capabilities specially for O&M had been weakened by this intervention. O&M of the weir and main canal was taken over by the Government, so subaks lacked ownership of the schemes, which they originally constructed. The social cohesiveness of subaks had declined, and a dependency syndrome had developed. The PPAR suggested that institutional assistance could help. Some of the schemes under the Project could not be handed back to the subaks because of technical complexity and divergence from locally evolved practices. The PPAR further suggested that farmer ownership, supported by institutional strengthening and credit, must be a criterion for irrigation projects. A complex and uncertain situation had emerged. The desirability and extent of continuing Government involvement needed to be addressed.

15. According to the PPAR, it was difficult to assess the Project's impact on production. Reliable data from various schemes were scarce. Even without the Project, yields and cropping intensities in Bali had increased because of the introduction of high-yielding varieties (HYVs) of rice. None of the beneficiaries interviewed reported any perceptible gain in output from the Project. The Project had some impact on wet-season rice, and a larger impact on the yields and cropping intensities for dry-season rice and other crops. The PPAR's estimate of the EIRR of the Project as a whole was 7 percent as against 25.7 percent at appraisal. The Project was a partial success on an overall basis.[1]

16. The PPAR recommended that (i) the significant rise in pesticide poisoning should be checked; (ii) the question of ownership and responsibility and funding for O&M should be resolved to prevent the schemes from deteriorating; (iii) successful pilot associations of subaks should be replicated; and (iv) Government resources should be provided to modify Project facilities to meet farmer needs and ensure sustainable production gains.

D. Reevaluation Rationale, Objectives, Focus, and Sources

17. The PPAR recommended that the Project be selected for reevaluation. The irrigation sector is one in which the Bank is active, and is likely to be active in the foreseeable future, in Indonesia and elsewhere. This was the first sector loan in a high-profile area. The O&M results for this Project run counter to the Bank's established policy of transferring O&M responsibilities to WUAs; interestingly this has happened in an area where traditionally WUA management has been sound and sustainable. Some of the findings of the PPAR were

[1] Disagreement was voiced by the Projects Department and by DGWRD with the PPAR's estimates of yields in the before-Project and without-Project situations, to differing schemes selected for postevaluation, and to the assessment of the Project weakening the subaks.

disputed by the Government and Bank staff. The Project's rating as partly successful could be amended either way, depending on subsequent actions and developments.

18. The focus of the reevaluation is on (i) the operations of the subprojects five years after postevaluation; (ii) the magnitude of Project benefits and their sustainability; (iii) an attempt at reconciling differences in the perceptions of different Government and Bank personnel dealing with the Project; and (iv) a deepening of the PPAR findings on relevant aspects of the Project in light of subsequent experience and literature. Pertinent aspects of the Project have been reevaluated. This reevaluation is based on the visit of the Reevaluation Mission (REM) to Bali and to five subproject sites in July 1997; discussions with serving and retired Government officials, subak chiefs, Project beneficiaries, international experts on subak systems, and priests at water temples; and on Bank files, Government data and statistics, and publications of international standing. Copies of the draft report were provided to the Borrower, the executing agency, field offices, and concerned Bank staff for review and comments. Comments received have been taken into account before finalizing the report.

III. REEVALUATION FINDINGS

A. Project Design

19. Project preparation was undertaken from August 1979 through February 1981 under a technical assistance (TA) grant.[1] The terms of reference (TOR) for the consultants were inadequately prepared and simply stated that "the feasibility report will be complete in technical, socioeconomic, financial and institutional detail..." They did not call for an evaluation of the institutions and technology developed by subaks, despite information emerging in the early 1980s that inappropriate assistance to farmer-built and operated systems, such as the subaks, was weakening viable resource management systems.[2] The Project designers failed to recognize and accommodate the relationship between the technologies employed by the subaks to ensure water rights and O&M responsibility essential for sustainable management. Investigation should have been made of traditional technologies used for proportional irrigation distribution and tunnel design and construction.[3] The consultants considered the Project primarily an engineering design and construction activity, when in hindsight it is clear that the

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1 TA No. 244-INO: *Bali Irrigation*, for $150,000, approved on 7 September 1978, accompanying the Bali Irrigation Project.

2 In the 1960s and 1970s numerous anthropologic field studies such as Geertz's (1967) on Balinese subak, were undertaken. In the same period, Grader's (1960) irrigation ethnography provided a straightforward description of the "ideal" subak organization. Social scientists gave early support to the value of strong social organization for resource management as often found in traditional irrigation societies, but at the time of Project preparation, most irrigation professionals remained unconvinced that simple farmer- operated schemes could be effective. Engineering studies in the early 1980s showed that farmers could, through intensive management, overcome the deficiencies of simple technology to achieve water use efficiency and agriculture production results comparable to technically sophisticated systems. Although much of this work was contemporary with the design of the BISP the findings were not taken into account by Project designers.

3 Proportioning weirs designed by subaks are central to enabling equitable water sharing, tunnels are effective for safely conveying the irrigation supply out of the steep-sloped ravines, and Balinese construction workers specialized in this technology were available.

Project should have concentrated on processes for enabling subaks to access technical inputs that improved manageability, lowered O&M costs, and increased sustainability.

20. Given that (i) improvements to subak irrigation under the BIP were just starting, and meaningful experience regarding the appropriateness and acceptability of the technology and approach being used was not yet available; and that (ii) both the Bank and DGWRD had limited experience in providing assistance to farmer-managed irrigation schemes,[1] the sector loan approach was not suitable. The Provincial Irrigation Service (now PWRS), the provincial arm of DGWRD, was a relatively weak agency prior to the Project.[2]

21. The Project design called for upgrading traditional subak systems to the "technical" system level.[3] Technical systems use irrigation scheduling to determine the crop water demand and to assign irrigation delivery in proportion to the demand.[4] To implement irrigation scheduling, adjustable structures are required at each important offtake. When correctly implemented, irrigation scheduling provides efficient use of the irrigation supply, which was the design objective. This objective had to be modified during Project implementation (para. 24).

22. The 150 ha cut-off criterion for selecting subprojects under the sector loan was too high for a mountainous area. It excluded many of the poorest subaks. During implementation adjacent subaks were combined, so that the aggregate area was greater than 150 ha and therefore qualified for a scheme. This was a cost-effective approach, but effective implementation required the support of organization facilitators or community organizers, which was not built into the Project design.

23. Project design called for expansion of irrigated paddy by 5000 ha. This was based on the expectation that upgraded infrastructure and more efficient irrigation would save water and make it available for new land. Project design failed to recognize that most subaks had already extended paddy cultivation to all available land where water resources were available.

B. Implementation

1. Engineering Aspects

24. Irrigation scheduling, as intended for technical systems, is a complex undertaking. At regular ten-day intervals, field data are collected to analyze the crop water

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1 Experience of the Bali Irrigation Project was in lowland irrigation schemes, whereas the schemes under the Project were mostly highland schemes. The consultants also had limited experience with local conditions.

2 Considerable institutional strengthening and training provisions were included in the Project design to remove these weaknesses.

3 See Appendix 1 for a discussion about technical systems and the underlying assumptions relating to design and water allocation.

4 The subak concept of irrigation allocation allows irrigation distribution to be done with proportional flow dividing structures that require no adjustment.

requirement and to calculate the irrigation demand. Hydro-meteorological data are used to predict the water availability for the next irrigation period, and the delivery is adjusted uniformly so that the available irrigation supply is proportionally allocated to the crop needs. This exercise is necessary to determine the gate settings for the distribution system. Correctly implemented, irrigation scheduling is the most efficient way to use scarce water resources to meet crop needs. It works best where the same crop is grown in large blocks, such as in sugar plantations in Java. It is unmanageable and costly for small systems with a group of small landholders such as the Bali subaks. Faced with evidence that PWRS could not manage irrigation scheduling for lack of sufficient staff, and with mounting opposition from subaks to the changes being made to their traditional method of water distribution, the approach of the Project was modified in 1986 to accept increased design input from subaks for distribution system improvements. Thus, irrigation scheduling was never actually implemented.

25. Considerable reconstruction was required in some systems to restore traditional proportional dividing structures. These had been replaced by masonry division boxes with narrow openings that did not maintain distribution according to members' shares and were easily blocked by floating debris. The special maintenance program restored a number of the subak-designed dividing weirs. Subak members were responsible for making some of the changes and repairs using their own financial resources under coordination with the Project authorities. Additional requests were also accommodated using the Government's budget. However such structures still remain.

2. Institutional Aspects

26. It has been demonstrated that it was possible to facilitate formation of a federation of subaks to provide the organizational structure necessary for subaks to maintain their independence within subak activities but to act jointly on decisions and activities that affected the larger group. [1] During implementation, as the importance of this issue became apparent, the Project approach should have been modified. Facilitators should have been fielded in locations where it was proposed to combine subaks to use a common weir; the facilitators could have assisted in the formation of a federation of subaks that could then participate in designing the water-sharing arrangements.

3. Consultancy Services for Project Implementation

27. Response to feedback on problems with irrigation scheduling and subak management of Project facilities was late. As a result, inappropriate designs were used until almost the end of the Project (para. 28). Most of the work required to restore proportional distributions structures, some of which was carried out under the special maintenance program launched to correct defects introduced by the Project (para. 11), would have been avoided if the design had been changed earlier.

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[1] See Appendix 1, para 11 for discussion of a participatory approach used by Udayana University. It illustrates a process for assisting in the formation of a federation of subaks.

28. The major failing of the consultancy services provided under the Project was in the area of investigations and detailed design, and in specifications for subprojects, which constituted the bulk of the work under the Project-financed consultancy services. This was due certainly in part to the TOR of consultants as contained in Appendix 12 of the Appraisal Report, which were overly engineering oriented and did not pay attention to beneficiary participation or sociocultural aspects. There were also shortcomings, in that consultants did not always adapt the technical design to the hill irrigation conditions in Bali (for example, the Palasari Dam had to be substantially redesigned by the same consultants). The consultants could have followed a process approach, i.e., they could have used feedback from earlier schemes to improve later ones.

29. A key element in the Project strategy to boost crop production through better irrigation management was to provide training at the Water Management Training Center (WMTC). The plan was to train about 80 people each year. WMTC is functional, and training there has been resumed with 80 or more trainees in each of the past three years.[1] In addition to provincial irrigation staff, WMTC provides training to subak chiefs and members. The trainees find it a convenient forum to air their concerns and draw attention to their problems. Increased funds can lead to more effective utilization of WMTC.

C. Operational Performance

1. Irrigation Achievements at Reevaluation

30. The REM found that the Project improved and extended 31,900 ha of existing subak systems in south-central Bali (an increase of 68 percent over the appraisal target) and developed 1,850 ha of new irrigation (a shortfall of 63 percent in the appraisal target), specially in the Palasari and Air Sanih schemes. The Palasari Dam scheme in western Bali converted about two thirds of its area from rainfed to irrigated production. The Air Sanih pump scheme installed pumps to lift water from a spring to a reservoir. Distribution from the reservoir is by gravity through pipes to taps in the command area.

2. Engineering and Institutional Aspects of Irrigation Schemes

31. In general, improved (masonry) weirs and canal lining provided by the Project are greatly appreciated by beneficiary farmers. However, site selection for weir construction and weir design were not always appropriate for mountain torrents, resulting in some failures.[2] In

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[1] The Project Manager (PM) of the Proyek Irigasi Bali or Project Irrigation Bali (PIB), the field office handling irrigation projects in Bali, has pointed out that starting 1996/97 about 2,000 participants (over 50 percent of whom would be subak members) would be trained at the WMTC under the ongoing Integrated Irrigation Sector Management Project (approved for an amount of $100 million on 20 January 1994).

[2] The PM PIB has pointed out that all such technical design deficiencies of a serious nature, which occurred prior to 1986, have been rectified under the special maintenance program or under the annual O&M program

numerous cases the structures for sharing low-flow conditions among subak along the river were not properly designed, causing conflicts with downstream subaks. Where prior consultation and negotiated water allocation agreements were made among affected subaks and appropriate structures were designed to distribute the water according to the agreement, the results have been highly satisfactory.

32. Upgrading subak systems to technical standards had other consequences that were not understood during Project design, because the institutional relationships had not been investigated. Irrigation scheduling required gated control structures at many locations where subak used fixed proportional flow dividers. Operation of gated structures continually modified irrigation delivery, and therefore distribution no longer matched each member's irrigation allocation or share of the available discharge. When distribution was reduced below a member's share, it caused many complaints from individual farmers and subak leaders.

33. Since subaks are created around their own source of water, most have their own weir. Combining subaks enabled the Project to upgrade one weir to benefit multiple subaks. While this was a cost-effective approach, the Project did not recognize the complexity of long-standing water rights negotiated among subaks along a river or of how contentious it was to form new relationships. The subaks were not sufficiently involved in the decisions that related to their being combined to use one weir or in the irrigation allocation decisions for sharing the irrigation supply among the new grouping of subaks. This resulted in many conflicts, some of which remained unresolved for long periods. In such cases the Project should have facilitated the process of forming federations of subaks *(subak gede)* prior to making improvements (Appendix 1). However by now federations of subaks have been formed in all BISP schemes, and provide a mechanism for conflict resolution.

34. The Palasari reservoir has a small catchment, and in the dry years from 1990 through 1992 less than 150 ha of paddy could be grown in the dry season. However, since 1992 the reservoir has filled each rainy season. Inflow estimates used for Project design have been correct for five of the eight years since the dam was completed. In recent years the reservoir filled, and rice was grown on over 450 ha in the first dry season with palawija crops irrigated on the remaining 850 ha of command area. Palawija crops are also grown on part of the command area in the second dry season, leading to a cropping intensity as high as 275 percent.

35. The Air Sanih Pumping scheme developed 311 ha that is irrigable for nonrice crops. Of this area, the Project assisted in developing 195 ha, and the rest was developed using local funds. Farmers now grow palawija crops of mainly maize, sweet potato, red bean, banana, and chilies on about 60 ha. Perennial crops of mango and coconut also benefit from irrigation of the palawija crops. Except for a two-week period when an electricity supply disruption caused crop damage, the Air Sanih Pumping scheme has been operating reliably. There is a problem, however. At high tide sea water sometimes enters the collection area at the spring.[1] As a result, sea water is pumped through the distribution system and causes damage to salt-sensitive crops.

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of the Government and that no serious design and construction deficiencies currently undermine the operation of the Project hill irrigation facilities.

[1] This was the observation of the REM during its visit. However, the PM PIB subsequently indicated that this problem has been solved by the construction of a new intake wall. In any case, periodic maintenance of the intake protection wall must be undertaken.

3. Increase in Water Availability

36. Assistance to subak systems enabled irrigation to be extended to 406 ha of paddy land as compared with the planned 5000 ha. Most potential paddy land had already been developed by the subaks. Where land was available, water was generally the factor limiting expansion. Upgraded weirs and canals did not significantly increase water availability during critical periods of shortage but increased certainty of both quantity and timing of water delivery during critical periods of shortage.[1] In many cases downstream water rights exist, so diversion of what appeared to be extra water was not possible. Where individual subak systems are not efficient in extracting and conveying their irrigation supply, the losses return to a stream and are used and reused by other subaks. In the context of the subaks, evaluation of irrigation efficiency must consider an entire watershed rather than individual systems.

37. In upland locations where land and water were available, it was found that farmers preferred to grow high-value, irrigated, nonrice crops. Although expansion of paddy cultivation did not meet Project design expectations, in the farmers' perception, the system operation became somewhat more reliable[2] at greatly reduced O&M labor and management cost to them, enabling them to expand cultivation in the dry seasons to realize higher cropping intensities.

4. Impact on Yield and Cropping Intensity

38. The Appraisal Report used a pre-Project (1980) average yield of 2.4 t/ha in the wet season and 2.6 t/ha in the dry season, and expected this to rise on Project completion to 4.0 t/ha during wet season and 4.3 t/ha during the dry season.[3] The cropping intensity in 1980 was 173 percent and was expected to rise to 232 percent. The actual average paddy yield in Bali in 1996 was 5.5 t, and actual cropping intensity was 245 percent[4] (Appendix 4, Table 9). This was due to the more reliable availability of water at the time needed, increased use of HYVs, more effective use of fertilizer, and decreased use of pesticides due to the adoption of the integrated pest management (IPM) program. The Project was perceived by beneficiaries to have increased agricultural output, led to changes in the way cropping patterns were planned, and augmented incomes (Appendix 5).

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1 During periods of water shortage, subak members clean their canals and seal leaks to save water. Apparent inefficiencies are temporarily overcome for short but critical periods.

2 Reliability in this context means that, with improved structures for diversion, it is more difficult for water to escape even without maintenance, and delivery to each farmer is more certain in timing and quantity. During the rainy season, frequent floods damage the traditional nonmasonry diversion weirs and cause landslides that break canals. Until repairs are done, it may not be possible to deliver water and water stress can result if there is even a short period of water without rainfall. There is a general deterioration of the diversion, and canals during the rainy season sometimes require extensive maintenance.

3 The PPAR used figures of 3.8 t/ha and 3.2 t/ha for the wet and dry season in the pre-Project scenario.

4 In some of the schemes the REM visited, paddy yields were reported to be as high as 7 t/ha and cropping intensity as high as 275 percent, though the intensity of paddy cropping in such cases was lower. On the other hand, there were individuals who did not think the Project had made any difference to their yields or cropping patterns.

5. Operation and Maintenance and Cost Recovery

39. Upgrading the subaks to a technical standard required the Government to take over system operation. This was necessary to implement the irrigation scheduling program, considered essential for efficient operation. It conflicts, however, with the Government's national turnover policy that went into effect in 1987, requiring all systems under 500 ha to remain with, or be turned over to, WUAs for O&M (over two thirds of the Project-assisted subaks, even many that were grouped under one weir, are in this category). Systems larger than 500 ha do not fall into the Government criteria for turnover and will remain jointly managed by the PWRS and the subaks. The current O&M arrangements, under which funds are provided to PWRS for O&M on a per hectare basis, with no distinction for schemes below 500 ha and above 500 ha, have different implications for sustainability of facilities in these two categories.

40. For schemes under 500 ha, the subaks were unwilling to take over their former role as owners and managers of the entire system without rebuilding key structures that enabled them to restore proportional water distribution. Thus one major, if less visible, consequence of gated control structures was their potential disruption of O&M responsibility, especially in these schemes. A subak member's right to irrigation is balanced by an equal responsibility to share in all subak activities, including the cost of O&M of system. Shifting the method of irrigation allocation from members' shares to crop needs, made it difficult to monitor equity in irrigation allocation. This caused confusion and reluctance to accept responsibility for O&M. Although in most cases O&M has, in practice, largely reverted to the subaks after Project inputs were complete, and subaks are managing the irrigation distribution, formal turnover of below 500 ha systems assisted by the Project has been limited to 17 subaks covering an area of 933 ha. Project inputs have nevertheless made this group of subaks more sustainable by reducing their O&M costs. Much less effort now needs to go into maintenance, because labor and management requirements for maintenance are reduced.

41. The divided or unclear responsibilities for the O&M of these below 500 ha irrigation schemes has not so far adversely impacted their operational performance or agricultural production; the subaks are always there as a back-up arrangement. In some schemes, where the canal openings are theoretically being operated by PWRS functionaries, in practice they are often being operated by subak chiefs or members on behalf of PWRS officials. Subak members are not about to allow a deterioration of their schemes, and collectively continue to maintain their systems in a sustainable condition. (No subak in this group is known to have gone out of existence because of lack of maintenance).

42. When the Government became owner of the weir and other structures built by the Project, maintenance of these structures became its responsibility. Now farmers only contribute to maintenance of the Government-built structures at times when irrigation delivery depends on their input. Normally, they sit back and see what they can receive from PWRS in terms of O&M, but if crops are threatened, and PWRS response is slow or inadequate, they take over O&M responsibility. Even though Project improvements dramatically reduced the cost of maintenance, the Government subsidizes what subaks previously paid for on their own. Annual Government subsidies for O&M since 1992 averaged about Rp12,000/ha for Project systems. In schemes under 500 ha, PWRS staff could be removed without any risk to

agricultural production. Subaks would keep up adequate O&M for long-term sustainability without the need for further periodic rehabilitation, except in emergencies such as volcanic disasters or severe floods.

43. In systems larger than 500 ha, PWRS is responsible for the O&M not only for the weirs but also for the main canals and, in some cases (as in Gerana), even the secondary canals and tertiary canal openings. Establishment costs represent the first claim on PWRS funds, so that if the funding is not enough, maintenance does not get done. In such cases, if diversion gates and canals do not function properly for lack of maintenance, agricultural production can suffer. Periodic system upgrades are undertaken to restore the systems. Although optimal production is best served by continual maintenance, the PWRS opts for deferred maintenance or periodic rehabilitation with funds provided by the Government. Such periodic rehabilitation would be essential for system sustainability in the larger schemes. However, even here, all secondary canal maintenance could be turned over to subaks.

44. It can be concluded that improved diversion weirs and lining sections of main canals improved the operational performance by reducing subak maintenance requirements (cost and drudgery) and have therefore made the system more reliable and sustainable. However, this is not without the risk of system deterioration if periodic maintenance is neglected by PWRS.

45. Subak members of the Air Sanih pumping scheme pay an irrigation service fee of Rp17,500/ha/month for using one of the system's water taps. The fee is computed to cover the O&M budget based on payment from the entire developed area. Unless rates are changed, O&M costs will need to be subsidized until all developed area is utilized and farmers pay the user fees.

D. Roads

46. The 245 km of rural roads constructed under the Project helped to intensify the network of roads in the inner areas of Bali. Better roads made movement of agricultural production easier and provided greater mobility, leading to easier access to jobs in the nonagriculture sectors. The maintenance of the roads is variable.

E. Institutional Impact

47. The Project had a major impact on strengthening PWRS. To a lesser extent, it also strengthened the provincial department of agriculture. The Project-financed WMTC continues to play a role in staff and subak leader training.

48. Subaks welcomed Project assistance for weir construction and canal improvement and willingly gave up control of the weir. They realized a savings in maintenance cost and relief from the inconvenience of frequent trips to the weir to make repairs. However, loss of ownership of the weir and main canal reduces the subaks' bargaining power with upstream and downstream subaks over water rights, and in the long run, weakens the subaks' management capability.

49. In some subaks, government staff operate the system down to the tertiary canal level. In other cases, subak leaders are paid a retainer by the local government to carry out tasks that were the responsibility of the subak in the past. The practice of government taking over subak management functions results in a subsidy subaks generally did not request, and subsidy not to them alone. It could have been assumed that this O&M subsidy will be unpopular to withdraw in the process of turning over systems less than 500 ha. But this is not the case. Subaks are willing to take over responsibility of the irrigation distribution facilities without further O&M subsidies from the Government provided that, at the moment of the turnover, the irrigation facilities are in good operational condition. This goes to show that subaks consider government intervention not worth the subsidy they receive. Government takeover of O&M responsibility has impacted on the legitimacy of the irrigation service fee presently being implemented. Farmers perceive the irrigation service fee to be overstated and do not want to subsidize government operations.

50. Introduction of irrigation scheduling modified the principle of water allocation by fixed shares, and disrupted the relationship between subak members' rights and responsibilities. Irrigation scheduling has been abandoned, and in most locations, the proportional dividing structures have been restored. The reason given for modifying the Project's approach, however, was not that it undermined subak members' responsibility but that it lacked staff for proper implementation. The rights and responsibility relationship is fundamental to the functioning of the subaks. Continuation of the Project's original policy of irrigation scheduling could have destroyed or at least dramatically reduced the subaks' effectiveness.

51. Water temples and rituals associated with the subaks are extremely important in unifying the community of irrigators both within a subak and over the watershed. In the past the priests had a major role in coordination among subaks along some rivers. This included coordination of cropping patterns that enabled water sharing, pest management, and reduction of conflicts over the use of scarce resources. Government intervention to improve irrigation since the pre-independence period has steadily eroded the influence and authority of the temple system. By not taking into account the socioreligious side of subak irrigation, the Project contributed to this decline. It is not possible to single out the Project as the cause for shifting irrigators' queries about access to water sources and water allocation from the priests to the Government, but it has certainly contributed to an ongoing process. The water temple system is not about to collapse, but it has been weakened by the Project. One indication that the Government now understands and accepts the importance of religious practices is that the establishment of water temples is now considered a part of new weir construction.

F. Socioeconomic Impact

52. The Project has had a positive socioeconomic impact on beneficiaries in the Project area. In the rapid socioeconomic survey in the five schemes visited by the REM (Appendix 5), farmers indicated they were able to get up to 5 crops of rice and at least one

palawija crop every two years.[1] Net income per hectare in these five schemes ranged between Rp2,000,000 and Rp6,000,000. One major benefit of the Project to farmers was reduced time for maintaining the traditional subak-built weirs. This allowed them more time to engage in off-farm employment, for which there are growing opportunities in Bali, facilitated by Project roads.

G. Impact on Women

53. The landowner who receives water is the subak member. Since most land in Bali is registered to males, subak members are predominately male. When there is no male heir, women become landowners and subak members. As a fine must generally be paid if a member is not represented at a subak meeting, women do attend if no male is available to go. Given the increasing level of off-farm employment, the gender situation is changing rapidly. There are already subaks in which women are very active. For example, at a subak in western Bali, whence many male household members had migrated for employment, 18 women and 3 men attended a subak meeting. Irrigation and agriculture extension staff need to include women in Bali for training and information exchange if they are to continue reaching the population most active in agriculture.

H. Environmental Impact

54. Roads constructed under the Project do not appear to have had an adverse environmental impact. The rock quarry site used to supply rock for the Palasari Dam is now covered with dense natural vegetation. Environmental monitoring does not indicate adverse environmental impact from fertilizer and pesticide use. Tests on water quality unrelated to the Project indicate that nitrogen content and suspended solids are within the tolerance limits prescribed by Government. The success of IPM program resulted in sharp decline in the use of pesticides from 37,425 t in 1984 to 5,771 t in 1992, which has stabilized at about that level.

55. In Bali, about 1,000 ha are being converted annually from agriculture to other use mostly for tourism development, city expansion, and settlements. Currently, there is a large surplus of surface water in southern Bali, and shortages in the north. The possibility cannot be ruled out that a shortage of surface water may develop in some other watersheds. From an assessment of water balance for domestic and urban uses, it is predicted that a deficit of water in Denpasar and in some other areas may develop between the years 2005 and 2015. This will impinge on the availability of water for horticulture, as springs and groundwater supply water for both purposes. Although there has been no decline in forest areas during the recent years, plans are afoot to improve upper watersheds by reforestation and regreening, and to establish dams. The competing use of land, water, and forests among the tourism, industry, and domestic sectors could lead to pressures on the environment. Appendix 6 presents the salient features of the environmental impact assessment carried out during the REM.

[1] Farmers were unable to isolate the contribution of the HYVs and integrated pest management (IPM) to these developments.

I. Economic Reevaluation

56. At appraisal, the economic internal rate of return (EIRR) of the Project was estimated at 25.7 percent, and for the seven sample subprojects,[1] it ranged from 19 percent to 31 percent. The PCR reestimated the EIRR for five of these subprojects as ranging from 7.2 percent to 29.7 percent, but did not estimate the EIRR for the Project as a whole.[2] The PPAR estimated the EIRR of the whole Project to be about 7 percent.

57. REM estimates of the EIRR are about 5.6 percent (see Appendix 4). For the future without-Project scenario, the REM used the PPAR data, which assumed a 2 percent increase in average yields of paddy per hectare planted, and cropping intensities of 215 percent.[3] For the future with-Project scenario, the REM used the actual average production data for 1996 provided by the Ministry of Agriculture (MOA) of 5.5 t paddy per ha and the actual cropping intensities for the Bali province of 245 percent.[4] Lower actual paddy prices for the years since appraisal and low price forecast for the future have had a substantial impact on the EIRR.

58. Sensitivity analysis was conducted on changes in key assumptions and in the EIRR (Appendix 4, Table 20). The EIRR is most sensitive to change in paddy yields. It is interesting to note that, if MOA figures for without- and with-Project scenarios are adopted, the EIRR yields are negative (Appendix 4, para. 13).

J. Project Sustainability

59. By reducing the labor and management requirements from subaks of the irrigation schemes below 500 ha, the Project has contributed to their sustainability. However, Government takeover of the weir and main canals of subaks in the larger schemes has had a detrimental impact on system sustainability due to the absence of continual maintenance and the priority for establishment costs in the PWRS budget. Investment in maintenance is no longer determined on the basis of individual system needs, as it was when the subaks were responsible. When additional maintenance is required, funds are not available from the general budget. Subaks are reluctant to invest their own funds in what they now perceive as Government responsibility. System deterioration has to reach a point at which funds for rehabilitation must be provided. If such periodic or deferred maintenance is neglected, system infrastructure will deteriorate and functionality will be reduced.[5]

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1 The seven sample subprojects include Sampalan, Ababi, Sungsang, Yeh Satang, Pengaringan, Tungak Alas, and Pausan.

2 The PCR recalculated the EIRR for Yeh Satang, Sungsang, Pengaringan, Sampalan, and Ababi schemes.

3 No independent estimate of a future without-Project scenario were practicable, because there are no areas in Bali that have not been covered by some project or program.

4 During subproject visits, cropping intensities as high as 275 percent were reported, but in such cases the intensity of rice cropping was lower.

5 Of the actions recommended by the PPAR (para. 16), two have been successfully implemented. Pesticide poisoning has been virtually eliminated (Appendix 6). Federation of subaks now cover the entire Project area. The PM PIB indicated that the question of ownership and O&M responsibility are being resolved and it is planned to provide resources to modify Project facilities to meet farmer needs.

K. The Emerging Scenario

60. In Bali agriculture has been changing from within. Introduction of management responsive short-season rice varieties in the 1970s brought the green revolution to Bali. By the mid-1980s, most traditional long-season varieties had been replaced, resulting in a change in the cropping pattern. In addition to higher yield, the management-responsive varieties had other important benefits. In areas with adequate irrigation facilities it was now possible to plant five crops of rice every two years, plus one palawija crop, instead of only four traditional rice crops. However, intensification of cropping also disrupted the coordinated fallow periods, and pest and disease outbreaks became common. Resistant varieties and a return to the coordinated two rice crops per year plan, together with IPM techniques, have largely overcome the pest problems. Short season rice varieties enable growing a palawija crop in the second dry season.

61. Parallel to the introduction of management-responsive varieties, irrigation improvement took place in many subak irrigation schemes. The Project was only one of a number of programs introduced to replace traditional weirs built with stone and wood products, with new masonry or concrete structures. Subaks themselves built tunnels to replace surface canals that ran along the steep ravine banks. The improved structures made irrigation delivery more reliable, which enables higher cropping intensity and yields and reduced annual maintenance requirements. Government programs have made considerable contribution to this change, but sometimes at the expense of subak institutions. Agricultural production in Bali will continue to depend upon subaks, and future irrigation improvement programs must design activities that support and strengthen the management capability of subaks.

62. Subsistence agriculture has been in transition for several generations in Bali. Amenities available in urban centers to persons in the cash economy have appeal to rural households and especially the youth. The tourist industry and associated employment opportunities in craft production and sale have greater appeal than farming to many. Persons with skills to do more than manual labor can find employment with much higher returns than farming. In some communities, the number of subak members who are temporarily absent for off-farm employment has had an impact on system maintenance. From the labor-saving perspective, Project improvements that have reduced O&M labor have, to some extent, countermanded the decline in the sustainability of the subaks. This was not a stated objective of the Project, but since the opportunity cost of labor is now higher, the potential benefits of labor savings could be examined in greater detail in the future.

IV. KEY ISSUES

63. Sustainability of Project benefits, and of future investments in Bali irrigation systems, will depend on how the key issues in this sector are handled. These are as follows.

A. Resource Management

64. Analyses of entire watersheds show that subak management of water resources is effective and efficient. This is possible because of the strong institutions they have crafted and the supporting role of the water temple system. Safeguarding subak institutions is the key to effective management of water resources of irrigation systems. Government intervention to improve irrigation must consider the impact of assistance on the subaks' principle of equity. Equity links rights and responsibilities of members and empowers negotiations among subak members and among subaks over the sharing of water and activities that enable access to water.

65. The Project introduced adjustable gates that are not compatible with system operation based on the equity principle. Many of those structures have been replaced, but others remain and will need to be changed if the subaks are to return to full management of the systems or pay irrigation service fees. Programs and projects that involve local management of resources must fully investigate the origin and purpose of existing institutions before proposing change.

66. Competition for water and land is increasing in many of Bali's watersheds. Comprehensive investigation and planning is needed to identify water resources development options and allocate the supply among competing uses for agriculture, urban communities, tourism, and industries.

B. Coordination and Conflict Resolution

67. The watershed management coordination role of the temple system has diminished as the Government increasingly asserted its authority in allocating water resources. The Udayana University action-research project demonstrated that watershed-based coordination of planting that optimizes water use and reduces pest damage can be accomplished by an organized body based on representation of all subaks in the watershed. This is not a task that Government staff can do well, because they cannot respond quickly enough to water-sharing requests among subaks. Coordination of planting and water sharing is best done by subaks themselves. Formation of such groups has not been spontaneous, so a program providing outside facilitation should be considered. The legal issues in establishment of a subak-based watershed coordination body need to be addressed.[1]

68. The Project's attempt to join subaks, sometimes without meaningful levels of consultation, so that a common weir and main canal could be used by all the subaks, resulted in conflict between subaks, some of which persisted for long periods. As demonstrated through action-research projects, full subak participation in discussion and negotiation can result in agreement on water-sharing responsibility for joint subak activities. Successful formation of a

[1] The PM PIB has indicated that issues related to the establishment of apex subaks (*subak agung*) or associations of federations of subaks in all the catchments will be addressed under the ongoing *Capacity Building Project in the Water Resources Sector* (Loan No. 1339-INO) approved for $27.7 million on 6 December 1994.

federation of subaks in which each subak has representation provides an ongoing institution for conflict management. A program for providing outside facilitators with an understanding of subak institutions could help expedite this process.[1] By now, such federations of subaks have been formed for all schemes under the Project. The formation of apex subaks or associations of subak federations (subak agung), which has recently started, needs to be encouraged.

C. Ownership of Project Facilities and O&M

69. Subak members were not sufficiently involved in Project activities to influence the design or to control construction. This resulted in outcomes they did not consider satisfactory, shifted ownership to the Government, and reduced the subaks' feeling of responsibility for management. Each of these contributed to the undermining of the subaks' capacity to manage. Turning back ownership of the schemes below 500 ha to the subaks should be done immediately, before the knowledge derived from past management experience entirely dissipates.

70. Under the Project, weirs and other canal infrastructure were planned, designed, and constructed. That activity transferred ownership of the most important parts of the system from the subaks to the Government. Maintenance responsibility is perceived by the subaks to be linked with ownership, and the Government confirmed this by providing a maintenance budget. As a result, subak members, specially in subaks covering over 500 ha, have become dependent upon Government inputs and are reluctant to mobilize their own resources as they did in the past for regular maintenance. This threatens the long-term sustainability of the production system, since the Government budget is estimated to cover only 50 percent of essential annual maintenance.[2]

71. It was intended that irrigation scheduling be introduced in Project systems upgraded to the technical level. Irrigation scheduling was too complex for subaks to manage and presented another reason for the Government to take over O&M. With the decision not to require irrigation scheduling, and the replacement of gated structures with proportional flow dividers, subaks can again operate and maintain their entire system. The subaks' ability to survive for centuries has proven their ability to manage maintenance sustainably. With improvements made in the systems by the Project, O&M has become easier, and Government input for O&M of schemes below 500 ha will no longer required if the issue of ownership is resolved.

D. Caveats to Cost Recovery

72. If ownership and continued management by the subaks is to be successful, the mandated program of handing over full management of all systems less than 500 ha to subak

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[1] The PM PIB has pointed out that this is being done under the IISP II project currently under implementation.

[2] The PM PIB has indicated that upon implementation of the Irrigation Service Fee Program, the needs-based-budget practice is expected to be expanded to cover the Project areas, as is already the case for the areas under the IISP II project.

management must allow subaks to restore physical facilities that meet the requirements of proportional sharing of the irrigation supply. Subak members will not make full payment of irrigation service fees in systems larger than 500 ha unless their perceived and real problems in meeting equitable irrigation delivery are addressed.

V. CONCLUSIONS AND RECOMMENDATIONS

A. Overall Assessment

73. The Project had major design flaws: inadequate beneficiary involvement in Project design and inadequate beneficiary needs survey and assessment; the assumption that the technical irrigation systems would improve efficiency as compared to traditional equity-based systems that had stood the test of time, without regard to realities on the ground; noncoverage of the poorest farmers by schemes under the Project; assumption of the availability of land for expansion of irrigation without adequate investigation; and retrogressive provisions for transfer of O&M responsibility from subaks to the Government. Major implementation deficiencies included construction of structures not acceptable to the beneficiaries, many of which have been replaced, and of structures that forcibly joined some subaks together. The Project has problems of maintenance responsibility, cost recovery, and sustainability, and has contributed to erosion of the subaks' management capabilities.

74. On the positive side, the Project has improved the reliability of the availability of water. It has made maintenance of weirs constructed under the Project easier, and provided relief to farmers from labor for maintaining traditional weirs. In conjunction with the green revolution technology, it has resulted in changes in cropping patterns, and in increases in crop intensities, paddy yields, and farmer incomes, though it is difficult to segregate the Project's contribution to these achievements from that of the availability of HYVs and IPM. The EIRR of the Project is about 5.6 percent. On an overall basis, the Project's classification at postevaluation as partly successful is supported.

B. Lessons Learned

75. The Project provided benefits but also created avoidable problems. Future projects providing assistance to a well-established local resources management organization like the subaks should:

(i) take cognizance of the existence of well-defined roles and rules, sociocultural and religious interactions shaping human behavior, indigenous knowledge and practices of practical value, and technologies adapted to meet environmental conditions. They should develop an assistance process that starts by investigating viable indigenous resource

management systems and building upon their institutions and technology rather than replacing them;

(ii) examine water use efficiency by watershed rather than by individual systems or subsystems, because water may be reused many times as it travels down the watershed, and high losses from an upstream system have little consequence to irrigation efficiency over the entire watershed;[1]

(iii) fully involve the beneficiaries in all aspects of planning, design, and implementation;[2] and

(iv) consider beneficiary ownership an option for sustainable operation and maintenance.

C. Recommendations

76. It is recommended that the Government undertake the following studies and activities to improve the performance of ongoing and future irrigation and water resource development projects in Bali.

(i) The Government should conduct a comprehensive study of subak irrigation covering (a) an investigation of engineering aspects such as the suitability of different types of structures for distribution of water among subaks along a river course, among subaks sharing a canal system, and among subak members within a single subak that enable them to match the variable river supply conditions to allocation rules and rights in ways that can be monitored and managed satisfactorily by farmers and government; (b) compilation and evaluation of the experience, including the role of Balinese culture and religion, in forming federations of subaks for watershed-level water management and in apex associations of such federations for resolution of inter-federation issues; and (c) identification of approaches for upgrading and improving subak systems that would continue their ownership and management of all facilities so that further subsidy and support is not required from the Government except under conditions of natural disaster.

(ii) The turnover of irrigation schemes under 500 ha should be accelerated in the Project areas, even if it entails reverting to traditional flow dividers.

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1 The PM PIB has indicated that implementation of this has started. Water balances at the catchment level are being calculated to estimate the diversion requirements for different schemes using the same river as a source or irrigation water.

2 These lessons have been incorporated in subsequent Bank projects such as the IISP II, and more effectively in the *Farmer Managed Irrigation Systems Project* (Loan No. 1374-INO) approved for an amount of $26.3 million on 21 September 1995. This reflects positively on the feedback processes in the Bank.

(iii) In the introduction of irrigation service fees for the schemes above 500 ha, subaks should be given the option either to take over full management of their system without paying fees or to pay the fee established by Government.

(iv) Periodic maintenance of the diversion weirs must be done on a regular basis.

(v) A comprehensive watershed planning study should be conducted to identify and protect indigenous water rights for agriculture throughout the island while taking into consideration current and future competing needs of urban, industrial, and tourism development in allocating water resources for activities with high economic value.

(vi) Periodic maintenance of the sea wall and the outlet from the spring at Air Sanih scheme must be undertaken to prevent the ingress of seawater.

APPENDIXES