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Directorate General of
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Agency for
International
Development

Small-Scale Irrigation Management Project (SSIMP)

FINAL REPORT
GAPET DAM PROJECT
ENVIRONMENTAL ASSESSMENT

VOLUME I

MAIN REPORT

December 1990

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Prepared by

HARZA ENGINEERING COMPANY

in association with

Development Alternatives, Inc.

Global Exchange, Inc.

PT. Wiratman & Ass.

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CHAPTER I

INTRODUCTION

Background

This report has been prepared in conformance with the laws and regulations of the governments of the Republic of Indonesia and the United States of America, as administered by the appropriate agencies in terms of guidelines and decrees.

Indonesian Requirements

The basis for the Indonesian environmental assessment process is Government Regulation No. 29, 1986 (PP 29), as implemented through a series of decrees by the Ministry of Population and Environment. These decrees establish the process whereby a new project is the subject of a Preliminary Environmental Information (PIL) Report (Ministerial Decree No. 49/MENKLH, 1987) and, should the PIL commission so decide, a complete Environmental Assessment (ANDAL) Report (Ministerial Decree No. 50/MENKLH, 1987). In addition to the ANDAL Report, Ministerial Decree No. 50/MENKLH establishes guidelines for the Environmental Management Plan (RKL) and the Environmental Monitoring Plan (RPL).

USAID Requirements

The US Government requirements on environmental planning were first set forth in the National Environmental Policy Act of 1969, extended to US-funded overseas projects by the Foreign Assistance Act Amendments of 1986. The details of the process are set forth in USAID Regulation No. 16. The USAID regulations establish a process similar to the Indonesian PIL process, whereby if a project is determined to have a potential for significant environmental impact, then an environmental assessment (EA) is required, or if it lacks such potential, a declaration of "no significant impact" is made and no further environmental study is required.

Combined Process

Environmental specialists from the Ministry of Population and Environment, the Ministry of Public Works, USAID, and the engineering consultant firm, Harza Engineering Company, conferred in April 1988 to evaluate the need for an environmental study for each of the ten proposed surface water projects under

the USAID-funded Small-Scale Irrigation Management Project (SSIMP). It was decided that most of the projects had potential for significant environmental impacts. It was further decided that a combined team of Indonesian and American consultants would prepare a single environmental report for each project, structured so as to satisfy each government's requirements and prepared in both Indonesian and English. It was agreed that, although the Indonesian ANDAL is best translated into English as "Environmental Impact Assessment," that the ANDAL is most similar in intent of meaning, to what is known in the United States as an "Environmental Assessment."

This report for the Gapet Dam Project has been prepared by the SSIMP Technical Assistance Team and the University of Mataram Environmental Studies Center, with the support and assistance by the NTB Public Works' Water Resources Division.

Environmental Policy

The governments of Indonesia and the United States have similar policies regarding environmental management. Their attitudes are effectively stated in the preamble to Indonesia's Government Regulation No. 29 as requiring " ... within the framework of implementing development with an environmental outlook therein as a deliberate and systematic effort to manage natural resources rationally for sustainable development aimed at enhancing the living standard. Any activity as a rule has its impact on the environment, which shall be predicted at the initial stage of planning, in order ... to cope with any negative impacts and to enhance any positive impacts..." (translation by Canadian International Development Agency). The US National Environmental Policy Act (NEPA) contains similar language, mandating the inclusion of environmental planning in any action of the federal government that may exert significant environmental effects.

Objective of the Environmental Assessment

The major objective of this environmental assessment is to inquire whether there are any probable major negative impacts of this irrigation project on the environment. Conversely, this report also assesses possible negative impacts of the environment on the function and efficiency of the project. Once harmful effects are identified, a plan is provided to mitigate these major negative impacts.

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Scope of the Report

As a result of an Environmental Scoping Session held in Sumbawa Besar in December 1989, and in prior visits to the site by environmental experts, a list of priority issues was developed. This list has been reorganized into four basic categories to reflect the requirements of Indonesia's Government Regulation PP 29. These are: water resources, land resources, biological resources, and socioeconomic/cultural resources. Information on climate and physiography is also presented, as required by that regulation (PP 29). An account of the 1989 scoping session is found in Appendix C to this report.

Methodology

The methodology for each of the four main areas of assessment followed standard research procedures common to the respective disciplines. In brief, they were:

- Water Resources. Streamflow estimates were developed from simulation studies that relied on records of staff gauge readings, automatic water level recorders, discharge measurements and rainfall records. Water quality results were based on standard laboratory analyses done at the Analytical Laboratory of Mataram University. Water use estimates were based on household interviews.

- Land Resources. Land use definition relied on visual assessment of the study area in conjunction with inspection of available maps and aerial photographs. Some details on soils were obtained from soil maps developed by Fenco (1981). The agriculture analysis was based on a series of interviews with farmers and government officials in provincial, district, sub-district and village offices.

- Biological Resources. The primary methods of investigation of biological resources in the study area were to visually review local conditions and to interview villagers and officials from relevant sectoral agencies (Departments of Agriculture, Livestock, Fisheries, and Forestry). This was supplemented by appropriate published information for the area.

- Socioeconomic and Cultural Resources. This assessment relied on primary and secondary data that included quantitative and qualitative characteristics of the study area population. These data included results of the various "Rapid Rural Irrigation Appraisals" (RRIA's), a Farm Survey, and a number of in-depth interviews with study area villagers and officials from relevant sectoral agencies including the Departments of Village Development, Health, Statistics, Public Works, the Regional Development Planning Board, and both the District and Subdistrict offices.

Sponsoring Agencies

This project is jointly sponsored by the Ministry of Public Works of the Government of Indonesia and the Agency for International Development of the Government of the United States.

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CHAPTER II

DESCRIPTION OF THE PROPOSED PROJECT

Type of Project

The Gapet Dam Project is one of the surface water projects being studied under the Small-Scale Irrigation Management Project. It is a water storage project which will provide a reliable supply of irrigation water to farmers who are now unable to cultivate two or more crops per year.

Location of Project

The project is located entirely within Boal Village in the Empang Subdistrict of Sumbawa District, NTB Province, Indonesia. The Gapet river basin lies on the narrow isthmus which connects the two larger land masses which form the island of Sumbawa. The service area of 1,300 ha lies between the Dadap and Boal Loka Rivers, extending north as far as the tidal flats which border Saleh Bay (Figure II-1).

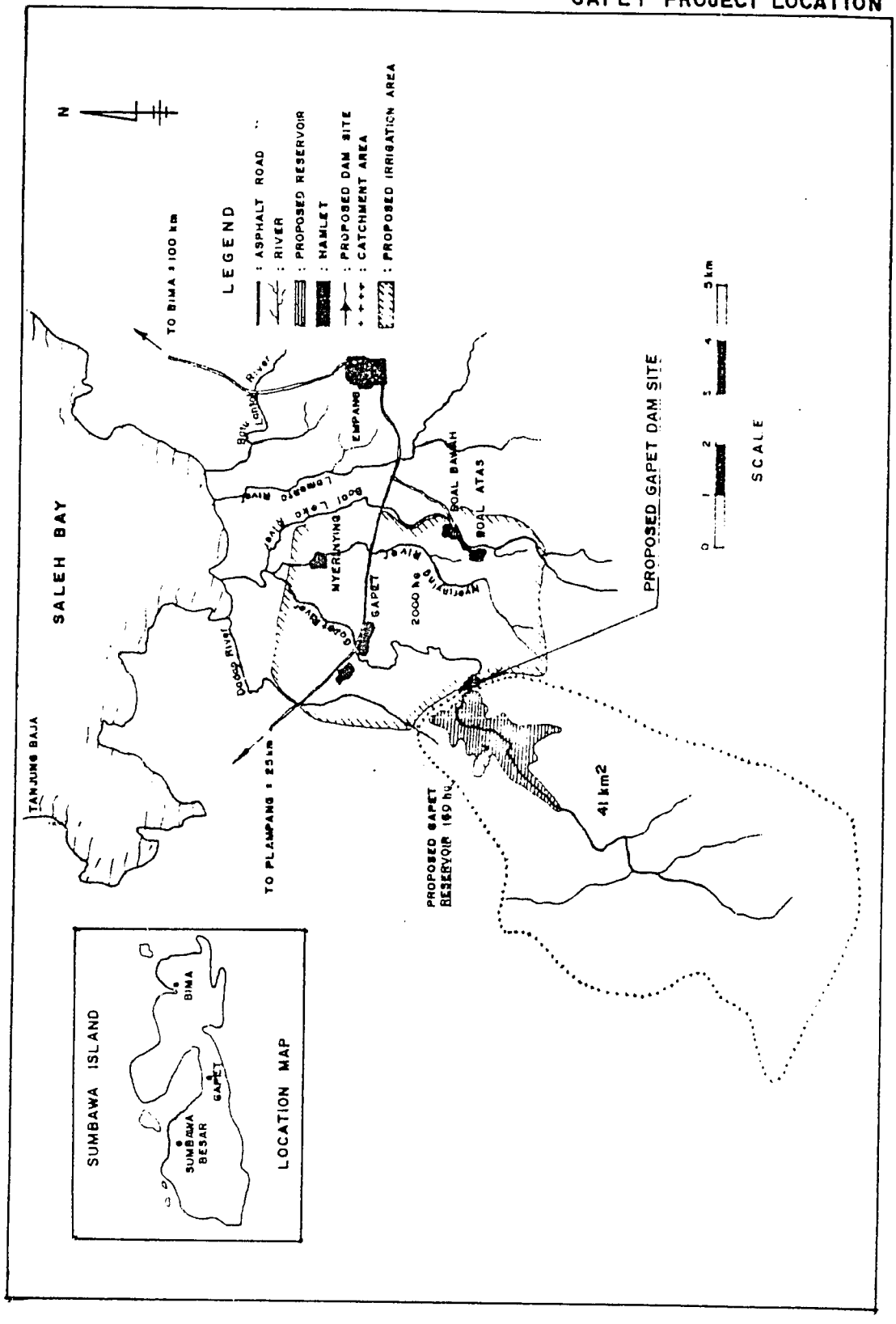
Limits of the Study Area

The study area for this environmental assessment consists of the entire river basin of the Gapet River, as defined in the previous section. The study area also includes the proposed service area, which overlaps the basins of the adjacent Dadap, Nyerinying and Boal Loka Rivers, as indicated in Figure II-1. As the catchment area, service area, and downstream area are all located within one village, the study area includes the land and population located within the administrative boundaries of Boal Village. All borrow areas are located within the river basin, there are no areas located outside that are directly affected by the project.

Project Life

For planning purposes, the life of the project is taken as 60 years, but there is no reason to believe that the structures, properly maintained, will not function for a much longer time.

Figure II — 1
GAPET PROJECT LOCATION



Description of the Project

Project Components

Major Structures: Water Diversion. The principal structure of the project will be a dam on the Gapet River, approximately 5 km upstream of its crossing the main highway. The dam will be a random fill structure with a height of about 20 m above the river bed, giving a crest elevation of 38 m and a crest length of 290 m.[1] An additional saddle dam will be required immediately to the right of the main dam, with a crest length of 328 m. The service spillway will be a concrete, free overflow structure located in a slight saddle of the rock knob that forms the right abutment of the main dam (see Figure II-2).

The reservoir formed by the Gapet Dam will have a surface area of approximately 160 ha at a normal surface elevation of 35 m. The reservoir will have a total volume of 13.8 MCM with dead storage of 0.7 MCM, at the drawn-down elevation of 21 m. This provides live storage of 13.1 MCM. Under extreme flood conditions the reservoir will fill or inundate a maximum of 200 ha.

Conveyance System. An outlet works structure will release irrigation water from the reservoir via a tunnel into a feeder canal which will convey it to the main/secondary canal system. The feeder canal will be sized to carry a flow of approximately 2.0 m^3/s. The canal will have a trapezoidal section with a bottom width of approximately 2.0 m and steep side slopes. The feeder canal will have a stone masonry lining.

Delivery System. Secondary canals will provide water to the subdivisions of the service area (see Figure II-3). Two principal secondary canals are planned to serve the left and right bank areas of the Gapit River. The total length of the main and secondary canals will be approximately 7.7 km. The main canal is sized nearly the same as the feeder canal. The secondary canals will range from approximately 0.5 to 1.4 m bottom width with 1:1 side slopes. These canals will be unlined except in areas of pervious subsoils.

A system of tertiary canals, from 0.5 to 1 m wide, will generally distribute water to quaternary canals, which in turn will provide it to the on-farm systems. There will be approximately 20.4 km of tertiary canals.

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[1] Figures pertaining to water supply, floods, and reservoir operation are being finalized and will appear in the Project Justification Report. These figures are expected to change slightly. With these changes, it is likely that minor changes will be required in the structures as described in this section.

Figure II - 2
MAJOR FEATURES OF THE
GAPET PROJECT DAM SITE

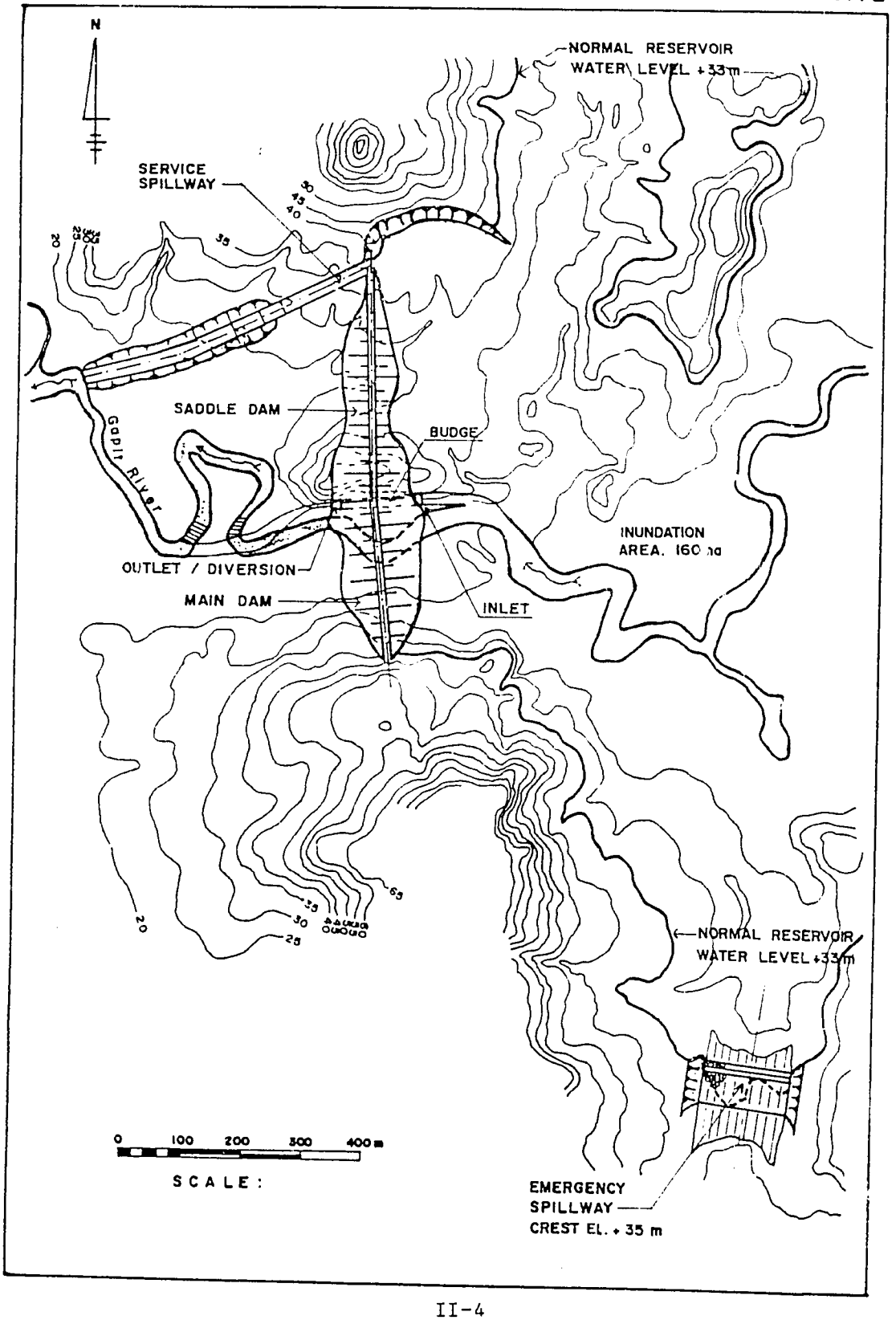
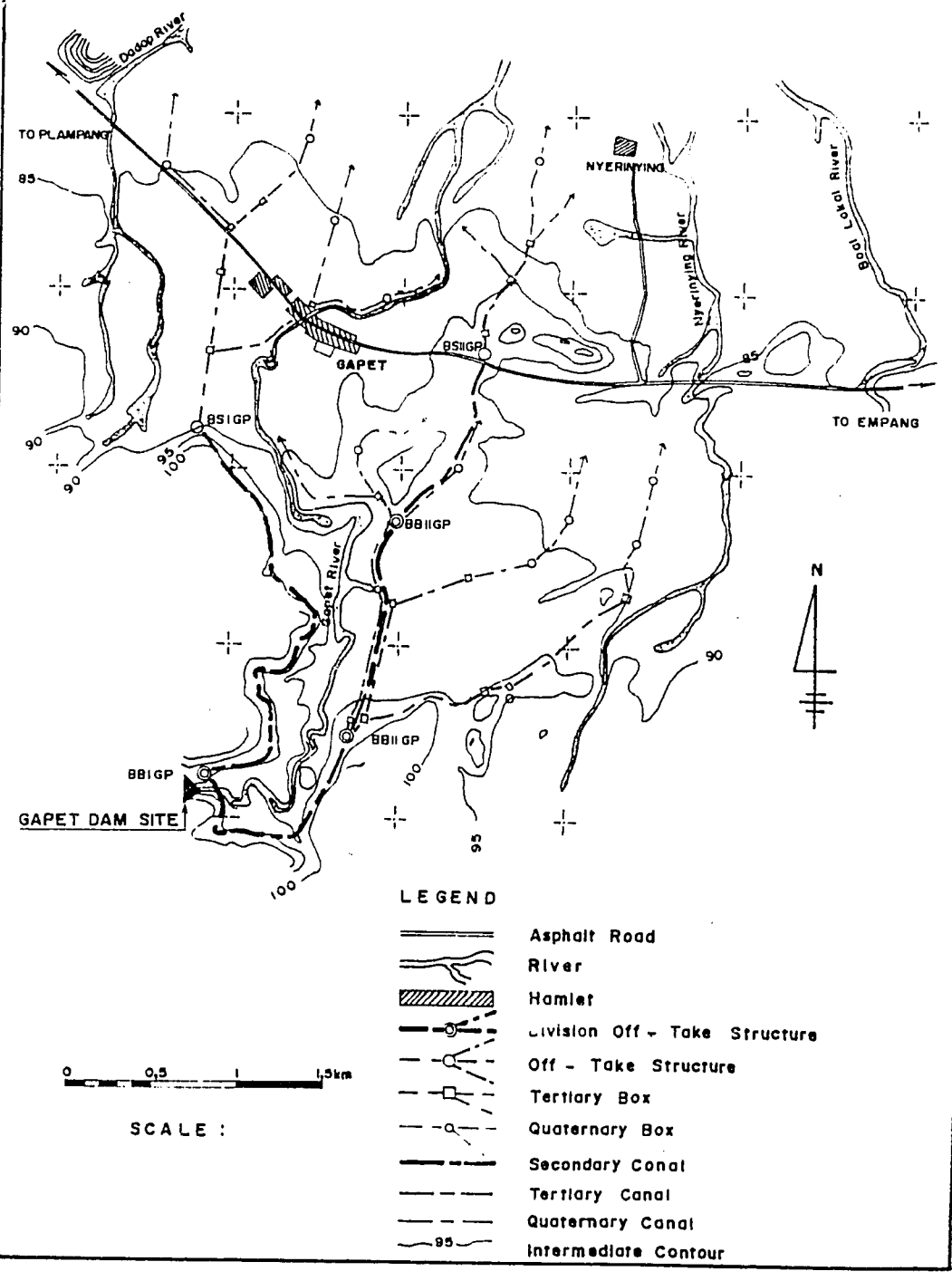


Figure II - 3
PROJECT MAP



Drainage System. Excess water will be removed from the fields by a surface drainage system and returned to the Dadap, Gapet, Nyerinying or Boal Loka Rivers, or to the sea, depending on location and topography.

Support Facilities: Roads. The existing track to the project dam site leaves the main road near Gapet hamlet. This road, passable for most of its length by four-wheel drive vehicles, will be upgraded to an all-weather asphalt surface road capable of handling heavy trucks. An alternative route would leave the main road about one kilometer east of the Gapet River and run south and west to approach the dam from downstream. Other roads will be constructed for access to borrow areas which are expected to be located within 2 to 3 km of the dam site.

Buildings. Project offices and housing for the project operating staff will be built in the area.

Pre-Construction Period

The Gapet Dam Project was investigated during the extension phase of the Sumbawa Water Resources Development Planning Study (Fenco, 1981). Preliminary designs for a small dam and reservoir were prepared by PEKSI in 1984. In 1985, CITA PRISMA conducted a geotechnical investigation consisting of 9 bore holes and several test pits. The associated laboratory tests for the soil mechanics aspects of this investigation were also included. PT Mettana was engaged by Provincial PU in 1985 to do additional design work on the dam, while PEKSI did the design of the irrigation system.

In March 1988, Provincial PU again contracted for the engineering services of PT Mettana to do a design review under the auspices of SSIMP. This work was intended to define the parameters of the final design, especially in foundation treatment under the main and saddle dams. It would also make a definitive selection of the location for the spillway and outlet works. At this writing, additional drilling is still in progress and no final decision is imminent on the location of these two features. These studies are being performed under the direction of Provincial PU with advice and guidance from the SSIMP Technical Assistance (TA) Team led by the Harza Engineering Company.

In February, 1988, a "Rapid Rural Irrigation Appraisal" (RRIA) was conducted at the Gapet site by several USAID SSIMP social scientists and engineers (Duewel, 1989). A Farm Survey and a second RRIA was then conducted in 1989 by the economist and the social scientist of the Technical Assistance Team, working with a survey team from NTB PU staff assigned to SSIMP. The Gapet site has been visited several times throughout 1989 and 1990 by TA Team environmental scientists and engineers. Information from these surveys and site investigations has been incorporated into sections of this Environmental Assessment,

particularly in Chapter IV, "Existing Environmental Conditions," and in the proposed Mitigation and Monitoring Plans.

Construction Period Conditions

Construction plans for the Gapet Project are not yet final. Based on previous SSIMP experience, there will probably be three separate contractors, under the general supervision of PU. The work will be divided approximately as follows:

Contract No.	Type of Contractor	Work Included
1	Local	Local Roads
2	"	Permanent PU Buildings
3	International	Main Dam, Saddle Dam, Appurtenant Structures and Irrigation System

Construction Schedule. The construction of the dam is expected to start in 1991 and require 30 months. Construction of the canal system will be performed concurrently with that of the dam, if the labor is available, and will require about 18 months. If the available labor force and contractors are not sufficient for simultaneous construction, the canal system construction may not be started until the dam is nearly complete.

The local contracts will be tendered prior to the other contract so that roads and buildings are available for use by PU and the international contractor as early as possible.

Equipment Use. All equipment used in the construction of the project, from shovels to bulldozers, will be provided by the construction contractors and retained by them on completion of construction.

Mechanical items, such as control gates and hoists, will be purchased from suppliers within Indonesia, but probably not in Sumbawa. Some of these items are manufactured in Surabaya. The contractor is expected to have a sizeable machine shop and metal working facility on site.

Resource Use: Types of Resources. The actual construction of the dam and appurtenant structures will require approximately 521,135 cubic meters (m^3) of rock, gravel, sand, and earth, as shown in Table II-1. In addition, cement will be required for concrete, lumber and plywood for forming and for constructing shops, sheds, and dwellings. The contractor will be able to obtain locally some unfinished wood for fenceposts and other uses that do not require sawn lumber but the contractor will be required to obtain these only from within the reservoir area.

Borrow Areas. Materials for the main and saddle dams will be obtained from required excavation for the two spillways and outlet works structures, from alluvial deposits within the reservoir area, and from clay borrow sites nearby. The main and saddle dams are designed for a rockfill section with an impervious clay core separated by sand and gravel filter/drain and transition zones. The upstream and downstream cofferdams will be integrated into the dam section. The materials volumes involved are not large, as shown in Table II-1.

Table II-1

Construction Material Requirements

Materials for Dams	Volume (m^3)
Shell material:	
Rock from required excavation	
Alluvium from river/reservoir area	
Random fill from other borrow	285,710
Clean Sand	110,280
Graded Crushed Stone	34,575
Washed River Cobbles	10,425
River Boulders	80,195
Total	521,185

Source: PT Mettana, Draft Bill of Quantities, September 1989.

Excavation and fill materials will be obtained from, and used in localized areas along the canal alignments. Sand, gravel, and stone will be obtained mostly from borrow areas.

Cement will be purchased by contractors on the open market at the nearest possible source (probably Surabaya or Ujung Pandang), depending on the economics of price and transportation.

Construction lumber and plywood are available in East Java and will also be shipped to Sumbawa. Steel reinforcing bars will be brought in from Java or imported.

All these construction materials will be shipped through Bada Port, located about ten kilometers west of Sumbawa Besar, or about three hours from the site. Materials will be transported from the port to the site by truck.

Energy. Energy required will be both electrical, provided by generators on the site during construction, and by

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petroleum-based fuels, such as diesel fuel, for powering vehicles and heavy equipment.

Transportation and Storage. The construction contractors will use motorcycles, trucks, and probably four-wheel drive vehicles on the site. Stockpiles of materials will be maintained near the dam site and other major structure sites, in quantities sufficient for meeting the construction schedule. Materials excavated from the canals will be stockpiled nearby for subsequent use on dikes and roads, or where fill is needed.

Waste Disposal. The usual practice in Indonesia, especially in remote areas, is to dispose of solid waste in any convenient depression or water course near the site of consumption. That practice, although environmentally unsound, probably will prevail at the Gapet site, with or without contract stipulations. It may be possible, however, to force the contractor to cover his trash heap with sand or gravel, which would keep down rats and render it less unsightly.

Human sanitary waste will be disposed of in pit latrines, which will be moved, and the pits filled in, at appropriate intervals.

Work Force. It is anticipated that construction of the dam, saddle dam, appurtenent structures, and irrigation system will require a total work force of approximately 850 people over a 30 month period. Of these, approximately 700 will be unskilled laborers, 100 will be semiskilled (drivers, mechanics, carpenters), and 50 skilled and managerial.

Contractors on Sumbawa customarily draw their work crews from a large pool of construction laborers on Lombok and from their own full-time employees rather than from the immediate project area. The crews generally come without their families.

Work Area. The dam contractor will require an area of about two hectares near the dam site for the field office, equipment storage, and materials stockpiling. Of the estimated 850 workers, about 400 laborers will live in a tent village near the dam site, with more adequate housing for the managerial staff and supervisory personnel. At the main camp, water and sanitation will be provided by the contractor. Water will be drawn from the river, when possible, and boiled for drinking.

The irrigation system subcontractors will establish base camps and offices near the canal alignments. Tents will be provided for most of the labor force; some may find lodging locally.

The contractors will either provide rice and fish to the workers as part of their pay or make arrangements with local entrepreneurs to bring those and other commodities to the camps for sale to the workers. Fuelwood will either be provided by

the contractor, or some local entrepreneur will sell fuelwood to the laborers.

Some permanent buildings of brick, timber, and concrete will be constructed at the site. These will include office, workships, and residences for the PU management-level and permanent operating personnel.

Training Program. No training program is planned for the construction work force. The contractors are expected to have on their staffs or among regular part-time employees, the required skilled and semi-skilled workers for their contracts.

Operation Period Conditions

Division of Responsibilities. Established GOI policy provides that PU assume responsibility for operation and maintenance of diversion facilities, primary and secondary canals, tertiary offtakes, and the first 50 m of each tertiary canal. Water users' associations (WUA's) and their members are responsible for operation and maintenance of tertiary canals, quaternary boxes, and quaternary canals.

PU responsibilities for system operation are at the Cabang Dinas office, which normally covers about 25,000 ha of technically irrigated lands in one or more district; at the Ranting Dinas office, which normally covers one or more systems totalling about 7,500 ha; and at the Sub-Ranting office, covering about 1,500 ha forming all or part of a system. PU's contact at the WUA/farmer level is the gate keeper who covers several tertiary offtakes and passes information back and forth between farmers and the Sub-Ranting personnel.

The Cabang Dinas office for Gapet will probably be in Sumbawa Besar, three hours drive from the project site. The Ranting Dinas will probably be located in Empang. The Sub-Ranting office will be at the project site.

Irrigation: Method of Operation. The project is designed to store water from the Gapet River and then to release it through the primary and secondary canals, to meet the crop water demands determined for each tertiary block. Water delivery at the tertiary offtakes is normally continuous over a period of time. To limit peak demands of the tertiary offtakes, delivery to blocks within each tertiary unit will probably be rotated on a schedule determined by the WUA. Diversions are typically adjusted every two weeks, but shorter time periods may be adopted for the project to improve water use efficiency during drier months.

Diversion amounts and gate settings are typically determined at the Cabang Dinas level. Gate keepers report requests for water for each tertiary to the Sub-Ranting office, where they are consolidated and reported to the Ranting office. The

Ranting consolidates Sub-Ranting requests, compares them with the estimated available storage water, and recommends a release rate which is approved or adjusted by the Cabang Dinas. Gate settings for each structure are then determined and passed down to the gate keepers.

Equipment Use. Operating equipment for the system includes primarily the permanently installed, manually operated gates for control of flows. Gate keepers will use bicycles and Sub-Ranting personnel will use motorbikes to inspect the system and keep in touch with users and each other.

Hand tools for routine maintenance, clearing of brush, etc., will be provided to PU staff. Heavy maintenance, such as gate or masonry repairs, will probably be contracted out or performed by special staff of the Ranting or Cabang Dinas offices with access to a pickup truck, welder, hoist, etc. Periodic measurements of flows, water quality, etc., will be conducted by trained staff from the provincial or Cabang Dinas office using special instruments.

Resource Use. The main project impact on resources will be the storage and redistribution of water in the area, which is the purpose of the project. There will be little energy used in operation of the manually controlled system. Some fuel will be needed for operation of project vehicles. Small quantities of sand, gravel, stone, cement, and other building materials will be used on a continuing basis for routine maintenance.

Chemical inputs will gradually increase with intensification of agriculture, but Indonesian farmers generally apply fertilizer at rather low rates. Pesticide use also tends to be at rates below those recommended by pest control specialists; presumably factors such as cost, labor input, and the inability to measure precisely the amount dispersed enter into the situation.

Labor Force. The basic operation and maintenance of the tertiary and quaternary systems will be performed by the WUA's and their members, with advice and some logistic support from PU and Agriculture Extension Services. Most area farmers have basic agricultural skills in rainfed paddy culture and palawija crops, but will require some training for effective intensification of cropping.

Operation and maintenance of the system will be performed by the PU staff described above. Initially, the staff is expected to include one Sub-Ranting head, a dam tender, and gate keepers. In total, there should be a staff of 10 to 15 persons for the Gapet Project. Cleaning of the primary and secondary canals is the responsibility of PU, and will probably be contracted out. Cleaning of tertiary and quaternary canals will be done by the farmers using the system.

Training Programs: Operating Work Force. The PU will provide its local staff with orientation training for operation and maintenance of the system. This will also include training in the keeping of flow records and other types of records. Training will be conducted during the final months of project construction and during the turnover period.

Farmers. Extension training will be provided to farmers who are not accustomed to reservoirs and technical irrigation systems. The training is expected to consist of evening lectures in the hamlets, supplemented, with field advice by extension agents through the Contact Farmer system. PU will receive assistance in WUA organization and in on-farm water management from the Indonesian non-governmental organization, LP3ES (Lembaga Penelitian Pendidikan dan Penerangan Ekonomi dan Sosial).

Domestic Water Supply: Method of Operation. The simplest means of providing downstream domestic water during the dry season is to allow for minimum downstream releases from the reservoir and/or irrigation canal system. Under current conditions, flow in all of the rivers (Gapet, Nyerinying and Boal Loka) ceases during the dry season, forcing the population in the hamlets of Gapet and Nyerinying to use shallow wells. Residents of Boal Atas and Boal Bawah hamlets usually have domestic water available from the main canal from the small weir upstream on the Boal Loka River.

It would probably be more efficient (in terms of water consumption) to provide a piped water supply to the hamlets of Gapet and Nyerinying from the Gapet reservoir. The project will install filters, discharge control facilities, main delivery pipes and main distribution water reservoirs to these two hamlets. The PU O & M Section will be responsible for maintaining the automatic water offtake system and discharge control facility that supplies water to the two hamlet's individual, community water distribution reservoirs.

Public Bathing and Livestock Watering. Public bathing and laundry steps for the use of villagers in the service area will be built by the project along secondary canals that go close to hamlets. Once built, there will be some monitoring of the structures to see that they remain in good condition.

The project will construct livestock bathing pools and drinking troughs to minimize damage to canal banks on secondary canals that go close to hamlets. These structures will be standard in accordance with published PU specifications. PU will monitor the condition of these sites once the system is operating, to see that they remain in good condition.

Community education and, eventually, community-led enforcement programs initiated through the joint efforts of Public Works, LP3ES, Agricultural Extension Services, and the

District's Departments of Food Crops and Livestock will be required if the canals are to be effectively protected from violation of the no-livestock regulations. In fact, the entire village population would benefit from a program to instill respect for the irrigation system. Maintenance of the livestock watering holes could be incorporated into an overall community livestock management program.

If begun before the system is installed, and continued vigorously, the education program could reduce the amount of plant matter and domestic trash thrown into canals and drains, illegal taps, and other abuses of the system.

Waste Water Management. Waste water created by this project, consisting of irrigation return flows and rainfall runoff, will be returned to the nearest part of the river through a system of surface drains.

Project Outputs. The project outputs will be a reliable supply of irrigation water, a much smaller, but equally reliable, supply of domestic water, and provision of sites along the canals for public bathing, laundry washing, and livestock watering pools and drinking troughs.

CHAPTER III

ALTERNATIVES TO THE PROPOSED PROJECT

No Action Alternative

In the event that the project is not implemented, some very limited advances in yields might be expected through improvements in the efficiency of existing irrigation schemes. However, overall, if the project were not implemented, it is expected that current land use and cropping patterns would remain relatively stable. Probably little or nothing could be done to improve cropping intensity without the project. Low rainfall, the intermittant nature of the Gapet River and other rivers in the area limits the yields from existing irrigation and makes two-crop farming impossible for 90 percent of the proposed service area.

Any local improvements to existing irrigation could not be expected to keep pace with natural population growth. The area would continue to experience a steady outmigration of individual working age adults and whole households, moving out permanently, or living as circular migrants searching for work elsewhere. Without the project, population density would remain fairly low as it now is. Unless some major development were to occur nearby to provide employment, it is likely that the Gapet area would remain one of subsistence farmers, more or less locked into a low living standard.

Alternative Irrigation Technologies

Water Sources

Two basic water sources are present in this region: surface water and ground water. Studies for this project indicate that the annual flow of the Gapet River, applied over two growing seasons through the use of a storage reservoir, is sufficient to meet project objectives. Average annual yield is estimated at 27.65 MCM;[1] the total annual irrigation demand (based on a lower than average rainfall year) is taken as 21.12 MCM. (A quantitative analysis of streamflow at the Gapet site is presented in the next chapter - see Table IV-3).

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[1] Again, these are preliminary figures, as noted in Chapter II. They are expected to change slightly, with completion of the Project Justification Report.

Ground water supplies, on the other hand, are sufficient for most domestic demand during the wet season and for some households during the dry season, but could not provide sufficient dry season irrigation water for more than a few hectares.

Improved Water Management

A review and, if necessary, strengthening of the local system of irrigation distribution control is part of this project. Other systems of water management, such as automated or metered systems would not be practical in rural Sumbawa society. The community organizations (water users' associations) also will be strengthened. This organizing will be accomplished by the Department of Public Works and the non-governmental organization, LP3ES.

Site Location Alternatives

Project Structures

Dam. The Gapet dam site has been selected as the most downstream site that will provide the storage required for the project. Two other locations for the dam were considered, but they required more fill material for construction, and were thus rejected as uneconomical.

At the site, several alternative configurations were studied prior to the selection of the present locations for the emergency and service spillways (Mettana, 1989). The selected dam height was determined by optimization studies using a 28-year half-monthl, reservoir operation simulation to derive crop areas and benefits relative to project costs for a range of dam heights.

Canals. Placement of irrigation canals is largely governed by the location of the service area relative to the water source (in the case of the main canal), the configuration of the service area (in the case of secondary and tertiary canals), existing irrigation systems, and local topography. These factors are interrelated and combine to restrict the alternatives available for the project layout.

In the final analysis, canal design, routing, and sizing decisions are made on the basis of economic criteria, within internationally established guidelines for the design of reliable irrigation systems, but with local constraints always taken into account in matters such as control structures and system maintenance.

Service Area. Selection of the service area has been based on water availability, existing cropping patterns, soils, topography, and the areas used as rainfed paddy fields.

Auxilliary Structures: Roads. Topographic considerations basically dictate the placement of the access road to the site. The alignment of the existing track, as shown in Figure II-3, is the most direct route to the site. Access along the east side of the Gapet River would require a longer road, so the shortest route is preferred. The existing track is to be upgraded as a permanent project access road.

Construction Camp. Only a few areas near the dam site are suitable for the construction contractor's workshops and vehicle storage. Actual selection of an area has not yet been made. Residential structures near the dam site will be required only for managerial personnel. Temporary facilities will be provided for the labor force.

Scheduling Alternatives

By their small size, projects of this type do not lend themselves to phased implementation, such as staging the development of the dam as water demand increases. Project justification studies indicate that complete development, to the maximum capacity of the water resource, can be absorbed quickly by the local community, providing the water users' associations are strengthened, as planned.

CHAPTER IV

EXISTING ENVIRONMENTAL CONDITIONS

Methodology

The methodology employed in the study relies upon a checklist developed from the initial Scoping Meeting held during December 1989 in Sumbawa Besar. Assessment of the boundaries of the total catchment area is based on maps developed from aerial photographs (Fenco, 1981). The study area population is based on the administrative boundaries of the village (i.e., Boal Village) whose administrative boundary encompasses the catchment, irrigation, and downstream areas.

Socioeconomic information, and some of the information presented on domestic water use, agriculture, forest use, wildlife, fishing, etc., were collected through field interviews, surveys of the local population, and from government offices. These interviews were conducted by Public Works staff assigned to SSIMP, by USAID staff from Jakarta, and by the TA Team. Most of this information has already been made available in several reports, including results of a Farm Survey (FS), a "Rapid Rural Irrigation Appraisal" (RRIA), a "Site Profile", and a series of internal memos and reports. In addition, PT Mettana prepared a Preliminary Review Design from which climate, streamflow, and engineering data were extracted.

Climate

Sumbawa Island, in common with much of Indonesia, has a wet tropical climate with pronounced wet and dry seasons controlled by prevailing winds in the Inter-Tropical Convergence Zone (ITCZ). The southeast trade winds bring relatively dry weather from May to October, with wetter northwest winds prevailing during the balance of the year.

Temperature. Monthly average temperature at the Plampang weather station (elevation +/- 25 m) is 27.9°C, with small variation through the year of less than 5°C. Temperature decreases with elevation.

Wind Velocity, Relative Humidity, Evaporation. Average wind velocity is moderate, less than 6 km/hr, the prevailing direction being from the southeast. Relative humidity is high,

with an annual average of 85.1 percent. Pan evaporation averages 5.9 mm/day.

Rainfall. Actual precipitation data for the service area is available from a rain gauge at Gapet which has been in operation since 1978 (Table IV-1). For the earlier period of 1958 to 1977, monthly rainfall has been calculated (by the Thiesen Polygon Method) from actual data collected at the nearby Plampang and Empang stations. The wettest months are December through March when up to 700 mm/mo can fall. The dry months of May through October see 6 to 60 mm/mo rainfall on average, with some months receiving no measurable rainfall in some years. Total rainfall for any one year ranges between 750 and 1950 mm/yr with an average of 1400 mm/yr.

Air Quality. Air quality in the region is good, there being no significant sources of air pollution. Some burning of paddy and palawija stubble occurs in the dry season, along with fires to clear land for agriculture. There is some dusting during windy periods in the dry season.

Topography and Geology

Topography

The project area is divided between a hilly catchment area upstream of the dam site and a relatively flat coastal plain. The coastal plain, especially near the dam site, is interrupted by low, scattered hills that rise up to 20 m above the surrounding terrain.

The catchment area of the Gapet River at the dam has an area of approximately 41 km^2 and reaches an elevation of approximately 810 m above sea level at the south end, about 13 to 14 km from Saleh Bay (this peak is 5 to 6 km from the nearest part of the south coast).

The service area is largely flat (less than two percent slope) or gently undulating (two to eight percent slope). Geological maps indicate no major slip faults in this area, but generally this part of Indonesia can be characterized as one of moderate earthquake risk, with a danger of infrequent, major shocks (RePProT, 1989). The nearest volcano, Mt. Tambora, is located about 60 km to the north of the project area. It is dormant; its most recent eruption occurred in 1815. Mt. Sangeang Api is the nearest active volcano, creating its own small island off the northeast coast of Sumbawa Island; its most recent eruption occurred in 1964-65, with mainly lava flows.

Table IV - 1

Monthly Rainfall Data, Gapet Station,
1958 - 1987*

YEAR	Monthly Rainfall (mm) MONTH												TOTAL
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1958	114	430	339	102	63	29	33	10	8	51	174	328	1681
1959	242	240	223	100	71	37	0	0	0	2	70	275	1261
1960	271	356	211	125	103	0	7	26	27	35	179	125	1465
1961	261	199	65	24	16	0	0	0	0	0	56	127	749
1962	260	321	19	148	20	7	32	0	0	37	37	429	1311
1963	710	253	222	50	39	4	0	12	0	0	1	111	1392
1964	154	160	260	339	43	41	0	1	62	274	267	91	1693
1965	253	224	284	30	0	0	0	0	0	0	58	101	950
1966	258	301	497	39	14	16	0	13	35	17	66	355	1611
1967	492	335	237	34	1	4	2	1	4	28	43	250	1431
1968	335	508	117	136	141	33	120	0	0	40	25	242	1697
1969	160	268	273	22	13	6	2	1	16	0	5	37	805
1970	236	269	140	59	34	5	0	0	13	13	99	242	1110
1971	315	428	346	30	82	0	3	0	14	95	142	254	1710
1972	229	259	305	72	0	0	0	0	0	0	12	164	1040
1973	382	241	269	141	179	5	8	5	59	16	86	163	1554
1974	196	472	262	35	33	0	0	0	36	45	206	132	1417
1975	209	337	321	364	134	0	32	0	84	195	93	476	2245
1976	369	341	257	28	4	0	0	0	0	0	11	85	1095
1977	389	295	459	16	15	2	0	0	0	9	24	304	1514
1978	492	333	329	145	22	398	29	34	11	79	115	256	2243
1979	182	315	198	2	122	19	0	0	29	38	64	266	1235
1980	511	377	63	174	12	14	10	0	5	10	133	495	1804
1981	600	652	125	111	35	16	12	23	14	10	107	235	1940
1982	326	260	194	29	0	0	0	0	0	0	0	236	1045
1983	157	178	102	181	10	0	0	0	0	30	226	74	958
1984	266	422	215	184	166	0	0	0	101	0	76	369	1799
1985	214	281	303	58	32	26	45	0	18	0	188	77	1242
1986	351	126	89	61	0	110	0	0	0	0	58	76	871
1987	307	273	55	0	26	0	0	0	0	0	107	101	869
Mean	341	322	167	95	43	58	10	6	13	17	107	219	1401

Elevation: Approximately 25 m.
* Years 1958-1977 have been simulated.
Source: PT Mettana (September 1989), Final Report, Preliminary Review Design, Embung Gapet.

Geology

The Gapet River catchment consists of volcanic sediments overlying volcanic base rock of Miocene age, covered in some places by Quaternary sediments. The underlying rock consists of tuffaceous sandstone, volcanic breccia, tuffs, and andesite.

Volcanic breccia is exposed in the hilly areas in the north of the catchment, including the dam axis. This rock is medium to highly weathered. Andesitic breccia is exposed widely in the southern parts of the catchment. River deposits consist of silty material and ranges from coarse sand to boulders, with depths of 2 m (at the dam site).

Water Resources

Major Surface Water Bodies

The Gapet River is a generally north-flowing river that drains a mountainous area of the narrow neck of land connecting the two larger land masses of Sumbawa Island.

The river, with some minor tributaries, has a length of approximately 20 km. It joins with the Nyerinying and Boal Rivers shortly before its discharge into Saleh Bay. The river gradient is very steep in the upper reaches and becomes almost flat at the estuary. The downstream reach meanders, and flooding is common in the wet season.

Another small river, the Dadap, forms the western boundary of the service area. There are two small weirs on the Boal and Dadap rivers, respectively. Two rivers to the east, the Lamenta and Batu Lantai, also flow into Saleh Bay.

Streamflow

Streamflow records for the proposed dam site have been generated (by the simple water balance method) by Mettana (1989) for a 30-year period, 1958 to 1987 (Table IV-2).[1] Since there are no streamflow records for the Gapet River, its flow was estimated on the basis of measurements of streamflow and rainfall in the Plampang and Empang basins. By comparing catchment areas and assuming similar runoff characteristics,

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[1] As noted in Chapters II and III, figures pertaining to water supply, floods, and reservoir operation are being finalized and will appear in the Project Justification Report. Figures shown in the this Environmental Assessment are thus expected to change slightly.

the streamflow for the Gapet River could be simulated. The simulation, corroborated by field observations, indicates that there is little or no flow in the Gapet River for most years between April and November. During the months of December through March, however, the river discharges 1.5 to 3.4 m^3/s on a monthly average. Monthly minimum and maximum flows are 0.0 to 6.6 m^3/s for the simulated period.

River Water Quality

Water samples were taken in November 1989 at six locations in the project area (Figure IV-1) for analysis at the Analytical Chemistry Laboratory of Mataram University. The sample sites were as follows:

1. Gapet River at proposed dam site. This station characterizes water supplies from the catchment.

2. Dadap River, approximately 200 m downstream of the main highway (Plampang-Empang). This reach of the Dadap River will receive irrigation return flows.

3. Gapet River at Gapet Hamlet approximately 200 m downstream of the main highway. These samples indicate quality of water currently available for downstream use. The Gapet will receive return irrigation flows under project conditions. Note that there was no water in the river at this location during the November 1989 sampling.

4. Nyerinying River, approximately 200 m downstream from the main highway. This river will also receive return irrigation flows under project conditions.

5. Boal River, approximately 200 m downstream at main highway bridge. These samples illustrate the impacts of downstream water use.

6. Boal River at Boal Weir, upstream of Kampung Boal Atas. These samples will indicate the characteristics of surface waters in this basin.

The samples were analyzed for a broad range of parameters to permit characterization of standard physical and chemical properties. In addition to the laboratory analyses, certain measurements (pH, temperature) were made in the field. The results are presented in Table IV-3.

Table IV-2

Simulated Monthly Gapet River Discharge, 1958 - 1987

Year	Monthly Discharge (m^3/sec)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1958	0.14	5.41	3.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58	3.24
1959	1.83	2.09	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.31
1960	2.32	4.12	1.56	0.24	0.02	0.00	0.00	0.00	0.00	0.00	0.65	0.05
1961	2.37	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
1962	2.25	3.61	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.39
1963	8.54	2.46	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1964	0.58	0.90	2.10	3.82	0.00	0.00	0.00	0.00	0.00	1.40	1.79	0.00
1965	2.06	1.92	2.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1966	2.15	3.38	5.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.29
1967	5.25	4.12	1.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80
1968	3.33	6.62	0.00	0.45	0.53	0.00	0.17	0.00	0.00	0.00	0.00	1.84
1969	0.87	2.92	2.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1970	1.88	2.45	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79
1971	3.06	5.37	3.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.95
1972	1.66	2.50	2.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70
1973	4.10	2.34	2.26	0.47	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.69
1974	1.22	6.07	1.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.18
1975	1.42	3.49	2.82	3.38	0.36	0.00	0.00	0.00	0.00	0.64	0.00	5.36
1976	3.78	4.01	2.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1977	4.17	3.24	5.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.65
1978	4.60	5.92	3.57	0.48	0.00	3.94	0.00	0.00	0.00	0.00	0.00	2.61
1979	4.63	1.65	1.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60
1980	6.05	3.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.01
1981	5.32	4.51	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.87	1.87
1982	3.34	1.85	1.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
1983	3.98	1.41	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	1.84	1.44
1984	2.42	5.16	2.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.70
1985	1.33	4.74	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60
1986	4.60	1.63	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	2.91	4.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.30	0.94
Mean	3.07	3.43	1.20	0.32	0.07	0.13	0.01	0.00	0.00	0.07	0.30	1.49

Source: PT Mettana (September 1989), Final Report, Preliminary Review Design Embung Gapet.

The samples collected in November 1989 were taken at a time of minimum flow, and are therefore representative of dry season conditions. In terms of use of these surface waters, these data are representative of the poorest water quality which is present throughout the year.

At the time of sampling, the Dadap River was stagnant, with no flow past the main highway. There had undoubtedly been some concentration of solids in these waters through evaporation, thus producing the extremely high values for several of the parameters. There is a possibility that at very high tides, there may be incursions of sea water to this point, thus producing high chloride and dissolved solid levels. This situation is true of stations 4 and 5, which are also just downstream of the main highway. The Gapet River at station 3, near the hamlet of Gapet, was completely dry at the time of sampling; there was a minimal flow of less than 1 l/s in the vicinity of the dam site, but only a few stagnant pools were present in the upper catchment area, past the reservoir.

All of the streams sampled are clearly standard calcium bicarbonate waters, with possibly some marine influence at downstream stations, as noted above. There is some variation in concentration of the major ions among the stations sampled, but these differences are not great enough to be of practical significance in terms of water use. The levels of all the major ions are within the ranges found in Indonesian surface waters (Neame, 1988).

The pH values are slightly basic at all stations, ranging from 7.65 to 8.86. Conductivity, which is a measure of dissolved materials, was moderate to high, reflecting the levels of total dissolved solids. These parameters were all highest at the downstream stations, and lowest at the upstream ones.

Nutrient levels (P and N) were low to moderate at the upstream stations. This may reflect the relatively undisturbed nature of the watershed, as well as the geological nature of the region.

The upstream samples (1 and 6) are well within the recommended ranges for domestic raw water for irrigation supplies, based on the parameters examined here (MNKLH, 1988). While no bacterial analyses were possible with these samples, it should be expected that some contamination is present, and water should be boiled before consumption.

The upstream Gapet sample (station 1) is probably representative of water quality in the proposed reservoir and what is available for irrigation purposes.

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Figure IV - 1
WATER QUALITY
SAMPLING SITES IN THE GAPET
PROJECT STUDY AREA

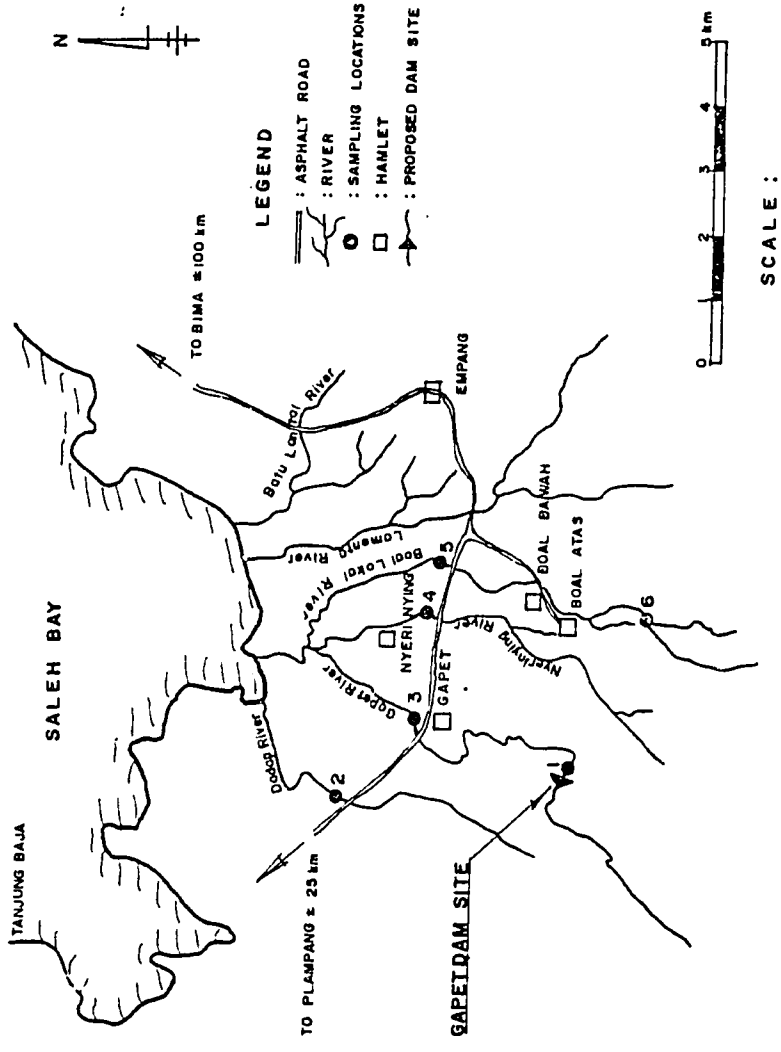


Table IV-3

Gapet Project Water Quality Results

Station No.		Sample No.	pH	Cond. (Umhos/cm)	Temp. (C)	CaCO3 (mg/l)	Na (mg/l)	K (mg/l)	Ca (mg/l)	SO4 (mg/l)	Cl (mg/l)	PO4-P (mg/l)	NO3-N (mg/l)	Total P (mg/l)	TS (mg/l)	TDS (mg/l)
1	Gapet	1	8.14	550	31.0	354	2.7	4.2	17.7	2.8	1.5	13	0.04	53	1220	1110
	River at	2	8.18	650	31.0	427	2.7	4.4	18.0	0.9	5.1	21	0.03	72	1130	960
	dam site	3	8.16	620	31.0	406	2.7	4.0	17.2	1.3	6.7	8	0.04	32	1250	1060
		Mean	8.16	607	31.0	396	2.7	4.2	17.6	1.7	4.4	14	0.04	52	1200	1043
2	Dadap	1	7.95	57470	32.0	222	1346	253	1892	108.0	27742	1671	0.15	5810	110440	87740
	River at	2	7.92	77700	32.0	203	1285	247	1883	37.5	12795	1181	0.10	5130	100700	81500
	main	3	8.04	58000	32.0	161	1356	255	1992	9.1	14889	2855	0.10	9025	112280	86830
	road	Mean	7.97	64390	32.0	195	1329	252	1922	51.5	18475	1902	0.12	6655	107807	85357
4	Nyerinying	1	7.65	4970	32.0	129	278	51.5	152	17.2	49.9	164	0.06	642	7780	6130
	River at	2	8.12	4840	32.0	354	264	56.8	149	15.6	55.3	105	0.05	463	7880	6230
	main road	3	8.18	5080	32.0	344	269	49.1	150	15.6	28.5	152	0.05	521	8040	5510
		Mean	7.98	4963	32.0	276	270	52.5	150	16.1	44.6	140	0.05	542	7900	5957
5	Boal	1	8.68	4570	32.0	439	266	51.2	164	7.8	33.5	236	0.03	1372	7270	4810
	River at	2	8.60	4510	31.5	441	259	52.4	150	10.9	36.5	116	0.01	423	7450	5600
	main	3	8.20	4500	32.0	427	271	58.6	152	1.6	49.0	175	0.02	612	7630	5100
	road	Mean	8.49	4527	31.8	436	265	54.1	155	6.8	39.7	175	0.02	802	7450	5170
6	Boal	1	8.30	550	31.0	300	0.3	5.0	4.2	0.7	1.7	15	0.01	51	1170	870
	River	2	8.17	630	31.0	286	0.3	4.9	3.6	5.8	0.9	23	0.04	85	2030	1060
	at weir	3	8.19	430	31.0	301	0.1	5.0	3.9	1.1	0.7	13	0.03	40	1380	1040
		Mean	8.22	537	31.0	296	0.2	5.0	3.9	2.5	1.1	17	0.02	59	1527	990

Note: Samples taken on 4 November 1989.

Legend: Cond. = Conductivity; Temp. = Temperature; Alk. = Alkalinity; $CaCO_3$ = Calcium Carbonate; Na = Sodium; K = Potassium; Ca = Calcium; SO_4 = Sulphate; Cl = Chloride; PO_4 = Ortho-Phosphate; TP = Total Phosphorus; NO_3 = Nitrate; TS = Total Solids; TDS = Total Dissolved Solids

Source: Analytical Chemistry Laboratory, Mataram University.

Ground Water

The ground water occurrence in this region is closely related to the distribution of the geological units. It occurs in joint fractures, foliation planes or weathered portions of the consolidated old volcanic rock units in the hilly or mountainous area of this region, and within the intergranular pore spaces of the unconsolidated alluvial sediments in the lower topographic portions of this region. The ground water potential in the consolidated rock units is poor because it occurs in the limited thickness of the upper zones of the jointed or weathered products of the bed rock formation. The unconsolidated alluvial sediments, on the other hand, have usually poor to fair ground water potential.

A relatively wide alluvial plain occupies the proposed Gapet irrigation area. This plain is covered mainly by unconsolidated sediments of alluvio-marine origin overlying the basement of old volcanic rock. Infiltration of precipitation and runoff from the adjacent high lands gives this plain a relatively higher ground water potential. The texture and thickness of these deposits vary considerably, and their water-yielding capacity also differs from place to place. Ground water in the unconsolidated alluvial deposits is generally unconfined. Its static water level is a few meters below the land surface.

In its review of ground water potential in Sumbawa, RePPProt (Vol. 1, 1989: 182) indicates this area may likely yield shallow reserves, although no pump-testing of existing hand-dug village wells has occurred.

Reportedly there are a few small springs in the upper catchment area, but they are located far from hamlets. There are no springs of any significance in the alluvial plain area.

Domestic Water. Most domestic water supplies in the project area come from river water or from ground water taken from simple hand-dug wells, or, in a few cases, from handpumps, depending on location. Drinking water is boiled before use, and will continue to be boiled, with or without the project. During the drier months, water availability becomes a problem, and those households that rely on river water part of the year must either dig pits in the river bed to get water, or seek water from existing wells that have not dried up.

As flow in the rivers decreases significantly or stops, the water table drops and there is salt water intrusion so that only some wells remain reliable. In 1989, the Gapet River at the hamlet of Gapet was completely dry by early November. Domestic supply is obtained exclusively from wells during such periods. Sub-surface flow of the Gapet River becomes minimal,

but some people attempt to utilize it for livestock watering by digging pits or wells in the river bed.

The hamlets of Boal Bawah and Boal Atas have access to limited, dry season water from the pool formed by the weir across the Boal River, and very limited, seasonal amounts of water in the canal, while there is still some river flow. The hamlet of Nyerinying is dependent upon wells year-round for its water supply, and despite its proximity to the coast the ground water is still non-saline for those wells in the paddy fields. Water for washing is also taken from brackish water wells closer to the coast.

Fresh Water Demand

Domestic Requirements. The World Health Organization (WHO) recommends a minimum per capita supply standard of 60 liters per day (l/cap/d) for domestic consumption. However, drawing from the experience of the Tiu Kulit site to the west of the Gapet project area, an SSIMP-sponsored survey of domestic water use indicated a current per capita use level of approximately only 21 l/cap/d. Between 6 to 8 liters of this are used for drinking and cooking water, and approximately 11 to 16 l/cap/d are required for bathing, laundry, and sanitation.

These figures are in fair agreement with the 25 l/cap/d initially assumed by Mettana (1988) for domestic piped water demand in the Tiu Kulit project area. Some of these repeated activities occur in the same water of river pits, so water is not consumed and can be used for more than one person. This considerably cuts down on the overall amount of water required. However, domestic consumption of water in the area remains low relative to recommended WHO and GOI standards.

These figures (21 l/cap/d), if applied to the Gapet project area, which, if anything, probably has less water available, indicate that the total domestic water demand of Boal Village, taken as 4200 persons, is roughly 88,000 to 105,000 l/d, or 1.0 to 1.2 l/s.

Livestock Requirements. Boal Village supports a large livestock population (see Table IV-5), estimated at about 3700 water buffalo, 50 Bali cattle, and about 2,000 horses. Recommended daily drinking water requirements for cattle and horses are 20 to 40 l/head, and for water buffalo it is 30 to 50 l/head (Agricultural Compendium, 1985: 607). In total, the large livestock population would require between 152,000 to 267,000 l/d. The quantity of water required for livestock bathing and wallowing is unknown.

Aquaculture Development. Given the very limited, seasonal nature of current aquaculture development in the project area,

there is virtually no "demand" for fresh water for brackish fish ponds at this time.

Land Resources

Land Use

The resident population and agricultural land of Boal Village are concentrated on the flat lands of the northern coastal plain along Saleh Bay, although the village administrative boundaries encompass almost 25,000 ha, extending to the south coast of the island. Most of this interior and south coast land is uninhabited, with no roads or tracks suitable for 4-wheel drive. The population uses, at most, about 20 to 30 percent of village land, and only about 2 to 3 percent of village land is ever intensively cropped.

For purposes of this study, the land use areas have been delimited to the following:

- the catchment area above the dam site (4,100 ha)
- the inhabited coastal area, known as the irrigation area, that includes hamlets, roads, unirrigable land, and the 1,300 ha service area (2,030 ha)
- the downstream tidal flats and limited mixed agricultural area that is not part of the irrigation area (560 ha)

In total, 6,690 ha has been assessed for its current land use (see Table IV-4 and Figures IV-2 and IV-3).

Catchment Area. The upper catchment area (above the future reservoir) amounts to about 4100 ha and is covered with mixed forest, with areas of scrub and bamboo forest in the lower parts. The bamboo and scrub forest areas have likely been logged over in past decades, with the existing vegetation being a serial stage to the climax vegetation type. This area is roadless and accessibility is poor. Harvesting of bamboo is carried out in the lower areas, usually by dragging the cut bamboo out by hand or with the help of horses.

Reservoir Area. The inundation area for the reservoir is part of the catchment area and amounts to approximately 160 ha under normal water levels, and up to 200 ha under extreme flood conditions. This area is largely dry fields, seasonally planted in low-yield mungbeans and then left fallow. There is also some scrub and bamboo forest.

Table IV-4

Land Use in the Gapet Project Study Area

Land Use Category	Dam Catchment Area		Irrigation Area		Downstream Area		Total Area	
	ha	%	ha	%	ha	%	ha	%
Bunded Paddy Fields	10	0.2	740	36.5	40	7.2	790	11.8
Dry Land Agriculture	180	4.4	700	34.5	110	19.6	990	14.8
Grasslands/ Scrub	70	1.7	440	21.6	-	-	510	7.6
Tidal Flats	-	-	110	5.4	410	73.2	520	7.8
Bamboo Forest	1,620	39.5	-	-	-	-	1,620	24.2
Mixed Forest	2,220	54.2	-	-	-	-	2,220	33.2
Residential	-	-	40	2.0	-	-	40	0.6
Totals:	4,100	100.0	2,030	100.0	560	100.0	6,690	100.0

Source: Fenco (1981); and SSIMP, NTB TA Team calculations (1988-90).

Irrigation Area. The agricultural fields of the Gapet study area are concentrated on the flat lands of the coastal plain, resulting in a relatively sharp division of land use between the dam catchment area (upstream of the reservoir area) and service area.

The proposed service area is largely devoted to low-intensity agricultural activity. The land is a patchwork of bunded, rainfed paddy fields, dry fields, open pasture, and scrub. Large areas appear to lie fallow for extended periods. The paddy fields are scattered throughout the area but are most concentrated immediately north and south of the main highway, and between the Dadap and Boal Rivers. The rest of the service area is a combination of dry fields or scrub/pasture, with the proportion varying according to location.

Downstream Area. Close to the coast, there is a broad area (up to 1 km or more in width) of unvegetated tidal flats, with a narrow fringe of mangroves along its border with Saleh Bay. These flats have been suggested as being suitable for development of brackish water fish ponds, or tambak. There are currently less than 40 ha of traditional ponds in Boal Village along the coast area of Saleh Bay, but there are more immediately east of the project area. An attempt was made to construct fish ponds just to the west, but this was unsuccessful and the system is in derelict condition. It is not clear that either the amplitude or frequency of tidal action is sufficient in this area for optimum fish pond operation. The sandy coastal soils make it difficult to build ponds. The lack of freshwater inflow to the coastal waters during the dry season is, however, the most significant constraining factor.

Land Suitability

A land and soil survey was conducted by Fenco (1981) for the Empang area as part of the Sumbawa Water Resources Development Planning Study. The resulting land classification for the Gapet Project irrigation area, as adjusted by the TA Team, is displayed in Figure IV-4 and summarized in Table IV-5. About 70 percent of the irrigation area was judged to be moderately to marginally suitable for paddy and diversified crops. Undesirable soil structure and/or restricted rooting depth were the usual inhibiting factors. A total of 610 ha (30 percent) of the irrigation area's 2030 ha was cited as being unsuitable for irrigation due to high salt content, topography, shallowness of soils, possibility of flooding, or because it was a residential area.

Informal review of the FENCO guidelines for assessing land suitability indicates their classification to be conservative. Some of the land classified as unsuitable for irrigation can probably be safely converted within the proposed Gapet service area.

Figure IV - 2
LOCATION OF GAPET
PROJECT STUDY AREA

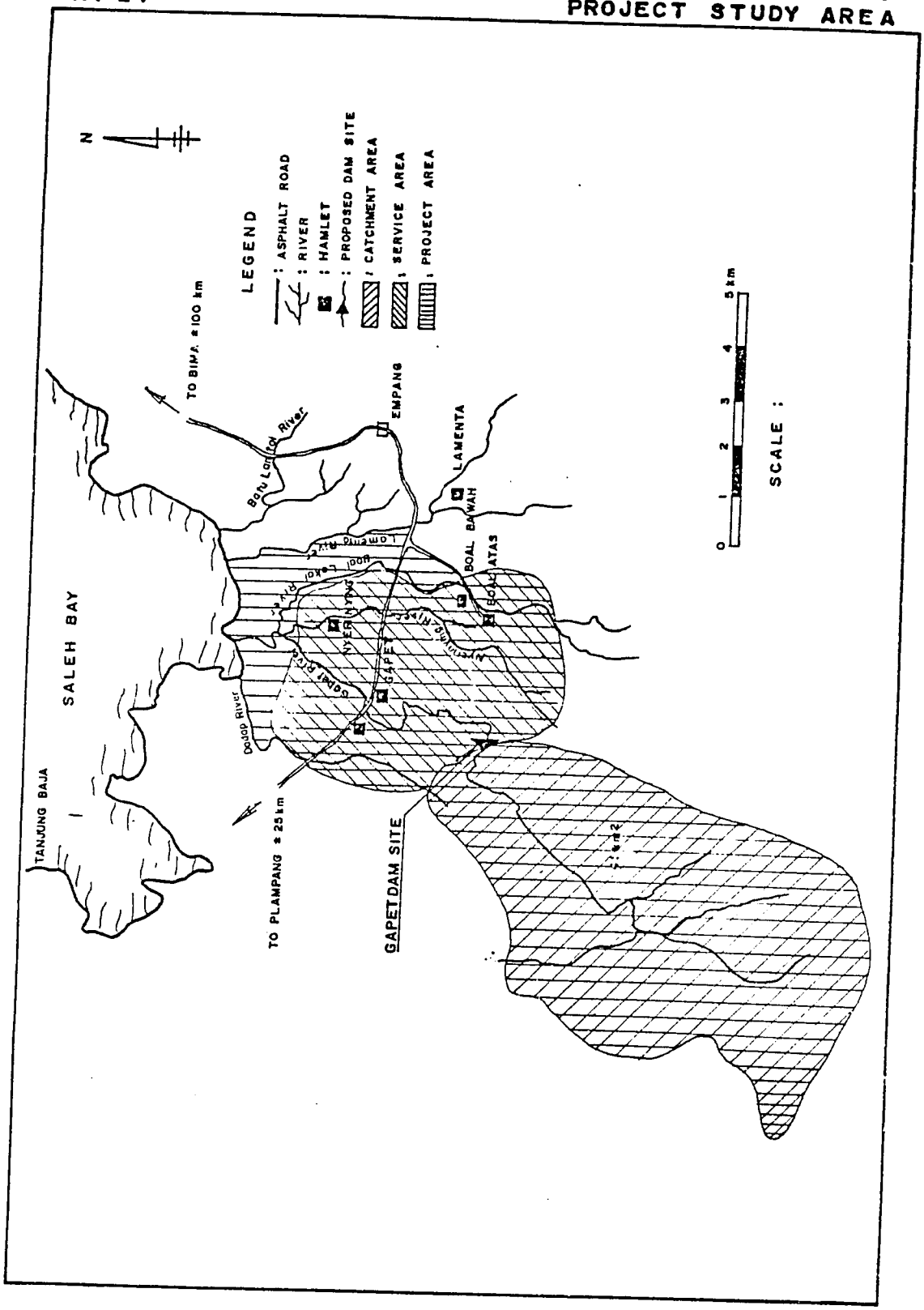


Figure IV - 3
LAND USE DETAILS

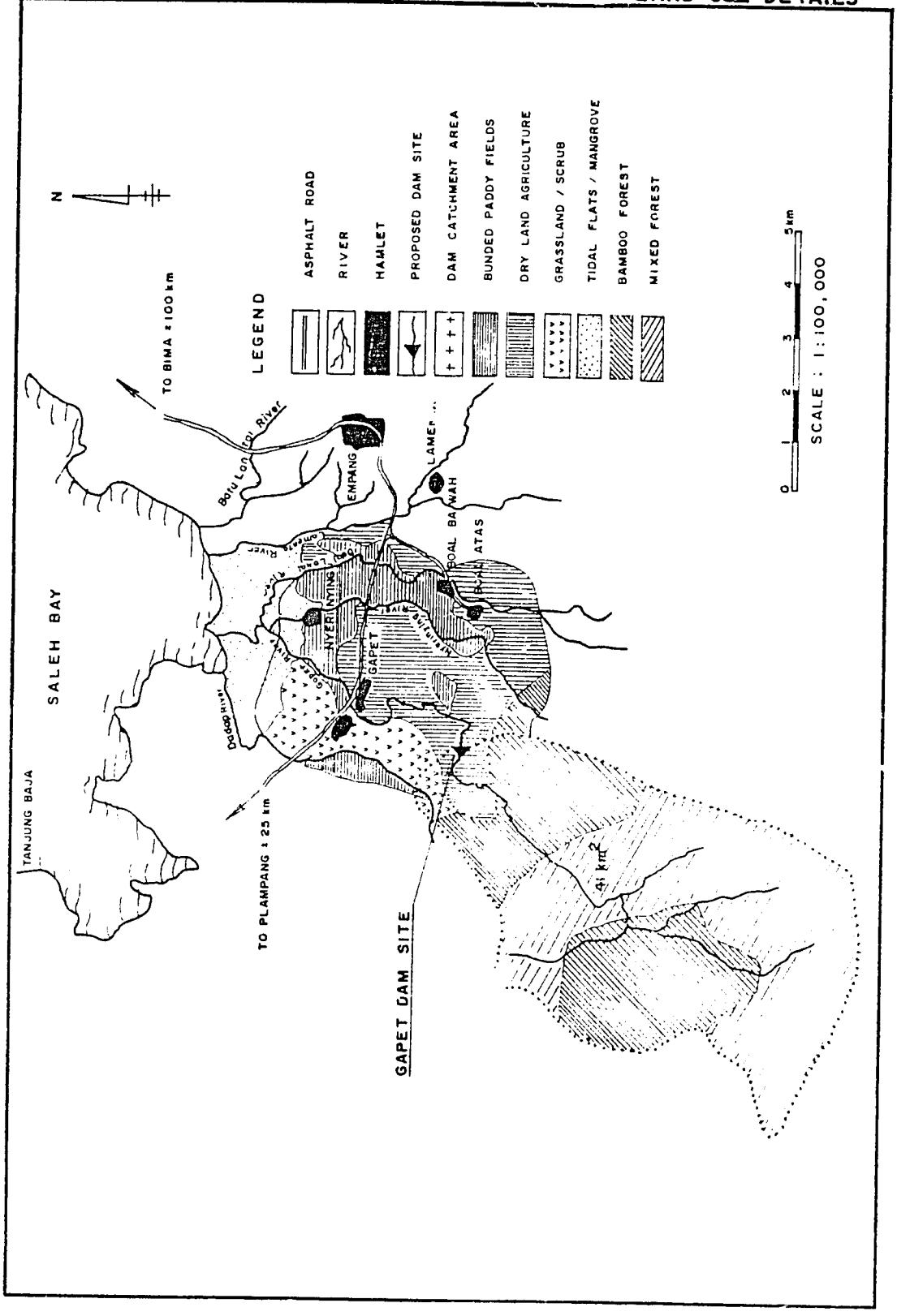


Table IV-5

Land Classification for the Gapet Irrigation Area

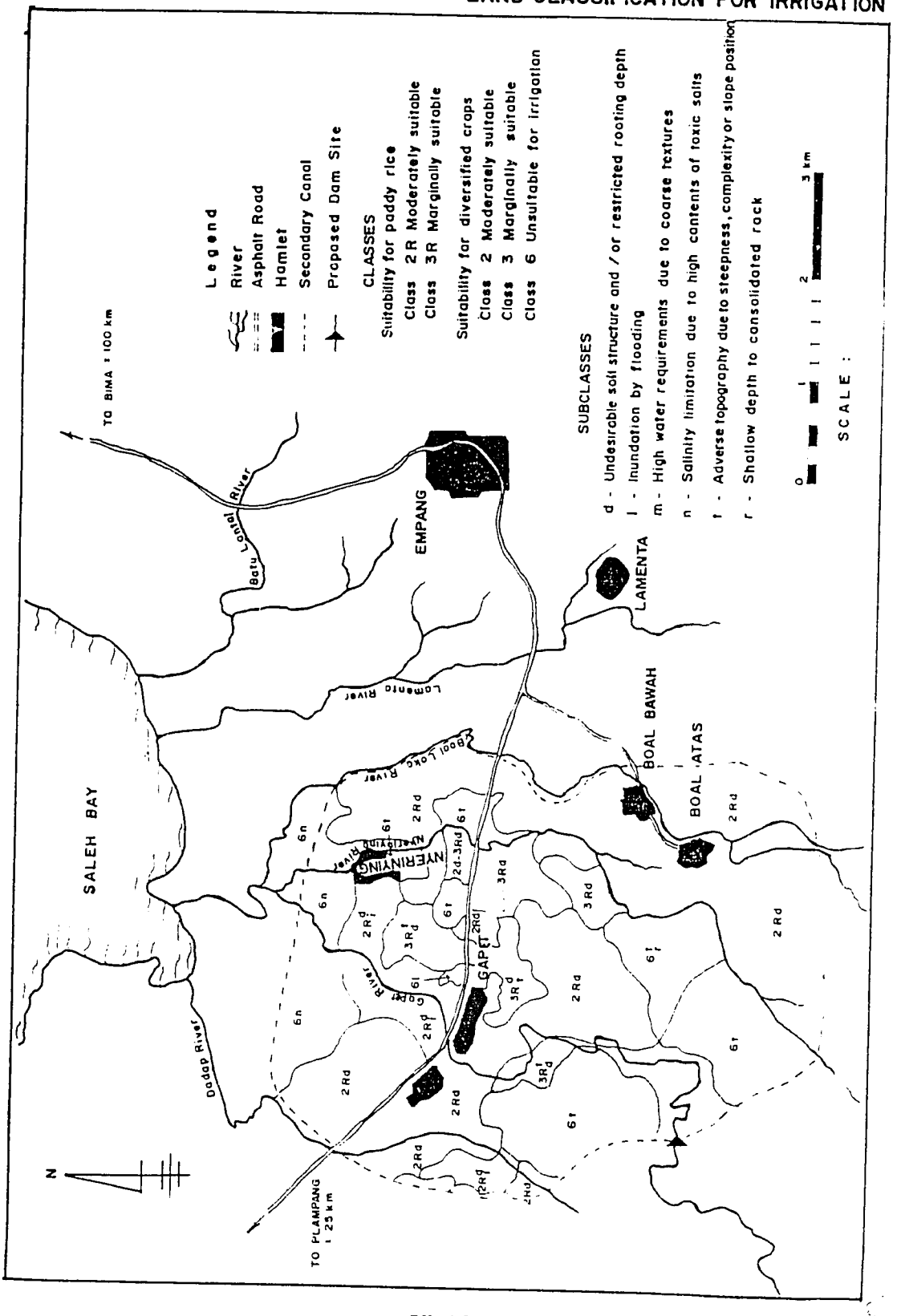
Class/ Subclass	Explanation	Area Ha	Area %
Unsuitable for Irrigation:			
6n	Too saline	142	7
6t	Too steep; adverse topography	325	16
6r,i	Too shallow; possible flooding	103	5
H	Hamlets; residential areas	40	2
	Subtotal:	610	30
Suitable for Irrigation:			
3Rd,t	Marginally suitable	365	18
2R-3Rd	Moderately/marginally suitable	81	4
2Rd	Moderately suitable	974	48
	Subtotal:	1420	70
TOTAL:		2030	100

Source: Original maps developed by FENCO (1981), based on aerial photographs. Calculations and interpretation by Mettana (1989), and by SSIMP NTB TA Team.

Soils

Soil maps of the region (Fenco, 1981; RePPProt, 1989) indicate that the service area is composed largely of alluvio-marine soils of the Plampang group. These are grumusols, and are moderately well drained, and neutral to slightly alkaline. Silty clays with some acid sulphate hazard are located nearer the coastline. These soils are classified as having moderate limitations for cropping due to limited soil depth. The marine tidal flats near the coast are saline, and strongly alkaline, consisting of silty to sandy clays and loams.

Figure IV - 4
LAND CLASSIFICATION FOR IRRIGATION



Most of the upper watershed and reservoir area is classified as volcanic hills and plains of the Moyo soil group. These are well-drained, slightly acid to neutral, non-saline silty loam to clay soils (lithosols) overlying rock. They are generally fairly shallow, and slopes range from 5 to 15 percent with many areas exceeding 40 percent. There is a small area of regosol soil in a relatively flat area of the upper watershed covering a gently sloping volcanic alluvial fan. Soils in this area are moderately deep, fine sandy loams. Upper watershed soils are characterized as having severe limitations for crops but acceptable for pasture or forest, with the major limiting factors being soil depth and steepness.

Erosion

Erosion does not appear to be a serious problem in the project area. There is a minor amount of erosion along the banks of the rivers, and on some of the steeper slopes in the service area which are grazed by livestock. RePPProT (1989) characterizes most of the land units in this area as having minor to no erosion potential.

Agricultural Production Practices

With a village area of almost 25,000 ha, only about 700 ha of it is estimated to be used for paddy production, another 200 ha for dry field crops and perhaps another 500 ha used variously as hamlets, pasture, and firewood collecting areas. Thus only about 5 percent of the land is used very intensively.

Cropping Patterns. Farmers grow crops in bunded lowland paddy fields, in a variety of dry fields, and in permanent house gardens. Most households own both bunded lowland and dry land plots. Land holdings per household tend to be larger than at other SSIMP sites, since these include fallow, and very low productivity lands. According to recent surveys, farm size is in the range of 3 to 4 ha.

Farmers ideally strive to plant rainfed paddy each year, but many cannot. The Farm Survey (1989) indicated one-third of the farmers did not plant any paddy in the previous rainy season, and restricted their planting to mungbean. The wet season paddy crop is followed by a very limited planting of a secondary food crop such as mungbean, or, less frequently, soybean or maize in a few areas. According to the Farm Survey, only a few farmers (10 to 15 percent) attempt this second season planting, restricted to within a few pump-irrigated and village-built irrigation systems. A second dry season crop is rarely, if ever, attempted, according to results of the Farm Survey. Fields are left fallow until commencement of the next rainy season.

The agricultural production strategy here might be likened to a compromise between shifting and sedentary cultivation. As a rough estimate, many fields are "fallow" for at least 5 to 6 years out of every ten. Some fields may only be planted to paddy 2 to 3 times, and 1 to 2 times in a secondary food crop during a ten-year period. This production strategy is combined with livestock raising (and some fishing and aquaculture).

Coconut, papaya, and banana are of minor importance as tree crops, and are mostly for subsistence. There are almost no trees raised to produce cash crops except for a few tamarind trees that are harvested.

Cropping intensity in currently cultivated agricultural areas is only 113 percent due to the dry conditons of the area (Table IV-6). Cropping intensity within the projected irrigation command, including presently uncultivated areas, is less, at only 96 percent.

Table IV-6

Current Cropping Patterns
and Intensity within Project Area

Crop Pattern	Average Area by Season Wet : (ha):	Dry 1: (ha):	Dry 2: (ha):
Paddy/Palawija	197	197	--
Paddy/	404	--	--
Palawija/	516	--	--
Agricultural Area:			
Cultivated	1,116	197	0
Uncultivated	46	966	1,163
Total	1,163	1,163	1,163
Grassland and Scrub:	205	205	205
Gross Service Area:	1,368	1,368	1,368
Cropping Intensity in Developed Agriculture Area:			113%
Current Cropping Intensity in Proposed Service Area:			96%

Source: Subdistrict Agriculture Office, 1989;
field surveys 1989-90.

Timing of cultivation activities differs between the rainfed paddy, the irrigated paddy, and the dry land fields. In the irrigated paddy fields, farmers attempt to plant a first season paddy crop in January/February, and harvest it in April. Because it is so risky, only a few farmers attempt a second paddy or a secondary food crop which is planted immediately after the first harvest, and which is then harvested in July. In the purely rainfed areas, farmers plant a wet season paddy crop in February/March, and harvest takes place in June. A second crop is not attempted on the rainfed paddy fields. In the dry fields, farmers wait until the late wet season/early dry season (about February), to plant mostly mungbean, which is harvested in May.

Virtually all land in the village within and surrounding the service area has already been converted to agricultural production or consists of bamboo or secondary scrub growth. Any primary forest that may have existed in this area was cut long ago. Much of the scrub areas are presumably rotational fields that are currently fallow. Farmers report that in former years, households confined their conversion of dry land to bunded paddy fields to the lower, flatter areas. Although the evidence contradicts this, they cite that only in recent years farmers have begun moving into the hilly areas surrounding the proposed service area, and have been opening up secondary forest to dry land cultivation. Reportedly, prior to opening up "forested" land, households need to seek approval from village officials. There seems to be no problem in receiving such approval. Thus, farmers in the area still engage in their own form of shifting cultivation on both the higher and lower/flatter land.

Conversion of long-term fallow or unused land to agricultural production is a protracted process. Farmers work together (gotong royong) in order to "open up" long-term fallow /scrub forest land, in order to create a field complex, known as an orong. It takes about ten farmers three months to convert one hectare of fallow land for the first year's crop. Each farmer will claim a portion of this one hectare area. If the yields are adequate, farmers will continue to make improvements to the field complex. Usually it takes 2 to 3 years to fully develop a complex.

Prices and Marketing of Agricultural Production

Paddy. The most important agricultural output in the area is paddy. Production is low at only 1 t/ha. In this area, about 84 percent of this production is consumed by the farm household. The remainder of the crop is used as wage payment, seed stock or marketed (Table IV-7). Paddy is sold to middlemen, who pick up and purchase at the farm; a limited amount of paddy is sold at local markets.

Secondary Food Crops (Palawija). Mungbean production in the area averages only 250 kg/ha, with 80 to 90 percent of production sold at an average farmgate price of Rp 575 per kg. Although mungbean has a lower production rate per hectare, it is more profitable than paddy because of its higher value and lower investment cost (Table IV-7). There are reported to be five to ten independent middlemen purchasing paddy, and roughly double that number buying mungbeans from farmers. These numbers indicate a fairly competitive purchasing market and imply that prices received by farmers should be fairly efficient (without distortions due to monopolistic or oligopolistic buying situations). The center from which the buyers operate is Sumbawa Besar, 90 kilometers from the project site. While floor prices have been set by DOLOG for palawija crops, in fact they have been set low relative to actual market prices, and the DOLOG has not been active in price stabilization for these crops. The implication here is that farmers are subject to more price uncertainty with palawija crops than with paddy.

Table IV-7

Agriculture Production Inputs, Yields and Crop Budgets in the Gapet Project Study Area

Input/ Item	Paddy Qnty (kilo)	Unit (ha)	Total Expend. (Rp)	Mungbean Qnty (kilo)	Unit (ha)	Total Expend. (Rp)
Seed	64	kg	3,500	15	kg	--
Fertilizer	25	kg	5,000	--	--	--
Agrochemical	.5	lt	2,500	--	--	--
Others*	--	--	15,000	--	--	7,000
Subtotal..... (Nonlabor Inputs)			26,000			7,000
Labor/ Family Exchange	93	days	--	22	days	--
Hired	19	days	20,000	6	days	12,000
Subtotal..... (All Inputs)			46,000			19,000
Crop Yield	1,000	kg/ha	--	250	kg/ha	--
Value	150	Rp/kg	--	575	Rp/kg	--
Gross Income/Ha			150,000			143,750
Net Income/Ha			104,000			124,750

* Including harvest shares, sacks, land preparation costs, pump costs, etc.

Source: Gapet Farm Survey, SSIMP, 1989.

Livestock Production

The number of livestock in Boal Village and Subdistrict Empang is summarized in Table IV-8. Livestock are used for draft power, as a means of storing wealth, and for consumption purposes, particularly for weddings and other feast occasions. Buffalo provide the main source of draft power. Evaluation of draft requirements and sufficiency indicates the herd is probably adequate to supply land preparation needs under the current situation, net of those buffalo too old, young, or otherwise not fit to work.

Table IV-8

Livestock Populations In The Project Area

Administrative Unit	Farm House-holds	Buffalo Qty.	Buffalo Avg /HH	Cattle Qty.	Cattle Avg /HH	Horses Qty.	Horses Avg /HH
Subdistrict Empang	6,057	18,550	3.1	2,072	0.3	5,465	0.9
Boal Village	849	5,479	6.5	58	0.1	1,432	1.7

Source: Subdistrict Empang, Livestock Office, 1989.

The area supports a large livestock population, with an average of 8.3 large livestock (including water buffalo, cattle, and horses) for every household. This is the highest average livestock holding of any village in the subdistrict (average for the subdistrict is only 4.3). Water buffalo are far more predominant than cattle; reportedly, 85 percent of households own water buffalo (or cattle in combination with water buffalo), and only about 15 percent only own cattle (sapi Bali). Yet in discussions with village leaders, livestock ownership was said to be less evenly distributed, than statistics indicated, with a substantial percentage of farmers owning none.

Bali cattle were introduced by the government, commencing around 1960, but the preference for the traditional water buffalo remains strong. Perhaps 15 households own more than 100 head of livestock here, and another 30 households may have about 50 head each. These large holdings puts up the overall average number of livestock per household. Based on these

statistics, the majority of farmers typically own 2 to 3 head of water buffalo, and 2 to 3 horses. Due to the limited agricultural potential of the dry lands, at present, management of livestock takes on relatively more importance as a factor in household income.

Pastures. Farmers are expected to reserve one ha of dry land out of every four, for livestock grazing during the wet season, according to village land use rules. Usually, most fields are opened up for general use as pasture, sometime after April. Reportedly there is some shortage of pasture between December and April.

Both bunded lowland and dry fields are generally protected from livestock intrusions by "living fences" (pagar hidup) consisting of cactus, other spiny, water-conserving plants, and small, tough trees.

Villagers are now required to apply for permission to open up new pastures located near hamlets, or higher mountain pastures. According to recent subdistrict rulings, opening new pastures may have a negative environmental impact. Also, the Bupati has recently stopped all forestry concessions in the district. The net effect of these rulings seems to have been that only a few fields can be called "a pasture". There is still a great deal of land being used for de facto pastures.

Livestock management practices in the area are generally a mix of extensive, and semiextensive practices. During the dry season, many farmers allow livestock to graze freely in grasslands and fallow fields. During cropping periods, livestock management becomes more labor-intensive with supervised grazing and tethering of animals, and cut-and-carrying fodder. Livestock are fed crop residues, together with grasses from bunds, river banks, roadsides, etc., and leaves from trees like Lamtoro and Sesbania.

Irrigated Crop Production versus Improved Pasture. Promoting the livestock industry has been raised as an alternative to developing the Gapet project area for irrigated crop land. Such a direction would not be a favorable choice for several reasons, most of which are described in the Fenco study[2] on livestock development for Sumbawa (1982). The natural carrying capacity of unimproved pasture land is approximately 0.25 to 0.5 AU (animal units) per ha. Enhanced pasture productivity,

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[2] Sumbawa Water Resources Development Planning Study, Technical Report Volume 9, Agriculture / Livestock, Fenco Consultants Ltd. (Lavalin International Inc.), 1982, for the Ministry of Public Works, Directorate General of Water Resources Development.

with investment of considerable time, management ability and money, can achieve a carrying capacity of up to 2.0 AU per ha.

Continuously cropped land generates crop residue of four to ten tons of useable dry fodder for livestock per ha per year. This fodder can consist of paddy straw, soybean and mungbean hays, and maize tops. Further, along with the crop residues available for feed from an irrigated crop area, improved fodder grasses and leguminous trees can be grown along bunds and canals, also contributing to the quality and variety of feed generated for livestock. Altogether, an irrigated, continuously cropped area, through fodder and feed generation, can achieve the same level of carrying capacity at 2.0 AU as an area of improved pasture, with the extra added boons of valuable crop production and an improved quality of water supply.

To illustrate economically, a farm of one ha under a continuous cropping pattern of Paddy/Palawija/Palawija can produce a net financial return from production of over Rp 1,000,000 per year. Employing improved pasture as an alternative use of the land, 2 adult animals per year can be sustained. Assuming a high herd growth rate of 20 percent per year, that would provide 0.4 cullable animals a year, which at a value of Rp 400,000 per adult animal, would provide Rp 160,000 per ha per year in gross income from livestock. If we add to that figure Rp 10,000 in draft income attainable per season per two adult animals, and sum that over three seasons, we have an additional Rp 30,000 per year, bringing the total gross value of the livestock operation up to Rp 190,000 per year. This level is still less than a fifth of that attainable from the value of irrigated crop land alone. In fact, as stated earlier the benefits accruable from improving pasture are also largely attainable at no extra costs from irrigated crop land.

Therefore, where water resources can be developed to improve agriculture, irrigated crop land production should be favored over livestock development because of achieving not only increased crop production, but also enhancing livestock productivity to comparable levels attainable by improving pasture. In areas where water resources can not be developed to support irrigated crop land, livestock and ranch programs could be pursued to convert the marginal productivity of extensive areas of scrub and grassland into economically valued output (meat). The land studies of the Gapet Project have determined that the soils and slope conditions are suitable to support irrigated crop land.

Biological Resources

Terrestrial Vegetation

Natural habitat in the Gapet catchment area consists of two basic types: tropical deciduous forest, on the upper slopes, and shrub savanna, often dominated by bamboo, on the lower and drier areas.

The long dry season has resulted in natural woodland composed of trees that shed their leaves or go into dormancy for much of the year. Many of the trees, such as Zizyphus, are thorny. In the upper catchment, south of the reservoir inundation zone, trees of fair size remain, but many of the larger specimens have been cut for timber. The plant community structure is largely one of a two-layered, discontinuous canopy, with frequent small clearings. Tamarind (Tamarindus) is dominant, with Barringtonia and Corypha also abundant. The dominant trees having timber value are jati (Tectona grandis), kolaka (Parina corymbosum), bungur (Lagerstromia speciosa), ketapang (Terminalia catappa), and laban (Vitex pubescens). The RePPProT (1989) report also lists Dipterocarpus spp., Eugenia sp. (batu), Calophyllum inophyllum, Tawar spp. and Pterospermum javanicum (bayur) as being important forest species throughout Sumbawa. The shrub layer contains numerous species, most of which have not been studied in detail in this area. In the broad rolling lowland area just north of the proposed reservoir, the original forest has probably been largely cleared, and is now replaced by large areas of bamboo. Other forest species are found scattered through the bamboo and particularly along river and stream margins.

In the clearings and where soils are unsuitable for trees, grasses of the genera Imperata, Paspallum, Pennisetum, and Chloris dominate. Milkweed (Asclepias sp.) is a common colonist of clearings and abandoned (or inactive) dry fields.

As wildlife habitat, the plant community appears to be fairly good, providing sufficient variety of cover, fruits and other plant material, and moisture for substantial animal diversity in the more secluded parts of the catchment area.

On the less sloping sections of the coastal plain, where agriculture and villages are the dominant land uses, what habitat exists is provided by home gardens, scattered fruit trees, paddy fields, and a few groves of bamboo or other woody vegetation around cemeteries and shrines. Faunal use of these areas is predictably limited.

In the estuary there are small areas of mangrove (Rhizophora, Avicennia, and Bruguiera), but these are not extensive.

Much of the "estuary" is composed of broad, unvegetated salt flats.

Wildlife

Detailed studies of the plant and animal life of the project area have not been done, but a 1986 report by the Forestry Department of NTB Province on the Dodo-Jaranpusang Forest (in the region, but not within the basin) gives an indication of the forms of wildlife that may be expected in the wilder areas. They report deer (Cervus timorensis), wild pig (Sus vittatus), and a macaque monkey (Macaca iris). Among the reported carnivores is a species of mongoose (Viverricula malaccensis). There are some omnivores, represented by a large rodents, such as porcupines (Hystrix javanica) and several species of smaller rodents. Bats are an important and diverse part of the fauna. Macaques were observed at three locations in the project area during field surveys in November 1989.

Birds, being more mobile, are better represented in the fauna of the Lesser Sundas than mammals. White and Bruce (1986) list 121 species of land birds for Sumbawa, many of which can be expected in the Gapet catchment area. The limited field observations made for this report added several species to that list, indicating that there is much more to be learned about the avifauna. Noteworthy among these is the green junglefowl (Gallus varius), one of several species ancestral to the domestic chicken. Raptors are abundant and some, such as the owls and the Brahminy Kite (Haliastur indus) are significant predators on pest rodents in agricultural areas.

The paddy fields are host to a small variety of water birds, especially the Java pond heron (Ardeola speciosa) which may concentrate in great numbers during insect outbreaks. The tiny munias (Lonchura spp.) and the Java sparrow (Padda oryzivora) are pests of paddy at times of harvest.

There are no parks or wildlife reserves in this part of Sumbawa. It has been recommended, though, that Pulau Rakit, just off the coast be protected as a tourist park (Taman Wisata) for its coral formations (RePPProT, 1989).

Freshwater Biology

Four rivers drain the project area: the Dadap, Gapet, Nyerinying and Boal. The latter two rivers are tributary to the Gapet, joining it shortly before its discharge into Saleh Bay. All of these rivers are intermittent, having relatively high flows which cause riparian flooding in the wet season, and little or no surface flow in the dry season.

The upper reaches of the rivers, particularly the Gapet, have substrata ranging in composition from coarse sand to large cobbles. There is evidence of substantial bed movement during periods of high flow. During the dry season, water remains in small isolated pools, which act as a refuge for aquatic fauna, including fish. These pools also act as a water source for terrestrial fauna. These pools are nutrient enriched due to allochthonous land-based input of organic matter and probably also have high levels of primary productivity due to attached algal films. They nevertheless have diverse populations of invertebrates, including aquatic insects such as dragonflies, caddisflies, hemipterans (water bugs), water striders, etc., as well as several species of mollusca. There is little macrophyte growth, probably due to the rigorous conditions during high flow periods when such plants would be destroyed and washed away. Some pools had large numbers of small fish, when examined near the end of the dry season in November 1989.

In the lower part of the basin (the service area and downstream of the service area), the rivers have a much less steep gradient and all have a mud substrata. Pools that remain during the dry season are highly enriched and hypertrophic, with floating mats of blue-green algae being commonly present. With anoxic sediment and high organic matter concentrations, these pools probably become devoid of oxygen at night, and are thus poor habitat for fauna. However, fish (tilapia) were observed in November 1989 being harvested from a pool on the Nyerinying River above the main highway. Tilapia are known to be hardly and able to survive extremely adverse conditions.

Estuaries and Coastal Mangrove

The downstream coastal area, located around the mouths of the Gapet, Boal and nearby Lamenta Rivers forms an estuary along Saleh Bay to the north of the service area. Coastal mangroves border the estuary. The estuary extends back from the coast in an irregular pattern and some of the estuary extends inland, up the Gapet River, crossing the main east-west highway and extending a short distance into the potential service area. This brackish area consists of salt flats and a few brackish pools of water.

River channels are shallow in this area and carry virtually no fresh water flow in the dry season. The distance inland where transition between fresh water and brackish water occurs varies by season. In the dry season the estuarine river channels contain only saline water as downstream riverflow is non-existent. Upstream, saltwater intrusions into the ground water, and the resulting capillary action and evaporation result in salt pans near the river beds. At this time, wells close to the rivers as far inland as Gapet hamlet become saline. Tidal action in Saleh Bay is very weak and there is

little difference between high and low tide intrusions of water into the estuary.

Fish Ponds. Brackish water aquaculture, known as tambak farming, is practiced to a very limited extent in the coastal estuary area. Most of these fish ponds have been there for some time, and are non-intensive, using traditional cultivation techniques. Most of these farmers are from the resident coastal Bugis population, but there are also a few of the ethnic Sumbawanese population who have ponds. Fish ponds are quite small, and the Department of Fisheries in Sumbawa Besar estimates there are perhaps 38 ha of fish ponds located in Boal Village, between the narrow fringe of coastal mangrove along the coast and a low inland rise of higher, largely non-productive ground. These fish ponds are clearly visible on aerial photos taken by PT Mega Plana in 1988.

Some of the coastal estuary area in Boal Village is part of a larger area, estimated to be between 650 to 750 ha, ceded to PT Alam Hijau several years ago. The private company got the land for commercial fish pond development. Although a road was begun in 1986 into the area, little tangible action has been taken. Reportedly, after investigating the area for use as commercial tambak, the company concluded there was little potential for development, and the plan was abandoned. One of the main reasons for abandoning the site was that there was an inadequate supply of fresh water in the long dry season, and there was a risk of flooding in the short wet season.

SSIMP environmental experts specializing in commercial tambak development and coastal estuary systems have reached similar conclusions independently of PT Alam Hijau. Without access to significant supplies of fresh water, the area cannot be developed into year-round tambak.

Virtually none of the fish pond farmers of Boal Village can pump any water from any of the local rivers into their fish ponds. What little water exists in the riverbeds in the downstream areas during the dry season is heavily polluted and saline. In neighboring Labuhan Bontong Village to the immediate east, there is somewhat better river flow from another river and fish pond farmers have recently purchased 6 pumps to intensify production on 30 ha.

Within the traditional ponds, there are reportedly three species--milkfish (bandeng or Chano chanos), tiger shrimp (udang windu, or Penaeus monodon), and a small, "white" prawn (udang putih, Latin name unknown), are raised. The majority of fish pond farmers use simple technology where the weak tidal patterns are manipulated by floodgates. Control over salinity is very limited and most fish pond farmers have only rainfall to reduce salinity. As milkfish are able to tolerate a wide

range of salinities better than shrimp, milkfish are raised where there is little or no control over salinity and shrimp are raised when there is more rainfall.

The Department of Fisheries reports yields of 200 to 500 kg/ha of milkfish during the driest four months of the year. Yield data on shrimps are unavailable, but believed to be fairly low.

There is one ice manufacturing plant in Empang, located less than 5 km east of Boal Village. Most fish and shrimp raised in the general area are for domestic consumption or sold locally, and little is sent by truck to Sumbawa Besar. Typically, in the local market in Empang, milkfish sell for Rp 500 to 600 each. Fish are sold at the ponds to local Bugis women traders for about Rp 300 each. Udang monodon, when produced, sell for a minimum of Rp 5000/kg. The small white shrimps, udang putih, are sold locally, where one half coconut shell goes for Rp 1000 to 2000 each.

Socioeconomic Resources

Population Profile

Project Beneficiaries. Direct benefits will accrue to owner cultivators (the majority of farmers) and sharecropper households having land in the service area. On average, households have 2 to 3 ha of bunded lowland (according to the results of a Rapid Rural Irrigation Appraisal and Farm Survey, conducted in 1989), although not all of this is cultivated to paddy each year. If all households had 2 ha of bunded lowland, then about 500 to 600 households, or between 3000 to 3600 people would directly benefit from this project. These beneficiaries are estimated to constitute 72 to 87 percent of the study area population. The direct beneficiaries are the target population and access to irrigation is expected to result in them experiencing substantial gains in net income and in standard of living. These farmers may be expected to hire out many of the tasks that they now do themselves. This will tend to distribute the economic benefits beyond the target population. Some farmers will also sell or sharecrop out some of their land, so that the direct beneficiary population is expected to be somewhat larger than the immediate resident population. Some rough estimates indicate the population could rapidly double in size with intensification of cropping.

The indirect beneficiary population of the study area are those village residents who do not receive direct benefits from the project in the form of irrigation water. They include households where the primary source of support is from other occupations in the community not directly involving growing

paddy or secondary food crops in the project service area. These households constitute about 13 to 28 percent of the study area. Some of these are expected to sharecrop or even purchase land in the service area, thus becoming direct beneficiaries.

The project will also benefit a few absentee owners and many migrant laborers who will have increased seasonal employment in the service area. Increased prosperity of the target population will benefit these people economically by increased demand for goods and services.

As is true of virtually all the SSIMP sites, landholding is not consolidated, and due to the inheritance (and some purchases) of small parcels of land, most farmers raise their crops in fields scattered across village sub-areas (dusun) and even beyond village boundaries. Thus, the population living in village sub-areas receiving irrigation is not necessarily the same as the population of direct project beneficiaries, although it is likely that the majority of residents of a particular sub-area will own and/or sharecrop nearby land.

Population Density and Growth. The Gapet Irrigation Project is located in Subdistrict Empang, District Sumbawa, NTB Province. In 1987, Subdistrict Empang had a population of 23,635, living in ten villages, with an overall population density of 29 persons per square kilometer. This is significantly less than the overall population density for NTB Province, which was 151 persons/km^2 in 1988.

Boal Village, the site of the project, has a population density of only 16 persons per square kilometer. The low population density is probably due largely to the dryness and relative isolation of the area, as well as the fact that most of the village land is uninhabited and unused forest and savanna.

Throughout this sparsely inhabited subdistrict, the population is organized into scattered hamlets, mostly located within 2 to 4 kilometers of the main east-west highway. Virtually no one lives on the south coast and there are no good roads to that area. Boal Village has the largest area of any of the villages, but the population effectively uses perhaps 5 percent (including the nearest areas used as pasture and to collect firewood) and the rest is unused forest or savanna.

Boal Village has five sub-areas (dusun), of which four are in the project area. The total population of Boal was 4152 persons in 1987 (Table IV-9), a 7.4 percent increase over the previous ten year period (Table IV-10). The annual growth rate has been highest for the hamlet of Nyerinying, at 1.9 percent, but it has been only 0.5 percent for the village as a whole in the same period (Table IV-10).

Household Size. The average household size according to village statistics, is uniform across sub-areas of the village, averaging 4.9 persons per household (Table IV-9). This includes an average of 1.6 children aged 0-14 years per household. No range of household size data was available from this source. The Gapet Farm Survey (conducted in 1989 by the TA Team and PU staff assigned to SSIMP), however, found that households averaged 6.0 persons.

Table IV-9

Study Area Population, Boal Village, 1987

Village Sub-Areas (Dusun)	Resident Population	Number of Households	Average Household Size
Gapet	896	183	4.9
Boal Atas	1139	233	4.9
Boal Bawah	415	85	4.9
Nyerinying	203	42	4.8
Lamenta*	1499	307	4.9
Total:	4152	850	4.9

* This sub-area is largely outside the project service area; it is located on the east side of Boal Village.
Source: Village statistics, 1989.

Table IV-10

Population Change in Boal Village, 1977-1987

Village/Dusun	Population			Percent Change	Growth Rate	
	1977	1982	1987	1977-1987	77-82	82-87
BOAL	3867	4041	4152	7.4	0.9	0.5
Boal A	1094	1119	1139	4.1	0.5	0.4
Boal B	370	390	415	12.2	1.1	1.2
Gapet	820	872	896	9.3	1.2	0.5
Nyerinying	163	185	203	24.5	2.5	1.9
Lamenta *	1420	1475	1499	5.6	0.8	0.3

* Outside project service area.
Source: Village statistics.

Migration and Resettlement. As noted above in Table IV-10, the growth rate for the area during the period 1977-1982 was only 0.9 and during the period 1982 to 1987 it dropped to 0.5. These low growth rates should be attributed to out-migration rather than particularly low birth rates, even though great strides have been reportedly taken in the recent effectiveness of the national family planning program in this area. The area has experienced a virtual " no-growth in population" situation for at least the past ten to fifteen years, indicating a tradition of out-migration as an indirect means of controlling population size in the area.

Locals assert that the Bugis population have a ready propensity to move back and forth, particularly to the cities of Surabaya and Ujung Pandang. The ethnic Sumbawanese population is reportedly much more sedentary with less propensity to migrate. However, since recorded growth rates are not available according to ethnicity, and because the majority of the population are ethnic Sumbawanese, it is likely they out-migrate in a manner similar to the Bugis, even if it goes unrecognized. Destinations of Sumbawanese migrants are unknown, but likely to be the towns of Sumbawa Besar, Mataram and other urban centers in NTB Province.

At the local level, within the subdistrict, there is limited movement of Boal Village residents to the very small town of Empang. There are several landowners who could be considered absentee where they sharecrop out their village land to relatives, because they have moved to Empang (or perhaps to Plampang, or elsewhere nearby). In most cases these absentee landowners once lived in the village, or they maintain houses in both the village and in town. Some of these people are employed in government service jobs and spend more time in Empang than in the village.

This village is not part of, nor has it ever been part of any formal, government-sponsored resettlement program that moved people either in or out of the village (transmigrasi lokal. As is true of many other villages in Indonesia, the population has been resettled into consolidated hamlets near access roads (this occurred in the late 1960s and in the 1970s). Reportedly some 200 people left the area in 1982, but this was a spontaneous exodus due to drought and widespread crop failures. There are no transmigration programs in the immediate area (there is a plan to move some people from Subdistrict Empang to Plampang; it doesn't affect Boal Village).

Age Distribution and Sex Ratios. Although the reported age data for Boal is not highly accurate, it is clear that the population is fairly young, with 46 percent of the population aged less than 15 years (Table IV-11). The 15 to 54 year age group, considered the working age cohort, contains 47 percent

of the population. Much farm labor is performed by children, even as young as ages 7 or 8 years, although their work contribution tends to be underreported in statistics.

Table IV-11

Population by Age Group and Sex, and Sex Ratios, Boal Village, 1988

Age Group	Males	Females	Sex Ratio
0 - 4	291	294	99
5 - 9	200	161	124
10 - 14	156	190	82
15 - 19	200	150	133
20 - 24	128	170	75
25 - 29	195	208	94
30 - 34	100	70	143
35 - 39	269	251	107
40 - 44	268	241	111
45 - 49	116	102	114
50 - 54	81	72	113
55 +	68	58	117
Totals:	2072	1967	105

Note: Some age misreporting occurs in the age groups 5 - 9 through 20 - 24.

Source: Daftar Isian Potensi Desa & Kelurahan, Desa Boal, 1988-1989.

The sex ratio is highly variable for the younger age groups, probably due to age misreporting. If the data were smoothed to reflect wider groups, then these large differences would disappear, but it would still be apparent that there is an excess of males over females. This may indicate that females from the area show a readier propensity to out-migrate than males.

Kinship and Marriage. Bilateral extended family ties are strong, with family members providing reciprocal labor and even economic assistance to each other in time of need and for ceremonial occasions such as weddings and funerals. Marriage partners are sought within the immediate village or in the region, within the same religious and ethnic group. Usually, agricultural land is inherited by sons, with daughters receiving their inheritance in the form of household goods and some cash at the time they marry. Generally, houses are inherited by the youngest child as this person tends to remain living in the parental house after siblings have married and moved.

Ethnicity and Religion

The study area population consists of ethnic Sumbawanese and ethnic Bugis, who are Muslim. Few if any of the local people are sufficiently wealthy to have made the pilgrimage to Mecca. The village has a total of four mosques.

Archeology and Cultural History

Given the relatively dry climate along the north coast of Sumbawa, the project area has probably always had only a small population and has never supported a culture where significant temples, mosques, towns, or any large buildings have been built. Although the island is along the great land arc from the southeast Asian subcontinent to Australia, and the area has probably been inhabited for centuries by sedentary agriculturalists, there are no known surviving neolithic sites or any other, later sites of archeological interest that can be observed from surface remains. This area, like much of Sumbawa, was inundated by volcanic debris when Mt. Tamboro exploded in 1815, killing virtually the entire population. Thus, there is not much physical evidence of the past on most of the island.

Historical records support the idea that much of Sumbawa is a kind of intermediate cultural zone between the Balinese-Sasak groups to the west (Bali and Lombok), and the Florinese, Timorese, and other ethnic, linguistic, and racial groups from the islands to the east. For at least the past 150 years, much of Sumbawa has remained under the influence of the dynamic Bugis culture coming from South Sulawesi.

Boal Village has several Muslim graveyards scattered through the project area. Virtually all burials are made on higher ground on small knolls, or, in some cases, near house sites. There are no known graveyards located in the reservoir /dam site area, or along the main and secondary canal routes.

Education and Literacy

In the past, many children either never attended school or dropped out before completing primary school. Today, there are 5 primary schools, one for each sub-area of the village. These schools teach agriculturally-related topics in classes 4, 5, and 6. Reportedly, most primary school-aged children (7 to 12 years) attend school and most children eventually complete primary school. There are 5 intermediate-level (SMP, SMPP, SMPGRI), and 2 senior-level schools (SMA) in the subdistrict, located only a few kilometers to the east. A number of children from Boal Village attend these higher level schools. Other children from this village go to school in Sumbawa Besar.

Among the study area population as a whole, about 51 percent have completed primary school, and another 2 percent (who still live in the village) have completed at least secondary school. The village boasts of successful students currently attending schools and universities in Yogyakarta and Malang, and claims to have graduates (who now live elsewhere), with university degrees in Livestock, Law, and Economics. Some adults have participated in government-sponsored adult literacy programs (Paket 'A'), and are now at least minimally literate. Overall, virtually everyone between the ages of 8 and 30 years is at least minimally literate.

Public Health

Domestic Water Supply. Domestic water supplies in Boal Village become increasingly less abundant as the dry season progresses and surface water flows cease, or become negligible and are restricted to increasingly polluted river pools. At the peak of the dry season, some of the wells are saline or go dry and the population relies mostly on the remaining year-round flow wells. Villagers located in the hamlets of Boal Bawah and Boal Atas currently have some of the best supplies of water in the village as they are near the irrigation canal and the pool formed by the Boal weir.

Water-Related Diseases and Health Conditions. The incidence of water-related disease is difficult to assess, given the lack of adequate sources of data. Statistics for any individual village or local clinic are not generally available and in any case, would, of course, only refer to the number of treated cases. There appear to be little or no sample survey information available for the area where copies of the reports have been locally retained.

According to health care officials in the main clinic in Empang, the local health clinics treat diseases such as dengue fever, malaria, and the diarrheal diseases. As is true for other parts of NTB Province, some chloroquine-resistant malaria is reported.

According to health officials, during the long dry season, the incidence of diarrheal and skin diseases increases as the number of relatively clean sources of water decreases. Some hamlets are located near standing pools of polluted, algae-filled water, frequented by both water buffalo and the local population, who wash clothes and bathe there. Some of the less educated population may also draw their drinking water from such places. Some of these polluted sites are seasonally saline, and so, undrinkable.

Housing and Sanitation. Most houses are built of local materials, in the "panggung" architectural style, where floors are

elevated one to two meters off the ground. Of a total of approximately 850 houses in the village, about 93 percent are of this traditional style, with wooden floors and either wooden or woven bamboo walls, and usually thatched roofs (only a few have corrugated roofs). The remaining seven percent of houses are combinations of wood, stone, brick and concrete, usually built on the ground. The elevated style is undoubtedly of some beneficial value as houses are kept free of livestock and are usually clean and airy.

Toilet facilities are very rudimentary. Only two to three percent of the houses are reported to have built toilet facilities nearby, the population preferring to use the rivers or fields. There is no domestic piped water supply or village drainage system in the area.

Health Care Facilities and Services. Boal Village has participated in standard health care training programs conducted by the Department of Health. Each village sub-area has a "traditional" midwife, equipped with a basic health kit. These midwives attend a one week refresher course each year, and any new midwives are sent to Sumbawa Besar for their initial training.

Limited family planning services began in 1974 in the subdistrict, but these services have become widely available only since 1985. Today, each sub-area of Boal Village has an active group of family planning acceptors.

The village has one main health clinic (PUSKESMAS Pembantu), located in the hamlet of Boal Atas. This clinic is open twice a month. The other four village sub-areas each have ancillary clinics that meet once a month on a rotating basis. These clinics are staffed by a travelling health care team consisting, at minimum, of a doctor, nurse and trained midwife. There is also a public health care worker who occasionally provides malaria-prevention training to villagers attending the clinics. The main health care program emphasizes immunization of infants and young children, general health problems, family planning services and nutrition. Although visits to the ancillary clinics are free of charge, patients are charged Rp 300 for their first visit to the main village clinic, and Rp 200 on subsequent visits. This includes costs of any medicine. The main clinic in Empang is staffed by a doctor and other health care workers, and is available for use by Boal Village residents, who can reach it by means of public transport along the main road. A hospital is located in the district capital town of Sumbawa Besar, about 90 kilometers to the west.

Economic Aspects

Income. Income levels in the project area are low, compared to provincial and national averages. Results from the SSIMP Farm

Survey indicated a median-sized farm was 3 ha, and an average-sized farm was closer to 3.5 ha. Estimates of net farm income from a median-sized farm was about Rp 579,000, including both crop and livestock production. This is just at the suggested DGWRD "poverty line" of Rp 570,000 for a household size of five (DGWRD, PSA-001, 1985: 432).

Land Ownership. Virtually all farmers are owner-operators and there are reportedly no households in the village entirely dependent on sharecropping arrangements for access to land. A few owner-operators also sharecrop/rent land.

According to the farm survey, most farmers inherit their land (65 percent) or acquire additional land by opening unused or "empty" land (11 percent), or purchase additional land (9 percent). Land registration in the area is through local registration books with sketches of field complexes, or more rarely, by government certificate title. As the area is stable and most land is claimed through inheritance on the basis of customary law, land ownership appears clearcut, and no major problems seem to exist regarding land rights or tenure in the service area.

Land and other types of inheritance follows Islamic custom where sons receive two parts and daughters receive one part. In the case of land that is inherited, it is recorded in village records, i.e., "registered" in the name of the person who receives it, so that men and women bring their own land into marriage. In the case of divorce, the woman continues to own the land she brought with her into the marriage (unless it has already been sold), or her children inherit it. Land that has been jointly purchased during marriage is divided between the couple in the case of divorce.

Land Values. Current land values are low. Results of an RRIA (1988) indicate that rainfed paddy fields in the area has a value of about Rp 1 million/ha, in contrast to irrigated paddy fields valued at Rp 2.5 million/ha. Dry fields are valued at Rp 600,000 to 700,000/ha.

Land Evaluation and Taxation. Agricultural land in Boal Village is being mapped for land use and ownership by PT Mega Plana, using aerial photographs taken in August 1988. The reported purpose of this survey is to re-evaluate or update the land tax base of the area. Much of the land that has been "opened up" over the past few years is still untaxed. Most of the land that is taxed now has a very low classification.

Completion of technical irrigation will probably be accompanied by a drive to upgrade land titles to the modern system. Probably the cadastral survey and mapping of the service area that is already underway could form the basis for the

land title registration program. Tax rates and tax efforts should increase as taxable capacity increases. Technical irrigation should raise income sufficiently to allow for future water users' fees to help pay for some of the necessary costs associated with operation and maintenance of the system.

Labor Availability. Given the low population densities in the area, Boal Village will be quite short of labor to be able to rapidly convert the land to 1300 ha of technical irrigation. Also, with relatively low yields and the non-intensive nature of agricultural production, the area currently attracts relatively few harvest laborers, although some reportedly arrive annually from the Dompu and Bima areas to the east on Sumbawa Island. Most households share agricultural tasks with neighbors rather than hiring laborers from outside the area.

With the project, and even if more families moved to the area, there would still be large labor shortages during peak periods of agricultural activity in the foreseeable future. One means of avoiding labor shortages during periods of peak activity is to stagger field preparation and planting so that different plots mature at different times. This strategy is currently practiced by farmers to allow them to rely less on wage/share labor, so that only household or exchange labor is necessary.

Current Occupations. Other than employment in agricultural production, economically competitive income earning opportunities are limited in the study area. The Boal Village labor force is overwhelmingly agricultural, with almost 90 percent of the population employed in this sector (Table IV-12). Some households may engage in collecting and selling fuelwood, honey, rattan and other forest products and some engage in coastal fishing, small-scale industry/handicrafts, petty trade or government service. Virtually, all of these income generating activities (except government service) are done during the off-season and do not compete with the demand for labor during peak agricultural periods.

Social Structure

Farmer Organizations. Farmer groups (kelompok tani) have been organized by village extension workers from the Department of Agriculture's Extension Service. The number of groups in each village follows a formula set by the extension service. Boal Village has one extension worker assigned to the village who works with 8 groups in the village, with about 525 members. Actual participation depends on the level of interest or motivation of individual farmers and of the individual extension workers.

Table IV-12

Primary Employment by Sector,
Subdistrict Empang, and Boal Village

Area	Sector								
	Agric.	Fish.	Lvst.	Fors.	Ind.	Trade	Trans.	Govt.	TOTAL
Number Employed:									
Subdistrict Empang	4,995	418	-	-	123	82	215	307	6,140
Boal Village	766	-	-	-	25	5	39	21	856
Percent Distribution:									
Subdistrict Empang	81	7	-	-	2	1	4	5	100
Boal Village	89	-	-	-	3	1	5	2	100

Source: Subdistrict Empang offices, 1989.

Each farmer group has a contact farmer (kontak tani) and some lead farmers (tani maju), of which there are 80 in the village. The rest of the farmers are considered to be usual, or regular farmers (tani biasa). In this village, there are relatively few activities, and little new technical information that is passed on from extension workers to farmers that requires much formal organization.

With only limited effectiveness of the existing irrigation in the village, there are severe limits to improving yields through any assistance from extension workers, and the farmer organizations remain weak. The main cooperation consists in sharing labor among farmers cultivating land within a single field complex, including field preparation tasks, harvesting, and joint post-harvest livestock grazing.

Although they are not very organized along formal lines, farmers do share a common, general consensus about agricultural practices as well as common ritual traditions. Prior to commencing wet season agricultural activities, farmers hold traditional group ceremonies and food exchanges (selamatan). There are special sites for these ceremonies. The ceremonies are usually conducted in December and organized locally by the hamlets. They are known as "turun ke sawah" selamatan, similar to practices elsewhere in Indonesia.

Irrigation Systems and Water Users' Associations. Approximately 50 percent of the service area consists of rainfed paddy

fields, and there are also more than 390 ha irrigated by privately owned pumps or village-built weir schemes, located along the banks of the Boal River. These two types of semi-technical irrigation systems require a higher degree of organization than the purely rainfed areas.

Organization varies among the irrigated complexes. Leadership combines mixtures of the duties normally attributed to the traditional field and water managers (malar) for rainfed paddy complexes, with the addition of more recent, irrigation-specific roles. Thus, the role of field complex managers has been expanded to new areas of responsibility in the irrigated areas.

Individual farmers remain rather informally organized in virtually all of the locally maintained irrigation systems. Thus, although the basis for a water users' association exists for the entire Gapet system, much work remains to be done to develop its management and organization.

Settlement Pattern and Administrative System

Settlements. The settlement pattern and administrative system are interlinked. Within the village (desa) are a number of sub-areas (dusun), each with several hundred people. Within sub-areas are hamlets (kampung) with one or more administrative units of 25 to 50 households. Boal Village has five sub-areas, four of which have agricultural land in the service area.

Virtually the entire population is now settled in consolidated hamlets. The majority of the population resides along the main east-west highway, or near several village roads that connect the hamlets with the highway. This enables the government to provide better services, particularly schools, health services, and roads.

Administration. Village heads (kepala desa) are appointed by the subdistrict government. Village administrative officers including secretary and office staff, are responsible for handling administration, development, welfare, finances, and miscellaneous administrative and record-keeping duties. The village head is advised by the LKMD (Lembaga Ketahanan Masyarakat Desa), a kind of planning council at village level. Members of this council are local key persons and representatives of semigovernmental organizations like the rural women's group (Program Kesejahteraan Keluarga, or "PKK"), key or contact farmers (kontak tani), the malar, or water users' association leaders (P3A), and village unit cooperatives (KUD). Proposals are made by the village advisory body, known as the "LMD" (Lembaga Masyarakat Desa), who finally make recommendations to the village head. In practice, the quality of the village administration strongly depends on the personal capabilities of

the village leaders rather than the activities of formal councils or committees.

Regional Infrastructure

Roads. The main highway across Sumbawa Island traverses Boal Village. This highway is asphalted and has been recently upgraded and now provides fast and convenient access to the small towns which constitute the major urban centers of the island. There are approximately 4 km of rock-surfaced roads from the main highway to the hamlets of Nyerinying and Boal Bawah/Boal Atas, all of which are in fair condition. Other access routes into the area are by rough tracks only suitable for four-wheel-drive vehicles during the dry season. There is a footpath leading south from the proposed reservoir area, but there is no vehicle access to the south coast or to the upland areas of the watershed.

Transportation. Public transport along the main east-west highway is readily available in the form of long distance buses, short distance mini-buses, and horse-drawn carts. With a reported 1,900 horses in the village, horse carts and horseback dominate as the main forms of transport along village roads and to the town of Empang. There are also at least 37 motorcycles and 50 bicycles in the village.

Communications. There is no telephone service in this area. Many households have radios; television sets are few, there being only 12 reported for the village, out of 850 households. Copies of newspapers are relatively rare.

Markets. There are four small shops (kios/warung) in the village. The nearest market is in Empang. There is one paddy mill and one paddy drying floor in the village.

Banking and Credit Facilities. The only institutional source of credit is the Bank Rakyat Indonesia Unit Desa, located in Empang, 3 to 4 km to the east of Gapet. Other non-institutional sources of credit are very limited; most common are loans between farmers themselves, usually in the form of seed and fertilizer inputs which are repaid in paddy at harvest. Middleman buyers would be another source of credit.

Electricity. There is no electrical system in the project area. There are some small generators to provide lighting for special events. Electricity is available in the evenings in Empang.

Regional Development

There are currently no plans for any integrated approach to development of this part of Sumbawa, nor any particular

development projects focussing upon Boal Village. The upgrading of the main trans-Sumbawa highway will contribute to the area by improving transportation facilities and thus the marketing of produce. UNICEF, CARE and AIDAB are all doing surveys for possible village water supply projects. CARE is currently assisting with development of piped water supply in several villages, but not in Boal Village.

The watershed is nominally managed by the Forestry Department. The area is categorized as "protection forest" in the upper areas, and "conversion forest" (conversion to agriculture) in the more low-lying parts. This latter includes the service area and parts of the bamboo forest in the dam area.

Attitudes Toward the Project

People in the project area are greatly in favor of the project, representing as it does a major improvement in water availability for agriculture. They do not oppose the taking of part of their land for project structures.

As a result of initial assessments, indications are that the Gapet site will be socially suitable for technical irrigation. This site meets the general USAID requirements that farms be principally smallholder, owner-operated and that knowledge and interest of farmers are sufficiently high so that provision of irrigation will result in maximum benefits. As some areas within the potential service area are either not cultivated at all or cultivated infrequently, it will be necessary to have a rather extensive conversion of land to bunded fields. This will require a major labor input initially, and a longer period before full benefits of irrigation could be attainable. However, initial discussions with farmers indicate they are very enthusiastic to put in the required effort.

CHAPTER V

POTENTIAL ENVIRONMENTAL IMPACTS

Methodology Used to Identify Project Effects

Identification of the potential impacts of a particular project usually are based on several types of information sources, any of which may prove appropriate or inappropriate upon close examination. These sources of information are:

1. The published literature on similar projects, worldwide;
2. Local knowledge of problems that have been experienced on similar projects;
3. Concerns expressed by local officials in reports or at formal meetings;
4. Extrapolation of baseline environmental conditions by analysis of the interaction of resources with the project.

All of these sources have been used to some extent to determine the likely environmental problems of the Gapet Project.[1]

Local knowledge and concerns were addressed through the "scoping" activities for the project environmental studies. In December 1989, a "scoping" meeting was held in Sumbawa Besar, with more than 20 participants, representing a number of government agencies, USAID, and technical consultants. The objective of the meeting was to bring to light concerns over general and specific effects of the Gapet Irrigation Project. An account of the meeting is presented in Appendix C to this report.

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[1] The theory and methodology currently available to analyse a complex series of interactions involving changing technology and human activities with the environment is incomplete and still evolving. Prediction of impacts in this context, with so many largely unquantifiable variables is an inexact science and does not, as yet, lend itself to very much analysis using numerical modeling.

Participants discussed both positive and negative interactions of the project with its environment. The same general areas of potential impact were discussed in the meeting as in this report: water, land, biological, and socioeconomic resources. The general areas of concern were largely those already identified by specialists at USAID and by the Technical Assistance Team. These are summarized below.

Pre-construction Phase

Work during the pre-construction phase such as site surveys and test bores have produced generally positive social impacts among the local population, and raised public interest in the likelihood of receiving irrigation.

The greatest negative impacts during pre-construction will be acquisition of some agriculturally productive land to be used primarily for supply and drainage canals. Since the land area to be taken is relatively small and the local population is enthusiastic about the project, the impact should be small. The reservoir will inundate an additional 160 ha of primarily brush forest, grass land, and some dry fields (usually planted in mungbean). It may be necessary to compensate a few families who have agricultural land in this area. It is important, however, that negotiations for compensation to the villagers for their land be conducted in an expedient and fair manner. Otherwise significant delays in the project and ill-will among the populace will be generated.

Fortunately, there are no hamlets in the reservoir area, although there are a few temporary shelters. No resettlement will be necessary.

Construction Phase

Potential environmental impacts during the construction phase will be mostly temporary ones. The local population will benefit positively from increased employment opportunities and the greater demand for locally procured goods and services while construction crews build the system. Prior to construction of the dam and canals the roads into the project site will be upgraded with the resultant improvement in transportation services in the area.

While construction is underway, the local population will be inconvenienced somewhat by increased traffic, noise, and dust; and there will be disruption of agricultural production along some of the canal routes as they are built. The disruption caused by the contractor, however, should be kept to a minimum. Clearing in the reservoir and borrow areas should be limited to just those areas, with fences if necessary. Contractors using local roads as access to any construction area

should attempt to minimize their disruption of village life. The labor and logistics camps will be placed where they will create minimum impact on the environment and villagers. Pit toilets will be provided and relocated occasionally. Trash will be burned and all hazardous materials such as used motor oil should be stored and later removed from the site. The contractor should be prepared to supply his laborers with housing, food, drinking water and firewood when these items are scarce locally; otherwise competition for resources with the indigenous population will result and create price inflation. It is especially important that the laborers not be allowed to take wood from the watershed, as this area must be preserved for soil and water conservation.

The one long-term, potentially harmful effect that may occur during the construction phase is that there may be excessive sediment erosion in the construction activity area. This sediment could easily be transported downstream during the rainy season into the riverbed, irrigation canals, or even into the fields. Such sediment build-up would require cleaning. If possible, the contractor should attempt to control erosion at the site. This would minimize immediate erosion and help prevent such a future problem after his part of the construction is completed. It might also be possible to require the contractor be responsible for any cleaning that proves necessary.

Post-Construction Phase: The Operation Period

Given that the SSIMP surface water projects are only small to medium-scale, and socially and environmentally non-controversial, the investigation of potential impacts has been relatively straightforward. Virtually all the potential environmental impacts that have been identified pertain to the post-construction phase, also known as the operation period. These potential impacts are presented here, following the same sequences as earlier chapters: water, land, biological, and socioeconomic resources. They are summarized in Table V-2, "Summary of Environmental Impacts", found at the end of this chapter.

Water Resources

Water Quantity

Streamflow and Water Distribution. The major objective of this project is the geographic and temporal redistribution of water, storing approximately 16.5 MCM early in each wet season for distribution to cropland during the latter part of the wet

season and into the dry season.[2] The filling of the reservoir will take approximately 65 percent of the 25 MCM estimated by Mettana (1989) as the average annual discharge of the Gapet River. Depending on the vagaries of rainfall, the reservoir will begin to fill in December and continue filling until March.

Under current conditions, some flow in the Gapet River is present on average from October through June (Figure V-1). With the project, this period is reduced to December through April in an average year. In terms of downstream water users, this reduces the period during which they can depend on the river for water supply from nine months to five, on an average.

The spill from the reservoir to the Gapet River, in an average year, will have a similar duration but lower flow than the river does now during its lowest annual pre-project simulated flow (Figure V-1). In very dry years, which occur with a frequency of about three in ten, no water will be released to the river. Additionally, the number of hectares which can be irrigated will severely be reduced during those years.

An additional impact of the project will be the creation of the reservoir behind the dam. This will have an area of 160 ha at full supply level (35 m), decreasing to 30 ha at maximum draw down (21 m). In most years the reservoir would not be drawn down below 22 m, or about 45 ha surface area.

Under project conditions, water will be distributed over the 1300 ha service area, with irrigation return flows contributing to increased flows over an extended part of the year in the Dadap, lower Gapet, Nyerinying and Boal Rivers. These streams are currently all dry or stagnant during the dry season, and the project will thus improve their flow regime by providing irrigation runoff water. This will indirectly contribute to lessening the risk of saline intrusion along the northern edge of the service area adjacent to Saleh Bay.

For the residents of those hamlets in the service area, the irrigation supply canals will provide an additional source of water for domestic use, and one which will usually be available throughout the year (Figure V-1). In most cases, however, this source will not be as conveniently located as the nearest river.

Fish Pond Development Potential. Reservoir simulation analysis indicates that under project conditions, farmers will be able to plant paddy/palawija/palawija, with a cropping intensity of 286 %. In this scenario, there will be no water in the river

[2] These figures are estimates and will be revised, based on a reservoir study that is currently being undertaken. New figures will be reported in the Project Justification Report.

(except from irrigation return flow) during the period April - November, in most years (see Figure V-1, particularly the line entitled "Post-Project Mean Year River Flow, from Reservoir to River").

Under these conditions, there will be virtually no water available for use in downstream fish ponds (tambak). What water there will be in the river will arleady have passed through the irrigation system, and through water buffalo watering sites. It is unknown, at this time, just how much return flow there might be, nor the level of chemical concentration (fertilizers and pesticides). If anyone seriously considers using such water to develop fish ponds, it is highly advisable that a study of the flow be conducted, as well as a full analysis of the chemical content of such water. Unless this were done and the results were favorable, any fish pond owner who pumped contaminated water into his ponds would run the risk of sudden die-offs due to the uncontrollable chemical content of the water. It may also be that intrusions of saline water from Saleh Bay into the the river's estuary (i.e., next to the fish ponds), would not be sufficiently diluted by the small amount of river flow, so that water in the river bed would still be unsuitable.

All these issues require a very thorough study--after completion of the irrigation system and commencement of its operation.

Ground Water. The increase in surface water on nearly a year-round basis, and normal seepage from the reservoir is expected to augment ground water, and generally improve the capacity of shallow wells in the service area.

Seepage from the reservoir will also likely enter the shallow alluvial aquifers of the river valley and make its way downstream, resulting in an increase in bedflow over present conditions. During the dry season, when the ground water table of the alluvial aquifers is lower than the stream level, some recharge will occur through seepage of river water to the surrounding lower water table. This is likely to improve the water level in wells near the river throughout the year. It may also prevent saltwater intrusion in some wells where it occurs presently. The seepage, when combined with irrigation return flows, will also result in enhancement of flow in the lower reaches of the Gapet, extending the season over which water is present and flowing. Upstream of the dam site, it is likely that the water level of the existing ground water surrounding the reservoir will become much shallower.

Water Quality

Reservoir. Water entering the reservoir should be the same or better quality than that observed at the dam site (Station 2, Table IV - 3); that is, low in nutrients with moderate levels

of major ions. Suspended sediments from the watershed will be deposited in the reservoir. There are no significant pollution sources in the upper watershed that would contaminate the reservoir, nor is there significant forest clearing being carried out for agricultural or commercial purposes, which would lead to the expectation of higher sediment and nutrient loads in the future.

The reservoir area has low-fertility soils and little vegetation. With minimal clearing of larger trees and shrubs from the inundation area before filling, there will be only a small amount of biomass remaining to decompose and increase the nutrient levels in the water. The reservoir should therefore stabilize rapidly in terms of its chemical composition, producing a relatively oligotrophic (low nutritient and low productivity) system.

The low nutrient levels will result in low primary (algae) productivity, and as a result the low biomass will likely mean that deoxygenation of the deeper waters of the reservoir will not be a serious problem. The high turnover rate (most of the volume flushed each year) will also prevent buildup of nutrients and organic matter.

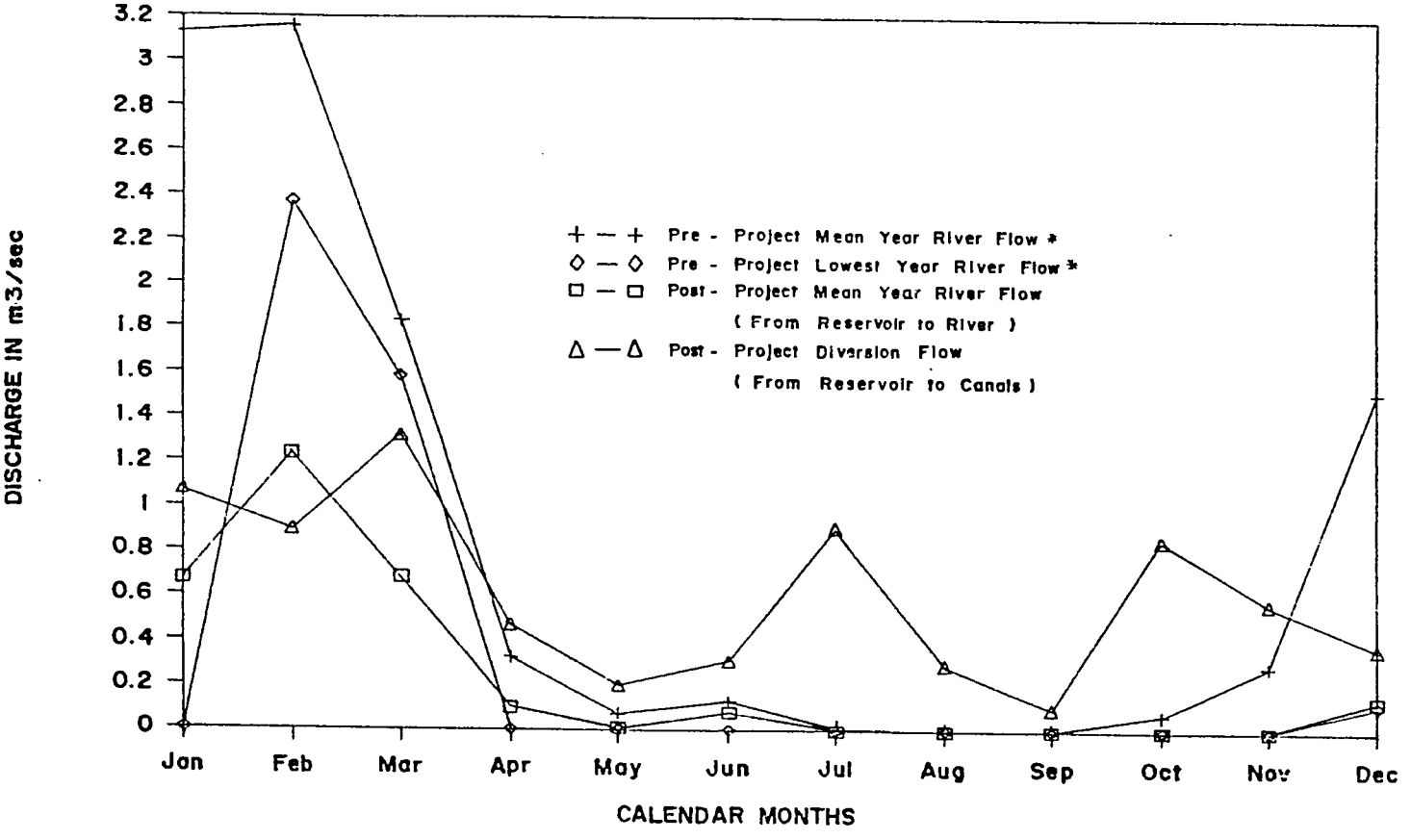
On the whole, the water quality in the reservoir will be suitable for irrigation and domestic use from the first filling.

Ground Water. Some contamination of ground water may occur in areas of exceptionally high fertilizer use, but the effect would be largely one of the taste. It is unlikely that, even with maximum project development, this will be a problem. Contamination by pesticides is a greater likelihood, not from normal crop applications but from careless storage or formulation, or accidental spills. Repeated mixing of pesticides at one spot often results in substantial soil contamination, especially when equipment is washed in the same area after use. This type of contamination is unlikely to be detected unless there are fatalities. Such incidents probably are not as infrequent as they appear to be, since deaths due to poisoning from pesticides would require sophisticated autopsies to detect.

Irrigation System. Water entering the irrigation system will be of good quality, as it is at the dam site under pre-project conditions. How long that quality will be maintained will depend on whether waste discharges into the canals are curtailed and what non-irrigation use is made of the water. The canal water, at its worst, will be of better quality than the surface water available to people of this area under present dry season conditions. In general, the main stem of the Gapet River probably will contain the best water during the middle part of the wet season, in years when the dam spills, but the canal system probably will be better during the rest of the year.

FIGURE : V - 1

GAPET RIVER AND IRRIGATION CANAL FLOWS



* Based on 30 Year Simulation

Source : P T. Mettana _ Preliminary Review Design, Embung Gapet Final Report, September 1989

Downstream. The quality of water from the spill from the dam during the wet season will be comparable to pre-project river flow conditions. However, the lower flows from the spill will result in more intensive use of the available water, and therefore the more rapid degradation in the quality of the water in downstream pools, which will remain degraded into the dry season. This will be offset by the availability of higher quality water in the distribution system. Water quality will remain high as long as discharge of human sanitary waste into the canals is restricted, along with limitations on the use of canal water for laundry, and particularly, livestock watering. The canal water, at its worst, however, will be of better quality than the surface water currently available in the river.

Livestock watering stations should be located downstream from sites generally used for bathing and laundry washing. At minimum, livestock water sites should not be in close proximity to hamlets. One alternative is to build water buffalo watering sites alongside tertiary canals, thereby keeping livestock water use more separated from domestic use.

Return irrigation flows are likely to contain higher levels of nutrients from fertilizers, pesticide residues, and human and animal wastes. This will form the main flow in the lower reaches of the streams concerned. Quality of this water will be poor, but probably no worse than under the stagnant conditions observed in the dry season under current conditions (Table IV - 3).

Water Supply

Domestic. As noted above, the project will result in marked changes in both quantity and quality of water available for domestic use by all the inhabitants of the hamlets of Gapet, Boal Atas, Boal Bawah, and Nyerinying. Water will be available in the river for a shorter period, and the quality will be lower. In compensation, water of higher quality will be available in local irrigation supply canals for most of the year. Also, the wider distribution at water across the area may raise the groundwater level, improving the supply from shallow wells. Overall, the water available should be of improved quality, and this will have undoubted benefits for the health of the population.

Enhancement of the system could be provided in two ways. One would be through the provision of specific locations (steps or other structures) in the canals for purposes of washing and bathing. This would contribute to minimizing damage to the canals. Secondly, a piped water system could be designed and installed as part of the irrigation works, to provide high quality water year-round to Gapet and other hamlets. This would abbreviate any remaining difficulties in obtaining water when the irrigation system and the river are both dry, which would occur in very dry years (approximately 3 years in 10).

The amount of water required for such a system would be minimal.

Livestock. The Gapet River is an important area for watering livestock throughout most of the year. During the months of November and December the inhabitants of Gapet hamlet must resort to digging holes in the riverbed in order to water their livestock. With the installation of the dam, water will be diverted from the Gapet river to crop irrigation for much, if not all the year. Some water, however, will still reach the river in the form of dam seepage, irrigation return flow, and rainfall runoff from the service area. The net effect is difficult to predict, and therefore some provision should be made in the canal dsign for livestock watering stations near Gapet hamlet.

Land Resources

Land Use

This project will result in some changes in land use. Much of the service area is presently used for some form of agriculture, but at very low intensity. Much of the land is pasture, or is fallow for long periods. Even the bunded paddy fields may not be used every season, or may be used only for a single palawija crop rather than for wet season rainfed paddy. Provision of irrigation water will result, over time, in substantial conversion of existing grassland/dry land into bunded irrigated paddy fields, along with significant increases in agricultural productivity.

The headrace (main) canal discharges directly into the secondary canals at the dam. The right bank secondary canal crosses the spillway at the dam. The left and right secondary canals will total 7.7 km in length, with a total width of 15 m (including the service road) for a total consumption of about 11.6 ha of land, most of it now in agriculture or along the field fringes. Parts will lie in the alignments of existing small canals. The tertiary and drainage system also will take narrow strips of land from the edges of fields. These are all minor impacts and a necessary part of the project.

Project structures themselves--the dam, spillway, work areas, borrow and spoil areas--will take land that currently is fallow or covered with scrub forest. Most of the materials sources are expected to be within the inundation zone of the reservoir or from the required excavation for structures. The contractor will be required to restore all borrow areas to a smooth and natural appearance with adequate drainage.

There is no evidence of the need for deep drains to lower the water table in any part of the existing service area presently under active cultivation. There are expected to be in-

stances where the alignment of the new canals will traverse or cross existing natural drains, thus necessitating construc-tion of a drainage channel immediately adjacent to (above) the newly built secondary or tertiary canal. In almost all such instances, material from the excavated drainage channel will be used in a balanced cut and fill operation to construct the secondary or tertiary canal.

In some reservoirs, there is an opportunity in certain gently sloping locations for agricultural use of the drawdown zone. At Gapet, such practices may be jeopardized by the erratic nature of the rainfall, and inflow to the reservoir, which could cause unpredictable changes in water level during the April-June period. Given the amounts of land available in the service area, it is unlikely that many farmers will want to accept the higher risk involved in attempting to plant in the drawdown zone.

Soil Chemistry and Waterlogging

No significant changes in soil chemistry are expected to occur with the project. Increased soil moisture is the general objective of the project, of course, to be accomplished in a controlled manner. Waterlogging and the attendant salinity problems are not common in Indonesian irrigation projects, partly due to the requirements of rice soils, partly to high ambient relative humidity, and partly to the use of effective drainage systems. Any build-up of salts that might occur in the surface soils during prolonged dry periods will be thoroughly flushed during the wet season.

Erosion, Sedimentation, and Soil Movements

Erosion and sedimentation rates in the catchment area are of interest because of the potential impact on the operation and overall life of the project due to sediment accumulation. A high rate of sedimentation could reduce the active storage volume of the reservoir to such an extent that the project benefits would not be achieved over time. Also, the design and operating procedures for the outlet works might need to be modified to accommodate sediment deposition.

A qualitative review of the Gapet catchment area indicates that erosion and sedimentation should not be a serious problem. The catchment has a dense deciduous, bamboo and teak forest. The field team performing the project environmental studies observed no areas of moderate or heavy erosion in the project area; only some minor local instances in the service area show the impact of overgrazing by livestock. There is the possibility of increased overgrazing as pasture is converted into irrigated agricultural land.

Extensive forest clearing in the future is not likely to be a problem since the timber resource itself in the catchment

is not extensive and the steepness of slopes makes extraction difficult. In addition, the Gapet dam and reservoir will effectively cut off existing access into the catchment area, so any future timber cutting will be more easily controlled.

An estimated soil erosion rate of 0.5 mm/yr over the catchment area has been adopted for design of the Gapet Project (Fenco, 1981). To accommodate sediment inflows and deposition over the life of the project, a dead storage volume of 0.76 MCM has been allowed in the reservoir. In the irrigation system, erosion of the earthen works can be minimized by effective design of canals to maintain low water velocities and to avoid unlined sharp bends where erosion can be expected. Project roads are being designed with effective drainage and foundations so as to avoid erosion. The permanent access road will be constructed to Bina Marga Class 3 standards, with construction supervision by PU inspectors. Cut slopes will be flat enough to ensure no local slope failure; earth cut slopes will be revegetated.

A serious source of canal bank erosion is the use of the channels for watering and bathing livestock. Additional availability of water in the dry season is likely to lead to an increase in this activity, to the detriment of the canals. Programs must be instituted to acquaint residents with the problems arising from such activities. The provision of an adequate number of designated stock watering points, at turn-outs from the canals, will provide a suitable alternative to the use of the canals themselves for the substantial numbers of livestock present. Public Works has standard designs for these structures. Such locations must be conveniently located, or the temptation to use the canals, especially by the children who tend the livestock, will be very great.

Farming Systems

Cropping Patterns. Emergent cropping patterns are dependent on several factors:

- o dependable water supply for crop requirements
- o land and soil suitabilities
- o crop marketing and profit potential
- o labor, livestock and input sufficiency
- o social acceptance and traditions, and
- o government policy

The paddy production oriented Indonesian farmer,when provided with a secure water supply, typically shows an initial

preference for paddy. This crop choice is based on several factors: farmer experience in paddy culture; paddy being seen as an essential to family food security; historically widespread demand for this food staple; and, in the past several decades, government support in promoting cultivation, and guaranteed markets. Irrigated paddy cultivation also tends to generate higher and more stable returns per area cultivated than most crop alternatives under presently employed technologies.

The envisaged Gapet dam project will store water which can be distributed on a supplemental basis in the wet season, and further provide water for one to two additional irrigated crops in the dry season.

Because of farmer cultivation preferences and the relatively abundant supply of rainfall from December through February, paddy is the crop of choice for the wet season. Beyond the wet season, the choice of crop mixes and extents is highly sensitive to the availability of water. The major crops that are currently seen in nearby existing irrigation schemes in Sumbawa include paddy, soybean and mungbean. According to agricultural officials, the soils existing in the project area are suitable for cultivation of these crops, and marketing channels for production are already established. The cropping patterns which were selected for closest analysis for this project include:

1. Paddy/Paddy/Palawija
2. Paddy/Paddy-Palawija/Palawija
3. Paddy/Palawija/Palawija

Table V-1 illustrates the timing and the relative extents cultivable of the three alternative cropping patterns. The areas and cropping intensities shown are based on reservoir simulation analyses. A Paddy/Paddy/Palawija cropping sequence over the growing seasons could only provide sufficient water for only 43 percent of the 1,300 ha in the second season and no irrigation water for the third season.

For the second pattern, Paddy/Paddy-Palawija/Palawija, hydroology calculations were made based upon a second cropping season with half the irrigated area cultivated in paddy and half in soybean. This cropping pattern attains an increase in irrigated area over the second-season paddy-only pattern, but like the paddy-only second-season option, this second cropping pattern falls considerably short of full command-area cultivation in the second season (irrigation of only 69 percent of the area) and leaves no irrigation water available for the third potential planting season.

For the third pattern, Paddy/Palawija/Palawija, the reservoir simulation analysis was conducted on the assumption of a second cropping season area divided between soybean (70 percent of the area) and mungbean (30 percent of the area), and a third season crop of mungbean. This pattern achieves a fully irrigable area in the second season (1,300 ha), plus an irrigable area of 1,118 ha in the third growing season. Table V-1 also summarizes the cropping intensities and irrigable areas attainable by the alternative corpping patterns proposed.

Table V-1

Cropping Patterns and Attainable Intensities

Cropping Pattern	Irrigable Area by Season (ha) Season 1	Season 2	Season 3	Cropping Intensity
1. Paddy/Paddy/Palawija	1,300	559	0	143 %
2. Paddy/Paddy-Palawija/Palawija	1,300	897	3	169 %
3. Paddy/Palawija/Palawija	1,300	1,300	1,118	286 %

In terms of relative profitability of the alternative patterns, indices are considered from two points of view: (1) financial returns for the farmer, and (2) economic returns from the perspective of the government-investor in the project. While paddy generally provides the most stable returns per ha of the crop alternatives, the consumptive water demands of paddy are such that only a limited area of the crop can be grown in the second season. As more area is planted to palawija than paddy in the second season cropping mix, the extent of area that can be irrigated increases, and along with the area increases, crop production and revenues from palawija production more than compensate for revenue losses associated with a decreasing paddy area. The factors of production that a farmer considers in the production process include land, labor, and capital. The average farmer's greatest returns for each of the factors of production are from the third cropping pattern: Paddy/Palawija/Palawija.

Livestock. The intensification and diversification predicted for the project is expected to lead to increased sophistication on the part of the farmer. The more aggressive and successful farmers may turn to mechanization of tasks now powered by animal or human means. This may gradually reduce the value of the buffalo as a source of traction.

Nonetheless, many farmers will not convert to using tractors, or there will be a long interval before they elect to do so. More intensive cropping of lands that now serve partly

to support the large herd will leave livestock owners looking for more grazing land. This will be partially offset by an increase in field-edge and ditchbank vegetation. Some owners, faced with higher demand for household labor in the fields (including that of their children who now do much of the livestock tending), may elect to sell off some of their animals. There will also be increased pressure to clear more land in the watershed or to overgraze the land. Ideally, livestock management practices will shift from the present generally extensive practices to more intensive means, such as tethering of animals and cut-and-carrying of grasses and leguminous leaves. This shift has been noted by the Livestock Department on other Sumbawa irrigation projects including the Kalimantong I Project.

The conflicting demands on family labor due to intensification of cropping may make the tending of buffalo, currently a task for the older, primary school-aged children, too time consuming. The balance may swing in the direction of culling the herd, especially as the investment value of the buffalo is replaced by a higher cash reserve. This whole process is likely to require several decades. Nevertheless, it would be of considerable value at this stage to develop an integrated livestock management plan to organize for the changes in watering requirements and land use, and ease the transition to an altered farming system.

Agricultural Chemicals. Increased cropping intensity and diversification almost invariably lead to greater use of fertilizers and pesticides. Moreover, faced with unfamiliar insect pests on his vegetable crops, the farmer, acting on the advice of a more sophisticated cooperative or extension agent, may find himself using chemicals with which he is unfamiliar. This often leads to errors in mixing or handling that can have serious results. In Pakistan, following a malaria pandemic in 1973, the Malaria Directorate switched from DDT wettable powder to Malathion liquid. The former is so safe for humans that spray operators had become careless in handling the chemical. Malathion concentrate is a potent cholinesterase inhibitor that is readily absorbed through the human skin. Failure to indoctrinate the mosquito control crews led to several fatalities among spray operators and the hospitalization of many others. Subsequent training of the operators and alerting of hospital staffs corrected the situation. Local agricultural agents should be alerted to the dangers of transporting, storing, formulating, and applying certain chemicals.

The other adverse impact of chemical use, frequently seen when agriculture is intensified, is the contamination of surface water by chemicals in agricultural runoff. Aquatic ecosystems (including fisheries) can be seriously damaged through food chain effects. In the Gapet area at present, there are no significant freshwater ecosystems and the chemicals reaching the estuary are likely to be diluted to the point where their effect will be negligible. Moreover, the pesticides in current

use are relatively nonpersistent. No significant effects, even under project conditions, are anticipated; however pesticide concentrations in river and well water should be monitored periodically to ensure that a health problem does not develop (see Monitoring Plan - Part 4).

Biological Resources

Terrestrial Habitat

Reservoir. The project will result in the conversion of approximately 160 ha of riparian scrub forest and open land (currently used on an intermittent basis for dry land agriculture) to aquatic habitat. This loss of terrestrial habitat is not significant, since there is no commercial timber nor is the agricultural productivity very high.

Some qualitative changes will occur in the vegetation along the edge of the reservoir over a number of years, (probably 20 or 30), due to the presence of higher groundwater near the reservoir. This will favor trees that are less tolerant of drought conditions, and may result in a narrow belt of evergreen vegetation along the reservoir margin.

The drawdown zone of the reservoir, however, will support no vegetation, there being no plants in the region able to withstand long periods (several months) of total immersion, followed by water withdrawal and drying. Submerged aquatic plants growing under those conditions are dessicated on drawdown and denied light on filling. Most reservoirs of this type world wide show the same characteristics: when drawn down, the banks are bare mud or gravel with some deposits of fine silt or mud where streams enter. When clearing is not performed, the bare skeletons of forest trees may remain for many years.

Rare or Endangered Species. No species of plants or animals in the project area have been identified as of special conservation or scientific importance, so no significant effect is to be expected in this respect. Little change in habitat is expected upstream of the reservoir, and the inundation area itself has already been extensively altered from its original natural habitat.

Commercially Important Species. The bamboo and mixed deciduous forests of the Gapet catchment contain a few tree species of considerable timber value and many more with firewood value. Some of each will be lost to reservoir inundation, unless salvaged. The additional access to the upper basin provided by the dam access road would be expected to augment illegal woodcutting in the catchment, but the lack of roads upstream of the dam, and the loss of the riverbed as a dry season route will balance any improved access provided by the project road. These forests are classified as " protection forest" by the

Ministry of Forestry, and forest harvesting has been prohibited by the local regional government. Given these constraints, it is unlikely that there will be significant changes in forest cover in the upper catchment in the near future.

On the other hand, improved living standards and more intensive on-farm labor may increase the market for firewood to the point where some farmers in the fringe areas, not served by irrigation, would become full-time woodcutters, placing greater pressure on the catchment area. The total firewood consumption of the project area will rise only slowly, however, and most of this demand will continue to be met from the hills around the service area. The improved levels of disposable income and standard of living in the project area may lead to house improvements that would place a demand on timber and other local forest resources. The number of such improvements is not likely to be great enough though to severely stress local forest resources.

The situation with wildlife and game animals is similar to that of firewood: the increase in living standards and improved access to the area may lead to additional hunting, legal and illegal. There is little reason to believe, however, that this increase will be much more rapid than the gradual increase in pressure on the wild fauna that is going on at present.

Aquatic Habitat

Reservoir. As aquatic habitat, the reservoir will not have a very high biological productivity. Worldwide experience with reservoirs subject to severe drawdown is that such water bodies never get a chance to develop the complex food chains and species diversity that characterize stable, shallow lakes. The nearest example of the latter is Lake Taliwang, which, for all its weed problems, is a highly productive ecosystem. The opposite will be true of the Gapet reservoir, whose aquatic productivity will be inhibited by the low nutrient inflow and high rate of flushing each year. The reservoir is thus unlikely to support a significant amount of aquatic vegetation, floating or rooted.

It may be possible to maintain a small freshwater fishery or aquaculture operation in the reservoir. As mentioned previously, the primary productivity of the reservoir will be low and annual environmental fluctuations high. This will limit fish species to only the more hardy varieties. Fish farming may be practical if the fish are held in cages and given supplemental feed.

Canals. The proliferation of aquatic plants in irrigation systems is a widespread problem in Indonesia and elsewhere. The increased use of fertilizers and the presence of water in drains year-round allows plants to survive the dry season, when

they would otherwise dry out and die back. The problem is less severe in the larger canals, where water velocities are rather high and nutrient levels low, than in the drains, where flows are sluggish and all sorts of waste products nourishes plant life. Pest plants are of several sorts: floating, emergent and submerged. All three types of pest plants should be expected in project waterways and all block the effective flow of water. Continual maintenance is necessary to eliminate such effects. The increase in canal area will almost certainly produce more mosquitoes, especially if weeds and trash are allowed to clog the canals.

River. Upstream flows on the Gapet River are already interrupted during the dry season, making it habitable year-round to only those aquatic species that can migrate downstream to saline tidal waters, or are tolerant enough to live in near-stagnant river pools. The dam and irrigation return flows will tend to moderate flows on the river such that peak floods and droughts are eliminated. It may be that species that could not tolerate such extremes before will find the river more habitable. The Gapet River will not supply as much fresh water, as before the project, to the downstream estuary. The effect should be slight however, since tributaries to the Gapet River, as well as other rivers in the area, also supply water to the estuary. Any species that enter or depend on the Gapet River for breeding (e.g., Tilapia sp.), also have these other unaffected rivers available. There may be some loss of fisheries in the non-tidal upstream portions of the Gapet River, but these fisheries at present do not appear to be significant in terms of their contribution to local diet or income.

Estuaries. It is impossible, given the limited scope of this study, to assess the effects of altered fresh water flows into the coastal waters. The influence of these flows on the environment and biota of the coastal regions is complex and not completely understood. It is recognized however, that river outflows have a large impact on nutrient and sediment deposition in the estuary. Changes in these factors can in turn influence river and coastal ecology, fisheries and navigation.

Fisheries. The existence of the reservoir will provide an increase in habitat available for fish. In spite of the expected low nutritient status of the reservoir, and the fluctuating water level, hardy species such as tilapia, which are already present in the river, will survive and reproduce there. A local artisanal fishery may develop, to provide low-cost animal protein to the families of the fisherman in the village. Given the ready availability of marine fish in the area, this is not expected to develop as a major local activity, however.

Interest has been expressed in the availability of fresh water for brackish water aquaculture purposes in the estuarine area near the coast. There are currently no operating fish ponds in the project area, and in any case the supply of irri-

gation water is insufficient to accommodate both the planned agricultural intensification as well as aquaculture use. Success of coastal fish pond culture depends or a wide variety of other factors beside fresh water supply, such as soil type and tidal amplitude which may not be optimal in this area. The RePPProT (1989) study suggests the presence of acid sulphate soils in the area of the tidal flats which would present difficulties for the successful establishment of fish and shrimp farms.

Pests

Crop Pests. Any intensification of cropping is likely to result in higher and more persistent populations of crop pests. These may be categorized by animal group:

1. Insects. Pests on both field and stored crops. Back-to-back paddy cropping is likely to allow insects to maintain their populations from one crop to another, necessitating higher insecticide use.

2. Birds. No bird species have been identified as special pests of paddy in the Gapet region, but munias and Java sparrows cause considerable damage in other areas where paddy is multiple cropped. Repetitive cropping of paddy followed by soybeans, allows these grain-eating birds to attain higher populations than they can sustain when forced to seek alternate dry season foods.

3. Mammals. Rodents are the main pests of paddy in the area, taking grain both in the field and in storage. The species involved are different, but the problem parallels that of birds. Additionally, increased living standards of the farm population leads to laxity in the disposal of waste. The result can be a severe increase in the population of the black rat (Rattus rattus).

Disease Vectors. The principal disease vector that benefits from year-round irrigation is the mosquito, which tends to breed in stagnant drains and field edges. With the increase in mosquitoes, there is a risk of an increase in mosquito-borne diseases, in this area malaria and dengue.

Socioeconomic Resources

The primary objective of this project is an increase in the living standard among local farmers through the provision of water for multiple-crop agriculture. The economic benefits of improved agricultural production will be distributed among members of the population, some of whom will receive direct benefits and others of whom will receive secondary benefits or

possibly even adverse effects. For the purpose of considering these secondary effects, which are generally considered "environmental," the local population may be considered in several categories (USAID, 1980):

1. Target Population. These are the group to whom the projects benefits are directed, in this case, farmers who will receive additional irrigation water.

2. At-risk Population. This group is outside the area of direct project benefits, due to location, occupation, economic status, or whatever reason, but vulnerable to some adverse secondary effects, such as loss of a resource, deprivation of an amenity, or even some minor inconvenience.

3. Migrant Population. This category includes both immigrants to the area, attracted by labor opportunities or potential markets for goods, and emigrants, whether officially resettled or driven out of the area by other factors.

4. Host Population. This broad group includes most members of the other three, being defined as all persons "living within the area of the project influence."

By the above definitions, the groups of greatest interest in a consideration of secondary project effects are the target population, which in addition to receiving the primary benefits of the project is likely to experience other effects, and the at-risk population, which while not in line for primary benefits may experience positive and/or negative secondary effects.

In general, the secondary effects of an irrigation project fall into several categories:

1. Secondary benefits arising from the primary benefits of increased crop production and disposable income.

2. Opportunities to enhance the use of a resource through secondary applications of project facilities, e.g., reservoir, canals, roads, drainage canals.

3. Potential adverse effects of project construction or normal operation, e.g., demand by the construction work force for scarce local resources, resource contamination, or conflicting demand for [illegible]ater.

4. Failure of the project to live up to expectations, due to over-optimism of planners, inadequacies of maintenance, or misuse by the local population.

This section on socioeconomic effects deals with both the effects of the project on living conditions and the potential effects of local society on the project. Both sets of effects, especially the latter, form feedback loops: if the practices of the local population compromise the effective operation of the irrigation system, that in turn may have effects on the health or economic status and the living environment of the local people.

Settlement Pattern and Movements

One positive factor in the siting of the Gapet reservoir is that there are no permanent dwellings in the proposed inundation area or at the dam site. It will not be necessary to relocate any people for the purposes of project construction.

The presence of irrigation, on land now farmed on a rainfed basis, may lead farmers from other areas, especially those nearby, to attempt to buy into the Gapet area. This would elevate land values and lease rates but probably only for lands in the project service area. It is unlikely that owners of the improved lands would sell, since the increase in production would be greater than what they could make on a one-time sale of land. Also, improved living standards and more economic opportunity in the target population probably will result in some of the younger farmers remaining in the area rather than migrating.

The area, at present, has a small population, that with intensification of farming, is inadequate to meet future labor requirements. Completion of the irrigation system will automatically create a large demand for labor. Some estimates indicate the population would have to double to meet these demands.

Increased agricultural activity in the area is likely to attract and hold many agricultural laborers who now visit the area only at harvest. Such laborers would need to sharecrop or find other employment if they are to take up residence in the area as harvest work will provide full-time work for only two months per year. Increased agricultural production and cash flow may also lead some entrepreneurs to relocate permanently in the area. Traders and middlemen will establish more shops and services as trade increases. Demand, in general, will increase for services and infrastructure (schools, health clinics, roads, transport, markets and extension services), and with this increased demand, and diversified population, the local social structure will become more complex.

There is a need to begin planning now for these increases in population and the subsequent increased demand for improved services and infrastructure. The district planning agency (BAPPEDA Tk. II) is the logical coordinating body.

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Regional Economics

Target Population. Farmers in the Gapet service area, experiencing increased disposable income, will spend much of it locally, on food, clothing, and home improvements. Some of the disposable cash will be spent on agricultural improvements, such as mechanized implements.

Greater affluence in a population generally results in non-economic improvements: better nutrition, increased awareness of health risks, with more demand for health services and pharmaceuticals, and more attention to education.

At-Risk Population. Farmers and others who do not receive the direct benefits of the project will, nevertheless, obtain some secondary benefits. Their labor probably will bring more income if they hire out and the natural products with which they augment their income, such as thatch, woven mats, and firewood, will see increased demand as the target farmers find themselves with less time for off-farm activities.

Land Ownership. Given that the population should experience significant increases to their income, it is expected that the farmers will prefer to have their more valuable land surveyed and registered under modern terms of land tenure. It is expected that there will be a cadastral survey and land registration program (PRONAS) in the near future. Conversion to a modern system of land tenure should also be followed by adjustments to the current system of land taxation and result in significant increases in the district's source of revenue.

Public Health

Vector-borne Diseases. With the possible increase in mosquitoes will come an increase in the risk of malaria, dengue and other vector-borne diseases. The risk tends to be lower when water is used conservatively, which it is when scarce, and higher when water is allowed to stand in drains or fields.

Other Water-related Diseases. The risk of increase in water-related diseases will depend in large measure on the reaction of a population accustomed to dry season water, now limited to pools in the river bed, to a greater availability of purer water in the canal system. It seems likely that intestinal and parasitic diseases, poliomyelitis, and typhoid will decrease as people utilize the purer water source, assuming, of course, that they continue to boil drinking water.

Social Structure and Farmers' Organizations

While the local community currently is fairly cohesive, with several examples of joint agricultural activities, the advent of the project will place additional demands upon the community for joint operation, regulation and maintenance of

the water system. There is a need to organize and train water users' associations. This is planned to be carried out jointly by PU and LP3ES on behalf of the project. This activity and other joint management activities in the area will contribute to enhancing social cohesiveness and stability.

Effects of Project Alternatives

No Action Alternative

The pressure of a gradually increasing population, dependent on a land resource with limited irrigation and an unreliable water supply, would lead to greater poverty and lower living standards among those who chose to stay. These would induce the younger members of the communities to continue to emigrate in search of urban wage labor or better farming conditions. Some might turn to exploitation of different resources, such as the forest or the wild fauna. In time, some improvements to existing village-level irrigation schemes might be made, but it is doubtful that local funding could provide the water storage reservoir on the scale required for effective utilization of the catchment's surface water resources.

Alternative Technologies

There being no viable technical solutions to the need for more water, speculation on the environmental effects of other systems would be meaningless.

Design Alternatives

Location. There being no downstream dam sites in the basin that offer the possibilities of the selected one, no environmental effects will be postulated for such alternatives. The location of the access road is fairly well fixed, but the environmental effects of the alternate routes would not be greatly different from those of the current plan.

Selection of the service area on other than topographic, soils, and geographic bases really is not possible if the project is to function. The environmental effects of alternative command area selections would be about the same as those of the proposed area.

Upstream dam site alternatives require more fill materials and therefore would be potentially more disturbing to the environment. Upstream sites would also reduce the size of the catchment area and reduce the amount of water that could be captured and utilized.

Reservoir Elevation. Conceivably, the reservoir elevation could have been lower, which would have had the effect of shaving project benefits. Raising the reservoir above its

proposed level is neither technically nor economically advantageous due to the need for additional saddle dams. Other than inundating more forest land, the larger reservoir would not exert significant environmental effects.

Scheduling Alternatives

The effects of scheduling the project so as to stretch it out over a longer period would resemble those of the no action alternative, i.e., continued poverty for the part of the target population not receiving water and, possibly, shifts of people within the area to take advantage of irrigation water.

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TABLE V-2
SUMMARY OF POTENTIAL ENVIRONMENTAL IMPACTS
GAPET IRRIGATION PROJECT

ENVIRONMENT COMPONENT	DESCRIPTION OF IMPACT	SOURCES OF IMPACT		IMPACT LOCATION			TIMING OF IMPACT			EXTENT OF IMPACT			REMARKS
		PRIMARY	ASSOCIATED	CATCHMENT AREA	IRRIGATION AREA	DOWNSTREAM AREA	PRE-CONST.	CONST.	OPER.	UPON?	DURATION	INTENSITY	
WATER AND ATMOSPHERIC RESOURCES													
Water Quantity	Reduced availability in river below dam	Water diverted from river to canal			X			X	X	People along river	Long-term	Moderate to severe	Water available in canals and domestic water supply systems
	Creation of a reservoir	The Project		X				X	X	Beneficiary farmers	Long-term	Major	Storing and redistributing water are the means to meet project goals
	Increased recharge of ground water	Percolation of irrigation water	Runoff and drainage		X	X			X	Ground water	Long-term	Minor to moderate	Good most years, but not enough to improve domestic water supplies there wells very much
Water Quality	Increase chemical concentration	Agricultural chemicals	Irrigation		X	X	X		X	Irrigation area	Long-term	Minor to severe	Proper use reduces risk of adverse impacts
	Provide domestic water supply	The Project			X			X	X	Service area residents	Long-term	Moderate to major	Mitigation requires provision to downstream hamlets
	Provide livestock water	The Project			X			X	X	Livestock in irrigation area	Long-term	Moderate to major	Mitigation required provision of water to livestock
Air Quality	Increased dust	Construction activity		X	X			X		Irrigation area	Short-term	Moderate	Mitigation involves contractor dust control (road watering)
	Increased smoke	Burning surplus straw			X	X			X	Irrigation area	Long-term	Minor to moderate	Straw burned when intensive cropping leaves no time for natural decomposition
LAND RESOURCES													
Land Use	Convert to bunded, irrigated fields	Availability of irrigation			X			X	X	Irrigation area	Long-term	Moderate to major	Much initial land preparation is required
Farming Systems		Multiple cropping	Dependable water supply		X			X	X	Irrigation area	Long-term	Very positive	A main purpose of the project
	Loss of grazing land	Multiple cropping		X	X				X	Livestock in irrigation area	Long-term	Moderate to major	Area lost partially made up for by improved fodder quality on irrigation area waste ground
	Loss of farm land	Construction of system	Increased population		X			X	X	Irrigation area	Long-term	Minor	Unavoidable. Small percentage of total area
BIOLOGICAL RESOURCES													
Terrestrial Habitat	Convert thickets from agric. use (scrub to reservoir and dam	The Project		X	X			X	X	A few landowners	Long-term	Minor	Unavoidable. Small percentage of total area
	Increased pest population	Multiple cropping			X				X	Irrigation area	Long-term	Moderate	Control measures needed
	Increased transmission	Dam construction			X	X		X	X	Irrigation area, riverbed, canals	Medium-term	Minor to severe	Construction period control measures needed
Aquatic Habitat	Preservation of aquatic weeds in canals	Increased nutrients	Inadequate maintenance		X				X	Irrigation area	Long-term	Minor to severe	Depends on maintenance
	Increased numbers of mosquitoes	Increased breeding area with irrigation			X				X	Resident Population	Long-term	Minor to moderate	Malaria and dengue fever may increase
SOCIOECONOMIC RESOURCES													
Settlements, Patterns and Movements	Increased population and immigration	Economic opportunity		X	X	X		X	X	Entire village	Long-term	Major	Area will require more labor to convert land and maximize potential benefits
Community stability	Disruptions of social patterns	Influx of temporary construction workers			X			X		Resident population	Short-term	Moderate to serious	Mitigation requires contractor cooperation, local involvement
Regional Economics and Development	Improvement and diversification of economy	The Project	Subsequent planned nonextensive development	X	X	X		X	X	Resident population and migrants	Long-term	Major	A multi-sectoral, long-term development plan is needed
Land Ownership and Tax Collection	More leasing and sharecropping; demand for cadastral survey and modern land registration; increased land taxes	Intensification of farming	Improved value of land		X			X	X	Beneficiary farmers	Long-term	Major	Unavoidable
Services and Infrastructure	Increased demand for social and infrastructure	Improved economy	Increased population		X			X	X	Resident population	Long-term	Moderate	Unavoidable
Public health	Increased disease vectors	More mosquitoes with irrigation	Lack of vector prevention		X	X			X	Resident population	Long-term	Major to moderate	Control required
Farm Support Organizations	Increased demand for farmer organizations	Need to operate system			X			X	X	Beneficiary farmers	Long-term	Intensive	Very positive impact

CHAPTER VI

EVALUATION OF ENVIRONMENTAL IMPACTS

Methodology to Identify the Most Significant Impacts

This chapter summarizes the probable major positive and negative effects of this project on the environment. It also points out possible negative effects of the environment on the functioning and efficiency of the project. Virtually all of the likely effects will occur during the operational phase of the project.

The methodology employed to identify the most likely significant impacts is as described in Chapter V. The evaluation of these impacts is likewise based on the following considerations:

- Experience, in retrospect, with similar projects, worldwide;
- Local knowledge of problems with similar projects in Indonesia;
- Detailed knowledge of local conditions and the design of the project, as it fits, or meets those local conditions;
- A best-guess assessment of how the most significant components of the environment and the project are likely to interact, given several scenarios.

If serious negative impacts had been identified during this evaluation, then a more thorough environmental impact study would have been recommended for this project and more detailed site-specific studies conducted.

Pre-construction

The main irrigation and drainage canals and the road will take a few hectares of predominantly agricultural land within the service area. Some type of compensation will have to be given to the owners. As for the remainder of the land, the villagers are expected to donate land for tertiary and quaternary canals at their own expense. Negotiations for the land must be conducted in a fair and expedient manner, otherwise the

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project may be delayed and ill-feelings will be generated among the project area population.

Construction

Water Resources

Downstream Flow. The water supply to Gapet hamlet and to a lesser extent Nyerinying hamlet will be affected by the dam irrigation scheme, since all water will be diverted from the river for most, and sometimes all, of a year. Irrigation return flows, and ground water recharge will lessen this to some extent, although the water may be degraded somewhat by agrochemicals. The villagers have indicated that in normal years there is enough water from wells for domestic needs. Watering of livestock, especially water buffalo, is currently dependent on the river or crop water runoff. For those years that are exceptionally dry, perhaps 3 out of 10 years, water will be diverted from the reservoir to irrigation for a full year or more, with no release to the river. During this time the villagers may have difficulties coping with an insufficient fresh water supply as ground water tables decline, salt water intrusion increases, and irrigation canal flows decrease. Since the ground water dynamics of the area are unknown, and the occurrence of droughts is unpredictable, it is best to provide some reliable source of fresh water to Gapet and Nyerinying hamlets (see Management Plan in Part 3 of this report).

Water Quality. Return irrigation flows will undoubtably contain higher levels of nutrients from fertilizer runoff. Water quality in the Gapet, Dadap, Nyerinying and Boal Loka Rivers will be somewhat poorer than at present, especially during the dry season. However, the extent of degradation is not normally expected to be great enough to cause problems for downstream users. For those who have access to a supply canal, the water will be of better quality than the rivers.

Land Resources

Land Acquisition. The creation of a 160 ha reservoir has the potential for positive impacts over the long term. The reservoir itself can be viewed as a water resource not only for irrigation, but for recreation, fisheries and domestic water supply. In the short term some pasture and woodland will be lost. Perhaps a total of 25 ha of agricultural land will be taken for supply and drainage canals.

Livestock. With the introduction of a more intensive cropping system, less land may be available for cattle, water buffalo, and horse grazing. The result may be overcrowding of the present land or increased pressure on upland pastures. Either alternative will contribute to erosion. The canals will be

used for bathing and watering livestock with a resultant erosion of the banks unless the proper structures are constructed. Some farmers may eventually sell their livestock to purchase tractors.

Agriculture. Some agricultural land will be lost to the construction of the primary and secondary supply and drainage canal system, for which the farmers will expect compensation. The project is expected to have signification impacts on the farming system, including higher agricultural yields of paddy and palawija crops, increased mechanization, and more frequent applications of agricultural chemicals.

Biological Resources

Pests. There is the risk that crop pests, aquatic weeds, and mosquitoes will all increase due to more abundant water and crops. Monitoring and control programs can offset these risks.

Sedimentation/Erosion. There is the risk that any sedimentation caused by erosion during the construction phase may wash downstream and clog the riverbed, irrigation canals, or even wash into the service area. Good monitoring of this potential situation and some control measures by the construction contractor can minimize this risk.

Socioeconomic Resources

Increases in agricultural production will lead to increases in income and improved living standards. This directly affects the target population, and provides secondary benefits to the at-risk and migrant populations.

Settlement Patterns and Movements. The demand for additional labor can be expected to lead to a large increase in the population. Some people who temporarily enter the area will decide to permanently settle there.

Services, Infrastructure and Social Organization. Improved living standards and more economic opportunity in the area will probably lead to increased trade and demand for services. There should also be an increased demand for more infrastructure (schools, health clinics, roads, transport, and markets).

Land Ownership and Tax Collection. Increased prosperity should make it possible for area farmers to bear some of the costs of a modern cadastral survey based on air photographs. Taxation rates would also be upgraded accordingly.

Public Health: Vector-Borne Diseases. The project will probably bring with it an increased risk of mosquito-borne diseases, particularly malaria and dengue fever.

Resource Use. Increased prosperity will lead to new house construction and housing repairs, with consequent increased demand for sawn lumber obtained from commercial outlets with sources outside the basin, or from the upstream forests.

Domestic fuel use will increase, and at least at first, the demand for fuel wood will increase.

Farm Support Organizations. Farmers will be organized into water users' associations. Agricultural extension services will be stepped up, and it is expected there will be increased activities of farmer cooperatives.

CHAPTER VII

CONCLUSIONS

The Gapet Dam Project is a reservoir storage scheme to supply irrigation water to 1,300 ha. Approximately 500 ha of the proposed service area is already planted in paddy and secondary crops for one or two seasons. The project will boost the service area's cropping intensity, which is currently 115 percent, to 286 percent.

The Gapet Dam will create a 160 ha reservoir, storing approximately 16.5 MCM of water early in each wet season for distribution to cropland during the latter part of the wet season and into the dry season. Irrigation water will be released from the reservoir to the canal system, the paddy fields, the drains, and then back into the river. The effect of this will be to significantly alter the streamflow regime downstream of the dam in terms of both quantity and duration of flow. Downstream water users will be forced to turn to other sources, including the irrigation supply canals.

Other potential environmental impacts of the project include additional recharge of the ground water aquifers, generally improved water availability and access to water, some agricultural land being used for project facilities, inundation of 160 ha of riparian forest and dry fields, decreased dry season grazing areas for livestock, increased crop pests and mosquitoes, and most importantly, substantially improved economic conditions for the local population. As discussed in the previous chapters, and in the following Environmental Management Plan, these impacts are not serious and in most cases can be mitigated.

Alternatives to the proposed project are limited. If no action is taken, it is doubtful that village-level irrigation schemes could ever provide sufficient water storage on the scale required for effective utilization of the catchment's surface water resources. There are no other viable technical solutions to the need for more water in this area. There are no downstream dam sites in the basin that are really suitable, and the service area is defined and limited by topography, soils and geography. Lowering the reservoir elevation would reduce project benefits, and raising the elevation would not be technically or economically advantageous. Delaying the schedule would only continue poverty in the area.

Based on these studies, the conclusion of this Environmental Assessment is that the Gapet Dam Project has no major detrimental environmental impacts which call into question the viability of this project. The project will result in spatial and temporal changes in water distribution which will have largely positive environmental benefits for the local population. The few potentially negative environmental impacts are more fully addressed in the Environmental Management Plan.

APPENDIX A

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No.	Name	Specialization
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Note: Preparers 1 through 11 are members of the SSIMP Technical Assistance Team; preparers 12 through 16 are PU staff assigned to the project.

APPENDIX B

BIBLIOGRAPHY

Acciaioli, G. 1989. "Searching for Good Fortune: The Making of a Bugis Shore Community at Lake Lindu, Central Sulawesi." Ph.D. thesis. Canberra: The Australian National University.

Acciaioli, G. n.d. "What's in a Name? Appropriating Idioms in the Implementation of the Rice Intensification Program in South Sulawesi, Indonesia." Unpublished paper delivered at the fourth annual California Universities Conference on Southeast Asian Studies, entitled "Rethinking Development in Southeast Asia," 14 - 15 March 1987, Berkeley.

Blaike, P. and H. Brookfield. 1987. Land Degradation and Society. London and New York: Methuen.

Canter, W. Larry. 1977. Environmental Impact Assessment. McGraw Hill Book Co., New York.

Conway, G.R. 1986. "Agroecosystem Analysis for Research and Development " Bangkok: Winrock International Institute for Agricultural Development.

Davidson, J. 1987. "Strategies for Implementing Social Forestry in West Nusa Tenggara: A Case Study in Southern Lombok." GOI/UNDP/IBRD - Project INS/83/013, PPIPD (Regional Planning Investment Preparation and Experimental Area Development Project for Nusa Tenggara, South East Sulawesi, and Irian Jaya).

Dove, M.R. 1985. "Swidden Agriculture in Indonesia: The Subsistence Strategies of the Kalimantan Kantu." New Babylon Studies in the Social Sciences 43. Berlin; New York; Amsterdam: Mouton.

Duewel, J.W. 1989. "Gapit - RRIA Notes."

DHV Consulting Engineers and Indec and Associates Ltd. 1988. Nusa Tenggara Accelerated Development Project Indonesia. Final Report of an ADB Project Formulation Mission.

Fenco Consultants, Ltd. 1981 Sumbawa Water Resources Development Planning Study. Technical Report, Volume 3:

Soils and Land Use. NTB Province: and Volume 3: Soils and Land Use Appendices. Report to the Directorate General of Water Resources Development, Government of Indonesia, Jakarta.

Geertz, H. 1967. "Indonesian Cultures and Communities." In: Indonesia. R.T. McVey, ed. New Haven: Yale University Press.

Harvey, M. n.d. "Manual for Implementation of the ANDAL Process." Draft Report. Kantor Menteri Negara KLH, Jakarta.

Hidayat, A. 1978. Methods of Soil Chemical Analysis. Central Research Institute for Agriculture, Bogor.

Hugo, G.T.; T.H. Hull; V.J. Hull, and G.W. Jones. 1987. The Demographic Dimension in Indonesian Development. East Asian Social Science Monographs. Singapore: Oxford University Press, Pte. Ltd.

ILACO B.V. 1985 Agricultural Compendium for Rural Development in the Tropics and Subtropics. Amsterdam: Elsevier.

Indonesia, Government of. Ministry of Transmigration, Directorate General of Settlement Preparation. 1988. Review of Phase I Results, Nusa Tenggara. Regional Physical Planning Programme for Transmigration (RePPProt).

Jhamtani, H. 1988. "Mangroves of Indonesia: Pressure from All Sides." In: Envirnesia 3(1,: 5 - 7, March.

Kantor Menteri KLH (Sekretariat Menteri Negara). 1988. Keputusan Menteri Negara Kependudukan dan Lingkungan Hidup Nomor: KEP 02/MENKLH/I/1988 tentang Pedoman Penetapan Baku Mutu Lingkungan. Jakarta.

Kantor Menteri KLH. 1987. Keputusan Menteri Negara KLH No.: KEP 50/MENKLH/6/1987 tentang Pedoman Penyusunan Analisa Mengenai Dampak Lingkungan. Jakarta.

Kantor Menteri KLH. 1987. "Mitigation of Pollution and Damage of the Environment", unofficial translation by the Environmental Management Development in Indonesia (EMDI).

Kantor Menteri KLH. 1986. Peraturan Pemerintah RI No. 29 Tahun 1986 tentang Analisa Mengenai Dampak Lingkungan. Also, in English: "Analysis of Impacts Upon the Environment", unofficial translation by the

Environmental Management Development in Indonesia (EMDI/CIDA).

Kantor Menteri KLH. 1982. Undang-Undang Republik Indonesia Nomor 4 Tahun 1982 tentang Ketentuan-Ketentuan Pokok Pengelolaan Lingkungan Hidup. Jakarta.

Kantor Menteri KLH. 1980. Pedoman Pembuatan Analisis Dampak Lingkungan. Jakarta.

Kantor Statistik, Kabupaten Sumbawa. n.d. Kecamatan Empang Dalam Angka 1987.

KEPAS (Kelompok Penelitian Agro-ekosistem), Badan Penelitian dan Pengembangan Pertanian, Departemen Pertanian. 1986. "Agro-ekosistem Daerah Kering di Nusa Tenggara Timur: Studi Kasus enam desa pengembangan pertanian."

King, Ben; Woodcock, Martin; Dickinson, E.C. 1975. A Field Guide to the Birds of South-East Asia.

Mackinnon, John. 1980. Birds of Indonesia. FAO, Bogor.

Merck, Damstadt. 1974. The Testing of Water. 9th Edition. West Germany.

Messi, M.N.; I. Saad; and G. Acciaioli. 1986. "Implementation of the Rice Intensification Program in South Sulawesi: The Case of SidRap." Center for Policy and Implementation Studies (CPIS), Jakarta.

Mettana Engineering Consultant (PT). 1989. "Preliminary Review Design: Embung Gapet. Final Report. NTB Province.

Metzner, J.K. 1982. Agriculture and Population Pressure in Sikka, Isle of Flores: A Contribution to the Study of the Stability of Agricultural Systems in the Wet and Dry Tropics. Development Studies Centre Monograph No. 28. Canberra: The Australian National University.

National Academy of Sciences. 1976. Making Aquatic Weeds Useful: Some Perspectives for Developing Countries. Report of an Ad Hoc Panel of the Advisory Committee on Technology Innovation, Board on Science and Technology

for International Development, Commission on International Relations. Washington, D.C.

Neame, P.A. 1988. "Hydrochemistry of the Lower Solo River, Indonesia." Verh. Internat. Verein. Limnol. 23. 1372-1378.

Needham, J.G. and P.R. Needham. 1963. A Guide to the Study of Freshwater Biology. San Francisco: Holden-Day, Inc.

Shaner, W.W.; P.F. Philipp; and, W.R. Schmehl. 1982. "Farming Systems Research and Development: Guidelines for Developing Countries." Westview Special Studies in Agriculture / Aquaculture Science and Policy. Boulder, Colorado: Westview Press.

Soedjiran Resosudarmo, Kuswata Kartawinata, and Aprilani Sugiarto. 1984. Pengantar Ekologi.

Steenis, CGGJ Van. 1981. Flora. Pradnya Paramita. Jakarta.

Steinlin, H. 1988. Menuju Kelestarian Hutan. Seri Studi Pertanian Kerjasama Jerman dan Indonesia. Yayasan Obor Indonesia. Jakarta.

Sudarsono. 1983. Kelas-Kelas Tanah Menurut FAO-UNESCO, Jurusan Ilmu-Ilmu Tanah. Bogor: Fakultas Pertanian, Institut Pertanian.

Sudarsono, S., and K. Takeda. 1978. Hidrologi untuk Pengairan. Pradnya Paramita. Jakarta.

Sudjadi, M., Widjik, and M. Saleh. n.d. Penuntun Analisa Tanah. Bagian Kesuburan Tanah. Lembaga Penelitian Bogor.

United States Man and the Biosphere Program; United States Agency for International Development; and R.E. Tillman. 1981. Environmental Guidelines for Irrigation.

U.S. Agency for International Development. 1986. Environmental Design Considerations for Rural Development Projects. Washington, D.C.

Van der Poel, H.P., and R.F. Schinkel. 1985. "An Appraisal of Farming Systems in 6 Villages on Lombok and Sumbawa." FONC (Forestry/Nature Conservation Project) Project Communication 1985-3. Yogyakarta: Fakultas Kehutanan, Universitas Gadjah Mada.

White, C.M.N., and M.D. Bruce. 1986. The Birds of Wallacea. British Ornithologists' Union Checklist No. 7.

Whitten, A.J.; M. Mustafa, and G.S. Henderson. 1988. The Ecology of Sulawesi. Yogyakarta: Gadjah Mada University Press.

APPENDIX C

RECORD OF SSIMP ENVIRONMENTAL SCOPING SESSION HELD IN SUMBAWA IN DECEMBER 1989

Note: This record was prepared by SSIMP/Mataram shortly after the December 1989 Scoping Session. Some rearrangement of responses to questions has been made in order to bring similar topics together. In addition, the Harza editors have added a few comments on some of the statements made by the meeting participants.

Introduction

In general, the purpose of an environmental scoping session is to inform the project participants of environmental concerns and to identify potential environmental problems that should be studied in greater depth. The results of the scoping sessions and the follow-up studies are then used throughout the project cycle for planning and management purposes, particularly with regard to efforts to ensure project sustainability.

On 18 and 20 December 1989, SSIMP/Mataram held the first of two joint USAID/GOI Environmental scoping sessions for the SSIMP sites, Gapet and Batujai Kiri, respectively, in NTB Province.

The Embung Gapet session was attended by representatives from several provincial, district and subdistrict levels Indonesian agencies, including PU, BAPPEDA Tk. II, Agricultural Services, Agraria (now called Pertanahan), Forestry, Fisheries, Transmigration, Village Development ("Bangdes"), Health, and Animal Husbandry. Representatives from the national level PU, Jakarta, also attended.

Record of the Meeting

The official session began on Monday, 18 December, with Drs. Latif, Secretary to the Bupati opening the ceremony. The second speaker was the Head of BAPPEDA Tk. II, District Sumbawa, followed by Ir. Wahju Djoko MSc., SSIMP-NTB Coordinator. Ir. Wahju talked about current SSIMP program activities and gave a brief introduction to environmental problems in irrigated agriculture. Following this, Drs. Ch. Nasri explained the new GOI policy regulations (AMDAL), a policy change that requires project analysis of environmental, as well as technical, economic, and management issues. Next,

Ir. Sudanta briefly described the key features of the project, such as the total area to be irrigated, the size of the affected population, etc.

After a short break, Ir. Gunawan Wijaya from USAID, Jakarta explained the rationality, goals, and procedures for the environmental scoping session. The discussion was led by Ir. Wahju Djoko, MSc., and is summarized below.

I. Water Resources

A. Fish Ponds and Fresh Water Supply
B. Location of Service Area

Questions/Statements and Answers:

1. Fisheries: There are local fish ponds along the seashore. Is it possible for them to get fresh water? It would help the farmers to increase their income.

   Response: Since they need much of the available fresh water (50 percent) the project cannot meet their needs and also have enough for irrigation (Ir. Sudanta).

2. Agraria: Farmers and land owners are very confused with regard to information on the location of the service area. They have been waiting for a long time, and the information they get is always conflicting.

   Response: It was not easy to choose the service area; it needed to be surveyed. We have also changed the dam's location four times. Now the project has settled on a location so we are sorry to have kept you waiting for the correct information (Ir. Sudanta).

II. Land Resources

A. Land Acquisition and Compensation
B. Land Taxes
C. Sedimentation in the Reservoir

Questions/Statements and Answers:

1. Agraria: Land acquisition and public interest sometimes is a problem. Why is land acquisition only for the primary and the secondary canal system? What about land compensation?

Response: Land acquisition is up to the secondary system and the project will pay for the land that PU acquires. Land compensation is not always in terms of money, sometimes it is in exchange for other lands or for other houses (Ir. Sudanta).

2. Dispenda: The Bupati of Sumbawa has a team who will take care of and pay a lot of attention to the project. Sometimes, we lose communication with the team and it means that we lose income (farmers do not pay taxes, etc.).

   Response: I do not think it is the project's fault. There should be the same information concerning objectives and products in the Land Affairs office and in the regional Local Income Office (Dispenda). Coordination in the three offices would be very helpful.

3. BAPPEDA Tk. II: What about sedimentation in the reservoir?.

   Response: Project design will allow for sedimentation and cleaning (Ir. Sudanta).

III. Biological Resources

A. Livestock Watering and Grazing Land
B. Water Weeds
C. Deforestation

Questions/Statements and Answers:

1. Animal Husbandry: Is it sufficient to have buffalo pools every 2 km [along the canals]: and are there plans for new grazing land?

   Response: The project team is studying the spacing of buffalo pools and the need for new grazing land to substitute for land lost to irrigation. If adequate watering is not available, people will water livestock in the canals, causing damage to them (P. Ames).

   Statement: Head, Provincial Public Works, suggests that grazing land and buffalo pools should be in one area (Ir. Sudanta).

2. Agriculture: What if we leave some of the water weeds that grow in the reservoir?

Response: Water weeds are dangerous, they quickly become bigger and spread out over the surface of the lake, especially during the rainy season (P. Ames).

3. DPRD: Thanks for attention paid to our area. We wish to have it known that we are now very strict in giving permits for cutting the trees in the forest (HPH); but without the help of other agencies, our planning efforts will not be effective.

   Response: Thanks for the information and we will pay attention to it (Ir. Sudanta).

IV. Environmental and Public Health

A. Waterborne Diseases and Mosquitoes
B. Agrochemicals and Runoff

Questions/Statements and Answers:

1. BAPPEDA: What will happen in ten years in the Boal Loka River?. During the rainy season it always floods and there is a lot of sediment and mosquitoes [waterborne diseases].

   Response: There will be both negative and positive impacts of the project on the environment, as well as vice-versa, and for that reason our team is here. We will do an ANDAL to review this. The Health Department will be responsible for the malaria problem (Drs. Ch. Nasir).

2. Agriculture: What do you think is the result of agrochemicals which run off during the rainy season [to the canals].

   Response: For sure it causes water weeds to grow and cover the surface of the canals [P. Ames].

V. Socioeconomic

A. Farming Systems
B. Land Acquisition and Records

1. Agriculture: Will there be any difference in the farming system when the project is finished? How can we increase the farmer's capability?

   Response: We need to give the farmers guidance in changing the system from dry/rainfed paddy to an

irrigated system. There will be a Water User Association Organizer (WUAO) in each area to help the farmers (Ir. Gunawan).

2. Dispenda Tk. II: There will be no problem with land acquisition, because it will be used in the public interest and there are land records that show the peoples' ownership of the land.

   Response: That is useful information and if possible there should be good cooperation between Dispenda and Agraria.

GAPET ENVIRONMENTAL SCOPING SESSION

LIST OF PARTICIPANTS

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a. DGWRD, Jakarta - Drs. Nasri

b. USAID, Jakarta - Ir. Gunawan Wijaya

c. Provincial Water Resources Division:

1. Pimpro Irigasi Embung - Ir. Sudanta
2. SSIMP-USAID Coordinator - Ir. Wahju Djoko, MSc.

d. Technical Assistance (TA) Consultants:

1. Team Leader SSIMP-NTB - W. J. Schoenleber
2. Environmental Specialist - Dr. Peter Ames

e. Local Government:

1. Head, Regional Development Agency (BAPPEDA, Tk II)
2. Head, Subdistrict Empang
3. Head, Boal Village
4. Agriculture Extension Services Staff
5. Forestry Staff
6. Fisheries Staff
7. Dept. of Health Staff
8. Land Affairs Staff
9. Horticulture/Tree Crops Staff
10. Animal Husbandry Staff
11. Regional Government Staff
12. Regional Development Division Staff
13. Regional Income Staff (DISPENDA)
14. Regional Public Works Staff
15. Branch of Regional Public Works Staff

PROGRAM OF THE GAPET ENVIRONMENTAL SCOPING SESSION

1.	08:30 - 08:45	:	Team visited Mr. Djalaludin Rambe, Head of East Sumbawa Public Works
2.	08:45 - 09:30	:	Team visited Sumbawa Regency and received by Drs. Latif, Regional Secretary
3.	10:05 - 10:15	:	Head, Regional Development Agency led the discussion of the Gapit Environmental Scoping Session
4.	10:15 - 10:30	:	A brief introduction of the Small-Scale Irrigation Management Project (SSIMP) activities by Ir. Wahju Djoko MSc, SSIMP -NTB Coordinator
5.	10:30 - 11:00	:	Description of the Gapit Irrigation Project by Ir. Sudanta, Pimpro
6.	11:00 - 11:30	:	Explanation of Environmental Scoping Session by Dr. Peter Ames, Harza Environmental Specialist
7.	11:30 - 11:50	:	Information concerning ANDAL and PIL by Drs. Ch. Nasri, staff of DGWRD, Jakarta
8.	11:50 - 12:00	:	Break
9.	12:00 - 12:10	:	Explanation of the rationality, goal and procedure for the environmental scoping session by Ir. Gunawan Wijaya, USAID
10.	12:10 - 13:00	:	Questions/Statements and Answers of the environmental scoping session lead by Ir. Wahju Djoko MSc, SSIMP-NTB Coordinator and moderator
11.	13:00 - 14:00	:	Lunch
12.	14:00 - 15:00	:	Continuation of questions and answers
13.	15:00	:	Gapet Environmental Scoping Session closed by Drs. Latif, Regional Secretary

APPENDIX D

GLOSSARY AND ACRONYMS

AID	Agency for International Development
AIDAB	Australian International Development Assistance Bureau
AMDAL-Analisa Mengenai Dampak Lingkungan	Environmental Impact Assessment
ANDAL-Analisa Dampak Lingkungan	Environmental Impact Study
APBD-Anggaran Pendapatan Belanja Daerah	Regional source for GOI operating budgets
APBN-Anggaran Pendapatan Belanja Nasional	National source for GOI operating budgets
AU	Animal Units
BAKOSURTENAL	GOI national mapping agency
BANGDES-Pembangunan Desa	Directorate of Village Development, under the Department of Home Affairs
BAPPEDA-Badan Perencanaan Pembangunan Daerah	Regional Development Planning Board, under the Department of Home Affairs
BIMAS-Bimbingan Massal Swasembada Bahan Makanan	Mass Guidance for self-sufficiency in foodstuffs, a farm input-credit package program
BKLH-Biro Kependudukan dan Lingkungan Hidup	BPE-Bureau of Population and Environment
BULOG-Badan Urusan Logistik	National food logistics body
Cabang Dinas	Branch office
Cipta Karya	Public Works; in charge of urban and some village water supply projects
Desa	A village

DGWRD	Directorate General of Water Resources Development
DIP-Daftar Isian, Proyek	Operating budget for a project
DOLOG/SUB DOLOG-Depot Logistik	Provincial food logistics body
DPUP-Dinas Pekerjaan Umum Propinsi	Provincial Public Works Services
Dusun	A village administrative sub-area
EA	Environmental Assessment
EIS	Environmental Impact Study
EMP	Environmental Management Plan or Environmental Monitoring Plan
FS	Farm Survey
GOI	Government of Indonesia
Harza	American Engineering Company
HHS	Household Survey
INMAS-Intensifikasi Massal	Massive Intensification, a farm input program
INPRES-Instruksi Presiden	Governmental law
INSUS-Intensifikasi Khusus	Special Intensification, a farm input credit program for groups of farmers with improved infrastructure facilities
IPEDA/PBB	Agrarian taxes
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for the Conservation of Nature and Natural Resources
Kabupaten	District
Kecamatan	Subdistrict
Kepala Desa	Head of a village
KUD-Koperasi Unit Desa	A village cooperative

KUPEDES-Kredit Umum Pedesaan	General rural credit program
KUT-Kredit Usaha Tani	Farmer credit scheme
LKMD-Lembaga Ketahanan Masyarakat Desa	Organization for Self-Reliance of the village community (Village community development committee)
LMD-Lembaga Masyarakat Desa	Village Development Council
LP3ES-Lembaga Penelitian Pendidikan dan Penerangan Ekonomi dan Sosial	Indonesian non-governmental organization with expertise in organizing water users' associations
MENKLH-Menteri Kependudukan dan Lingkungan Hidup	Minister of the Office of Population and the Environment
NEPA	(US) National Environmental Policy Act
NTB-Nusa Tenggara Barat	West Nusa Tenggara
O & M	Operation and Maintenance
Paddy	Rice
Palawija	Non-rice food crops, secondary crop, such as soybeans, mungbean, maize
Panggung	A house usually made of wood with its floor elevated one or two meters above the ground
PB 36, PB 42	Paddy seed varieties
PELITA V	Indonesia's fifth Five-Year Development Plan
PEMDA-Pemerintah Daerah	Regional Government (District, Subdistrict)
Pengairan	Irrigation; generally used in reference to the irrigation division of DGWRD-Directorate General Water Resources Development
Pertanahan	Directorate General of Land Affairs
Pertanian	Ministry of Agriculture

Pertanian Tanaman Pangan	Food crops services
PPL-Penyuluh Pertanian Lapangan	Field extension agent
Peternakan	Livestock Services
PIL	Preliminary Environmental Information Report
POM-Penylidikan Obat dan Makanan	Department of Health's testing laboratory
P3A-Perkumpulan Petani Pemakai Air	Water Users' Association
P3SA-Proyek Perencanaan Pengembangan Sumber-Sumber Air	Public Work's project for planning the development of water resources
PKK-Program Kesejahteraan Keluarga	Usually referred to as a village-level women's group
PUSKESMAS-Pusat Kesehatan Masyarakat	Rural public health service
PUSKUD-Pusat KUD	District cooperative office
Ranting, Sub-Ranting Dinas	Sub-branch, "sub"-sub-branch
RePPProt	Regional Physical Planning Programme for Transmigration
RKL	Environmental Management Plan
Rp	Rupiah
RPL	Environmental Monitoring Plan
RRIA	Rapid Rural Irrigation Appraisal
RT-Rukun Tetangga	Neighborhood units of 25-50 households
Sawah	Lowland, usually planted in paddy
SSIMP	Small-Scale Irrigation Management Project
Tambak	Brackish water fish pond

TK I-Tingkat I	First level of provincial government
TK-II-Tingkat II	Second level of government at district level
USAID	United States Agency for International Development
WHO	World Health Organization
WUA	Water Users' Association
WUAO	Water Users' Association Organizer

Small-Scale Irrigation Management Project (SSIMP)

FINAL REPORT
GAPET DAM PROJECT
ENVIRONMENTAL ASSESSMENT

VOLUME II

EXECUTIVE SUMMARY
ENVIRONMENTAL MANAGEMENT
AND MONITORING PLANS

December 1990

Prepared by

HARZA ENGINEERING COMPANY

in association with

Development Alternatives, Inc.

Global Exchange, Inc.

PT. Wiratman & Ass.

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VOLUME II

VOLUME I -- MAIN REPORT, and
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(in separate volumes)

PART I

EXECUTIVE SUMMARY

Introduction

The Gapet Dam Project will provide reliable irrigation to 1,300 hectares (ha) in Sumbawa District, NTB Province, by constructing a dam on the intermittent Gapet River. Experts from Indonesia and the United States have reviewed the project plans and concluded that it will accomplish its primary objectives, but that it will have some environmental effects. This environmental assessment, prepared under the laws of Indonesia and the United States, explores the potential effects of the project on human and natural resources and recommends actions to mitigate adverse effects and enhance benefits.

Sponsoring Agencies

The project is sponsored by the Ministry of Public Works of the Government of Indonesia and the Agency for International Development of the Government of the United States.

Objective of the Environmental Assessment

The major objective of this environmental assessment is to inquire whether there are any probable major negative impacts of this project on the environment. This report also assesses negative impacts of the environment on the function and efficiency of the project. Once harmful effects are identified, a plan is provided to mitigate these major negative impacts.

Scope of Report

Priority issues were identified as a result of an Environmental Scoping Session and these issues have been organized into four basic categories: water resources, land resources, biological resources, and socioeconomic and cultural resources. This is the scope of the report.

Description of the Proposed Project

Location

The project is located entirely within Boal Village in the Empang Subdistrict of Sumbawa District, NTB Province, Indonesia. The Gapet river basin lies on the narrow isthmus which connects the two larger land masses which form the island of Sumbawa. The service area of 1,300 ha occupies the area between the Dadap and Boal rivers, extending north as far as the tidal flats which border Saleh Bay (Figure ES - 1).

Limits of the Study Area

The study area for this environmental assessment consists of the entire river basin of the Gapet River. It also includes the entire land area between the Dadap and Boal Rivers, as far south as the dam site and the Boal Weir. It includes all of Boal Village, but particularly the sub-areas of Gapet, Nyerinying, Boal Atas and Boal Bawah.

Pre-Construction Period

The Gapet Dam Project has been investigated by a series of engineering studies during the 1980's. These include the Sumbawa Water Resources Development Study (Fenco, 1982); a Geotechnical Investigation by PT Cita Prisma in 1985; a dam design by PT Mettana in 1985, as well as an irrigation scheme design by Peksi, also in 1985. The most recent study included the preliminary design review completed in October 1989. Final design and tender document preparatory work is scheduled for completion in January 1991.

Construction Period

Major Structures. The project will contain two main types of structures: a dam and headworks complex at a gap in the hills some five kilometers (km) upstream of the main hamlet of Boal Village, and a system of canals to convey the water to the service area and distribute it to the fields.

The dam will be a random fill structure with a height of 18 m above the river bed, giving a crest elevation of 38 m and a crest length of 290 m.[1] An additional saddle dam will be

[1] Figures pertaining to water supply, floods, and reservoir operation are being finalized and will appear in the Project Justification Report. These figures are expected to change slightly. With these changes, it is likely that minor changes will be required in the structures as described here.

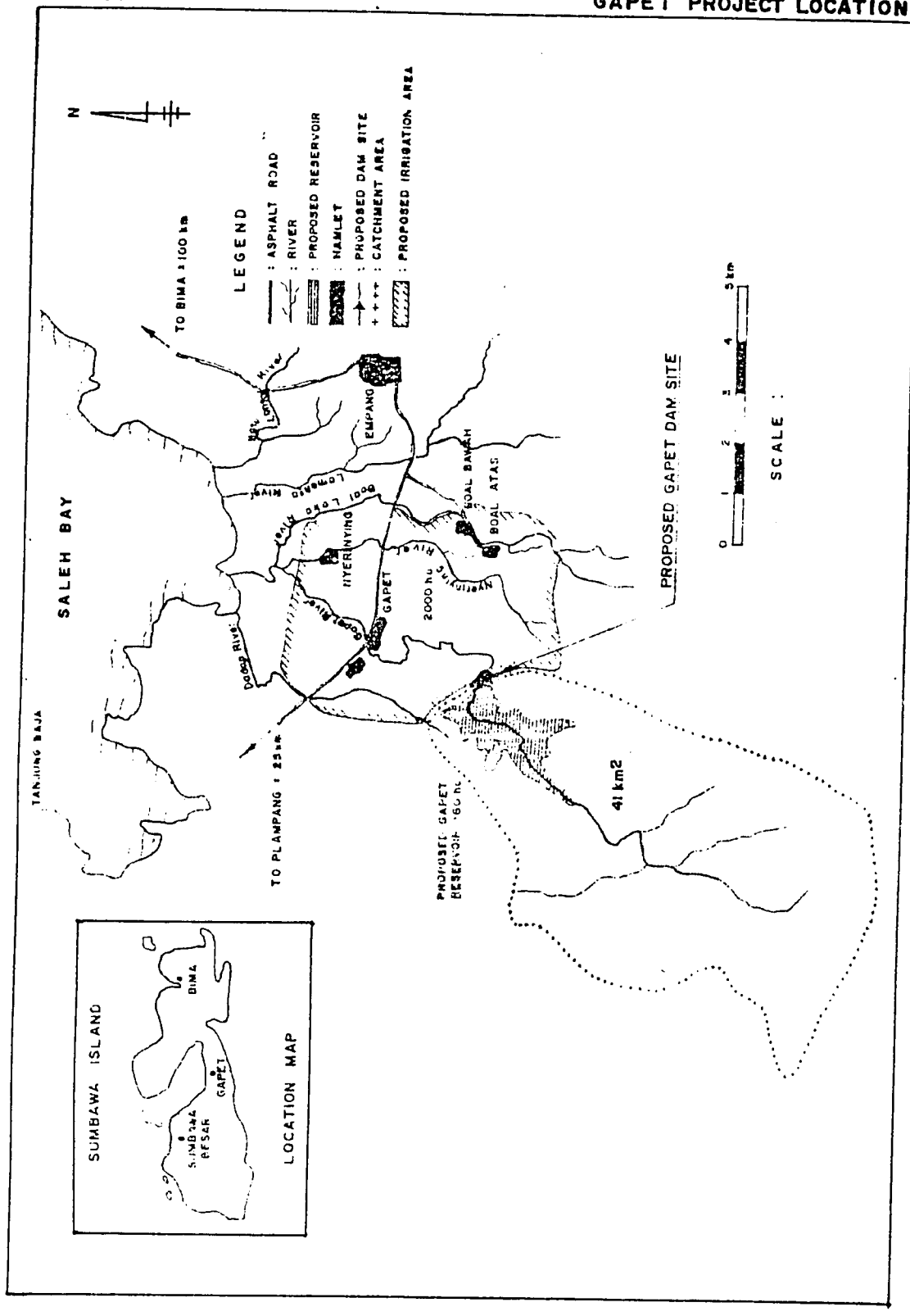
required immediately to the right of the main dam, with a crest length of 328 m.

The dam will impound a reservoir with a surface area of 160 ha and a live storage capacity of 16.5 MCM and dead storage 0.7 MCM.

Two secondary canals will originate at the base of the dam and convey water to the service area. The total length of the secondary canals will be 7.7 km. An additional 20.4 km of tertiary canals will be constructed, along with a system of drains to remove excess rain water.

Work Force. The total construction force for the dam and irrigation system is expected to number approximately 850 workers, of which 700 will be laborers, 100 semiskilled and skilled workers and 50 technical and management staff. Somewhat less than half of this total number will be required under the dam contract. The contractor may hire these laborers from the existing labor force in the district.

Figure ES – 1
GAPET PROJECT LOCATION



Schedule. Construction of the dam is expected to begin in 1991 and continue for 30 months. The canal system will be constructed concurrently, if labor is available; if not, as soon as the work can be redistributed.

Operation Period

Irrigation: Method of Operation. Water will be provided to the service area on an as needed basis, which is determined partly by rainfall. The reservoir will be filled during the early part of the rainy season, and will be full by about February. By April, the reservoir will begin its drawdown which will continue through the end of the dry season.

Equipment Use. Little special equipment will be required, other than that installed at the dam and in the canals to control flow. Some tools will be required for maintenance and will have to be carefully controlled if they are to be available when needed.

Resource Use. The only resources used by this project during operation will be water and hand labor. Virtually no mechanical energy resources will be required, since the system will be manually operated.

On-Farm Management. The functioning of local water users' associations (P3A) will be examined and, where necessary, strengthened. The relative roles of the locally elected malar (irrigation foreman) and the PU Operations and Maintenance (O & M) staff will be examined in terms of the effectiveness and reliability of the water distribution system.

Domestic Water Supply. The project will install a water supply system to the downstream hamlets of Gapet and Nyerinying. Public Works O & M will be responsible for maintaining this system to distribute water to the village main distribution water reservoirs.

Public Bathing and Livestock Watering. Public Works will install structures. Once built, there will be some monitoring of the structures to see that they remain in good condition. Community education and, eventually, community-led enforcement programs will be required to effectively protect canals and other structures from damage.

Waste Treatment. The only significant waste created by the project will be water in the form of irrigation drainage. Those flows will contain some fertilizer and pesticide residues from the fields, plus human and animal waste from villages. The flows will be returned to the rivers without treatment.

Operation and Maintenance. Operating and maintenance costs for the dam, major structures and irrigation system are estimated based on other studies and experience in the region.

Alternatives to the Proposed Project

No Action Alternative

If this project is not implemented, the present uncertainties of agricultural production will continue, with the local people remaining at basically a subsistence level. Continued emigration of younger farmers will occur as they do now, due to the attraction of better conditions elsewhere, and the inability of the land to support any more people than it currently does.

Alternative Technologies

Water Sources. The only alternative water source in the region, ground water, is not sufficient to meet irrigation needs.

Water Management. Effective management of existing surface water resources could not, of itself, improve the agricultural situation, since the river is too seasonal and its year-to-year fluctuation too great for reliable irrigation.

Siting Alternatives

The Gapet dam site is the only possible site that will provide the required storage. Several alternative spillway and outlet works arrangements were examined in arriving at the selected plan. Placement of the access road and the canals was dictated by topography and the configuration of the service area.

Existing Environmental Conditions

Climate

The project is located in an area of tropical moist climate. The average annual catchment area rainfall is 1,921 mm while service area rainfall averages under 1,355 mm, most of it in a four-month period. Temperatures average 27.9° with annual range of less than 5 degrees.

Topography and Geology

The project area is divided between a hilly catchment area upstream of the dam site (41 km^2) rising to as much as 810 m, and a flat to gently undulating service area with slopes of less than 8 percent. The area is largely of volcanic origin, with marine sediments along the northern coast.

Water Resources

The Gapet River system is the only natural surface water in the area, there being no lakes or ponds. The Gapet is a strongly seasonal river with peak monthly average flows of 4 up to 9 m^3/s occurring usually in February and decreasing to zero for several months of the year. Other small rivers, including the Dadap, Nyerinying and Boal Rivers, also drain the proposed service area. There is a small existing weir on the Boal River.

Water quality analyses made in November 1989, (at a time of a minimum flow in the dry season, show the Gapet at the dam site to be an unpolluted, slightly alkaline river, as would be expected from the relatively uninhabited nature of its upper catchment area. In the dry season, surface water in the service area is limited to a few residual pools in the lower reaches of the rivers, which become highly polluted.

Most households in the service area draw their domestic water from wells or from the river. During the dry season most turn to pits excavated in the riverbed, where they are able to obtain some sub-surface seepage.

Land Resources

Land Use. The catchment area above the dam site, totalling approximately 4,100 ha, is uninhabited and covered with tropical deciduous forest (about 60 percent) and bamboo forest (about 40 percent). In the service area and the inundation area of the reservoir, land use includes a patchwork of dry fields, grassland and scrub forest (bamboo), and bunded rainfed paddy fields. Some of the paddy fields are used only for a single annual palawija crop; other areas are left fallow for long periods. There is a broad band of unvegetated tidal flats bordering Saleh Bay to the north.

Agricultural Practices. Most households own a combination of bunded paddy fields and dry fields, ranging from 3 to 5 ha per household. The agricultural strategy appears to be a compromise between shifting and sedentary cultivation. Many fields are "fallow" for 5-6 years out of every 10. While most farmers hope to plant paddy in the wet season, there is often not

enough rain to permit this; many farmers will plant only a single palawija crop (usually mungbeans) per year. Only 10 to 15 percent of households attempt a second season planting. As a result, annual yields are very low in this area, with paddy averaging 1 t/ha and mungbeans 250 kg/ha. Cropping intensity is about 110 to 115 percent. Approximately 84 percent of the paddy crop is retained for domestic consumption. In contrast, up to 90 percent of the mungbean is marketed as a main source of cash income.

The number of large livestock is substantial, with an average of 6.7 animals/household, with water buffalo being dominant. Most livestock graze freely in fallow land throughout the dry season, but are more closely supervised or tethered during cropping periods.

Biological Resources

Terrestrial Habitat. In the upper catchment, the tropical deciduous and bamboo forest provide a variety of good habitat for wildlife. This area is largely uninhabited and does not appear to be under pressure for either timber harvesting or agricultural conversion. The service area has largely been converted to various low intensity agricultural purposes, with only scatterd areas of scrub forest and regrown pasture and dry field presenting limited habitat for those species able to coexist with man. The coastal estuarine area is largely unvegetated save for minor stands of mangroves at the shoreline.

Aquatic Habitat. Aquatic habitat is restricted to the small intermittent rivers of the area. During the dry season, these act as refuges for a variety of invertebrate species and small fish. In the service area, these pools become highly nutrient enriched and concentrated by evaporation by the end of the dry season, and serve as habitat for only the most tolerant and hardy organisms.

Fauna. A variety of wildlife is reported for this area, including deer, wild pigs and macaques, the latter of which were observed in several locations in the project area during the environmental studies. The bird fauna is diverse but not fully described.

Socioeconomic Resources

Population. Population density in the project area is very low, averaging only 16 persons/km^2. The population of the four sub-areas of the village within the project area totals 2653 persons (1987 data), with 896 in Gapet, 203 in Nyerinying, 1139 in Boal Atas and 415 in Boal Bawah. The population is young, with 46 percent aged less than 15 years. The population is

nearly static, with an average annual growth rate of only 0.5 percent for the entire village of Boal.

Village records indicate that 51 percent of adults have at least completed primary school. Virtually everyone under the age of 30 is at least minimally literate.

Public Health. Little reliable data on health exists, but diseases of the respiratory system, digestive tract and skin are reported to be the most common. Malaria is present, and there is some chloroquine resistance reported in this area. Waterborne intestinal diseases appear to be common, and are exacerbated during the dry season when clean water is restricted or unavailable. The village has one main health clinic, and several secondary ones, each open once or twice per month.

Social Conditions. The study area displays a uniform rural, agrarian lifestyle and a basic, primarily subsistence-oriented standard of living. Opportunities for cash earnings are extremely limited outside the agricultural sector.

The population is divided into the ethnic Sumbawan, who are farmers, living in the main agricultural area of the village, and ethnic Bugis, who farm some of the more marginal downstream land, living mostly near Saleh Bay. These Bugis farmers are also coastal fishermen. A small proportion of households earn some income by engaging in aquaculture (tambak) cultivation. Others (both Sumbawan and Bugis) sell forest produce (honey, rattan, firewood, bamboo), or work as petty traders. All residents are Muslim, and most were born in the area.

The majority of the farmers are local, resident, owner-operators, living in consolidated hamlets alongside the main east-west highway, or along village roads. A few are sharecroppers, living in nearby villages, or locals who own land but also sharecrop in other parcels of land. Virtually none of the households in Boal Village are landless. In general, farmers tend to work their own land that is located nearest their hamlet or residence. Land that is located at inconvenient distances away may be sharecropped out. Overall, land ownership and sharecropping arrangements are thoroughly intermixed throughout subareas (dusun). Direct benefits are expected to be spread throughout the village and extend, to a limited extent, to a few sharecroppers living in neigboring villages.

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Potential Environmental Impacts

Identification of Project Effects

Identification of project effects is usually based upon a combination of published information, local knowledge and concerns, professional interpretation and analysis of baseline environmental conditions. In December 1989, an environmental scoping meeting was held in Sumbawa Besar to review possible project impacts and to respond to local concerns about the project, which were principally oriented to aspects of the socioeconomic environment and the planning process. The environmental review has incorporated these concerns into the assessment of project impacts.

As might be expected, most of the perceptible side effects of this project will be related to changes in water use and availability that will occur in the post-construction phase of the project. These effects were sometimes alluded to by agency representatives at the 1989 meeting.

Water Resources

Water Quantity. The major objective of this project is the geographic and temporal redistribution of water, storing 16.5 MCM in the early wet season for distribution to cropland during the later wet season and into the dry season. The primary impact of this change will be a significant decrease in flow in the river below the dam, both in volume of flow and duration. There will be less water in the river, at least for the reach from the dam to Gapet, for fewer months of the year. In drier years, all water will be retained in the reservoir, and there will be no spill. There will be more water spread over the 1300 ha service area, for much, if not most of the year. Irrigation return will contribute to higher flow in the lower reaches of the river than is currently the case. This will also indirectly contribute to lessening the risk of saline intrusion along the northern edge of the service area. Increased infiltration over a larger area for a majority of the year will likely result in improved ground water recharge, thus improving water availability from wells. It is unlikely there will ever be sufficient supplies of fresh water for future fish pond (tambak) development.

Water Quality. The reservoir water will reflect current river water quality, which has moderate levels of major ionic constituents and suspended material but is fairly low in nutrients. Problems in the reservoir with excessive weed growth due to eutrophic conditions is not anticipated. Quality of water in the irrigation supply canals should be comparable to that of the reservoir if care is taken to restrict use of the canals for bathing, washing, stock watering and sanitary purposes.

Irrigation return flows will likely have higher nutrient levels as well as possibly some pesticide residues. Quality of these flows will nevertheless be substantially improved over current dry season water quality in the stagnant pools remaining in the lower reaches at these intermittent rivers during the dry season.

Domestic Water Supply. Many residents of Gapet use the river for domestic water supply, and these users will be forced to share wells or turn to the irrigation canal system for water. For Nyerinying, the project may improve the quality and quantity of well water supply.

Land Resources

Land Use. Changes in land use in the area will include:

1. Conversion of the service area from existing mixture of bunded, rainfed paddy fields, dry fields, pasture, and scrub to irrigated paddy fields and a concommitant, significant increase in agricultural productivity.

2. Conversion of 160 ha of dry fields, scrub and riparian forest into a reservoir. Use of the drawdown zone in the reservoir for agriculture is not anticipated.

In addition, small amounts of land will be used for the irrigation system canals, amounting to about 12 ha for the 7.7 km of secondary distribution canals.

No significant changes in soil chemistry or waterlogging are anticipated with this project. Likewise, sedimentation should not be a serious problem due to the lack of any land conversion activities upstream.

Farming Systems. Increased water supply is expected to transform the existing low input, risk-minimizing styles of agriculture in the area. The intensification and diversification of cropping is likely to have such effects as a trend to mechanization and alterations in existing livestock management strategies. Greater use of fertilizer and pesticide will result, with their associated environmental and health risks.

Biological Resources

Terrestrial Habitat. The project will result in the conversion of approximately 160 ha of riparian scrub forest and open land (dry fields) to aquatic habitat. This loss of terrestrial habitat is not significant, since there is no commercial timber nor is the agricultural productivity very high. The drawdown zone of the reservoir is not expected to support any vegetation, due to the conditions there.

The project is not expected to have any significant impact on watershed conditions. Access will not be enhanced and may even be hindered by the presence of the reservoir, which will inundate the current dry season routes to the upper watershed.

Aquatic Habitat. As aquatic habitat, the reservoir is not expected to have very high biological productivity, although it may develop a normal range of invertebrate and vertebrate fauna as are currently found in the river. Fish populations (particularly tilapia) may develop, and may support a low level of local fishery pressure.

Species of Special Interest. No species of plants or animals in the project area have been identified as being of special conservation or scientific importance. Little changes in upstream habitat is expected which would detrimentally affect existing wildlife.

Any intensification of cropping can be expected to result in higher and more persistent populations of crop pests, including insects, birds and mammals such as rats. Control of these requires an appropriate level of vigilance and techniques which will develop with the change in the farming system. Disease vectors such as mosquitoes can similarly to be expected to increase due to the increased water supply, and appropriate levels of health monitoring will be needed to respond to this change.

Socioeconomic Resources

Settlement Pattern. Since there is no one living in the proposed reservoir area, no relocation program will be required. The existing population distribution is likely to be maintained, but the population is expected to increase over time as improved living standards and economic opportunities encourage people to stay rather than emigrating. Increased agricultural activity in the area is likely to attract and hold some agricultural laborers who now visit the area only at harvest.

Regional Economics. The primary objective of this project is an improved standard of living for the portion of the population that receives irrigation water. The increase in disposable income may be expected to increase the demand for goods and services from those in the region that do not have access to irrigation. Certain tasks that the target population now perform for themselves will be more difficult for them as they devote more time to agriculture, leaving less time for house repairs, manufacture of furniture for their homes, and other activities required to maintain their living standard. With more cash available, they will hire labor or purchase goods

from others. This will have the effect of spreading project benefits through out the community.

The increased income levels will also result in demand for improvements to local infrastructure, and improved services such as education and public health.

Public Health. The project area may see an increased risk of vector-borne diseases such as malaria and dengue, due to the greater amounts of water in the service area. The improvement in quality of dry season water supplies may have the net effect of decreasing many of the current intestinal and skin diseases. Both of these effects should be considered by local health authorities in planning for their response to changing social conditions in the area.

Social Structure. The advent of the project will place additional demands upon the community for joint operation and maintenance of the irrigation system, as well as in planning for their response to other social and economic changes. All of these will contribute to the enhancement of social cohesiveness and stability in the area.

Evaluation of Environmental Impacts

Water Resources

Downstream Flow. The water supply to Gapet Hamlet, and to a lesser extent Nyerinying Hamlet, will be affected by the dam irrigation scheme, since all water will be diverted from the river for most, and sometimes all, of a year. In very dry years, when there is no water, or little water in the river, villagers may have difficulties coping with an insufficient fresh water supply. It is best for the project to provide some reliable source of fresh water to Gapet and Nyerinying hamlets.

Water Quality. Return irrigation flows will undoubtedly contain higher levels of nutrients from fertilizer runoff. For those who have access to a supply canal, the water will be of better quality than the rivers.

Land Resources

Land Acquisition. Although land will be lost for the reservoir, the reservoir itself can be viewed as a water resource not only for irrigation, but for recreation, fisheries and domestic water supply.

Livestock. With the introduction of a more intensive cropping system, less land may be available for cattle, water buffalo, and horse grazing. A good livestock management plan is neces-

sary, to safeguard against overcrowding, overgrazing, erosion due to cattle, and damage to canals.

Agriculture. Some agricultural land will be lost to the construction of the primary and secondary supply and drainage canal system, for which the farmers will expect compensation.

Biological Resources

Pests. There is the risk that crop pests, aquatic weeds, and mosquitoes will all increase due to more abundant water and crops. Monitoring and control programs can offset these tasks.

Sedimentation/Erosion. There is the risk that any sedimentation caused by erosion during the construction phase may wash downstream and clog the riverbed, irrigation canals, or even wash into the fields.

Socioeconomic Resources

Settlement Patterns and Movements. The demand for additional labor can be expected to lead to an increase in the population.

Services, Infrastructure and Social Organization. Improved living standards and more economic opportunity in the area will probably lead to increased trade and demand for services. There should also be an increased demand for more infrastructure (schools, health clinics, roads, transport, and markets).

Land Ownership and Tax Collection. Increased prosperity should make it possible for area farmers to bear some of the costs of a modern cadastral survey based on aerial photographs. Taxation rates would also be upgraded accordingly.

Public Health: Vector-Borne Diseases. The project will probably bring with it an increased risk of mosquito-borne diseases, particularly malaria and dengue fever.

Resource Use. Increased prosperity will lead to new house construction and housing repairs, with consequent increased demand for sawn lumber obtained from commercial outlets with sources outside the basin, or from the upstream forests.

Farm Support Organizations. Farmers will be organized into water users' associations. Agricultural extension services will be stepped up, and it is expected there will be increased activities of farmer cooperatives.

Conclusions

The conclusion of this study is that the Gapet Irrigation Project has no major detrimental environmental impacts which call into question the viability of this project. The project will result in spatial and temporal changes in water distribution which will have largely positive environmental benefits for the local population.

Based on the present studies, the conclusion of this Environmental Assessment is that the Gapet Irrigation Project is environmentally feasible, and that potentially negative environmental impacts have been adequately addressed in the Management Plan.

TABLE ES-1
SUMMARY OF POTENTIAL ENVIRONMENTAL IMPACTS
GAPET IRRIGATION PROJECT

ENVIRONMENT COMPONENT	DESCRIPTION OF IMPACT	SOURCES OF IMPACT		IMPACT LOCATION			TIMING OF IMPACT			EXTENT OF IMPACT			REMARKS
		PRIMARY	ASSOCIATED	CATCHMENT AREA	IRRIGATION AREA	DOWNSTREAM AREA	PRE-CONST.	CONST.	OPER.	UPON?	DURATION	INTENSITY	
WATER AND ATMOSPHERIC RESOURCES													
Water Quantity	Reduced availability in river below dam	Water diverted from river to canal			X			X	X	People along river	Long-term	Moderate to severe	Water available in canals and domestic water supply systems
	Creation of a reservoir	The Project		X				X	X	Beneficiary farmers	Long-term	Major	Storing and redistributing water are the means to meet project goals
	Increased recharge of groundwater	Percolation of irrigation water	Runoff and drainage		X	X			X	Groundwater	Long-term	Minor to moderate	Good assist years, but not enough to improve domestic water supplies from wells very much
Water Quality	Increase chemical concentration	Agricultural chemicals	Irrigation		X	X	X		X	Irrigation area	Long-term	Minor to severe	Proper use reduces risk of adverse impacts
	Provide domestic water supply	The Project			X			X	X	Service area residents	Long-term	Moderate to major	Mitigation requires provision to drainage exit receivers
	Provide livestock water	The Project			X			X	X	Livestock in irrigation area	Long-term	Moderate to major	Mitigation requires provision of water to livestock
Air Quality	Increased dust	Construction activity		X	X			X		Irrigation area	Short-term	Moderate	Mitigation involves contractor dust control (road watering)
	Increased smoke	Burning surplus straw			X	X			X	Irrigation area	Long-term	Minor to moderate	Straw burned when intensive cropping leaves no time for natural decomposition
LAND RESOURCES													
Land Use	Convert to bunded, irrigated lands	Availability of irrigation			X			X	X	Irrigation area	Long-term	Moderate to major	Much water land preparation is required
Farming Systems		Multiple cropping	Dependable water supply		X			X	X	Irrigation area	Long-term	Very positive	A main purpose of the project
	Less grazing land	Multiple cropping		X	X				X	Livestock in irrigation area	Long-term	Moderate to major	Area lost partially made up for by improved fodder quality on irrigation area waste ground
	Loss of farm land	Construction of system	Increased population		X			X	X	Irrigation area	Long-term	Minor	Unavoidable. Small percentage of total area
BIOLOGICAL RESOURCES													
Terrestrial Habitat	Convert natural farm, agric. use Partial to reservoir and dam	The Project		X	X			X	X	Area farmlands	Long-term	Minor	Unavoidable. Small percentage of total area
	Increased pest population	Multiple cropping			X				X	Irrigation area	Long-term	Moderate	General measures needed
	Enhance schistosomiasis	Farm communities			X	X		X	X	Irrigation area, riverbed, canals	Medium-term	Minor to severe	Construction period control measures needed
Aquatic Habitat	Proliferation of aquatic weeds in canals	Increased nutrients	Inadequate maintenance		X				X	Irrigation area	Long-term	Minor to severe	Depends on maintenance
	Increased numbers of mosquitoes	Increased breeding area with irrigation			X				X	Resident Population	Long-term	Minor to moderate	Malaria and dengue fever may increase
SOCIOECONOMIC RESOURCES													
Settlements Patterns and Movements	Increased population and immigration	Economic opportunity		X	X	X		X	X	Entire village	Long-term	Major	Area will require more labor to convert land and maximize potential benefits
Community Stability	Disruptions of social patterns	Influx of temporary construction workers			X			X		Resident population	Short-term	Moderate to serious	Mitigation requires contractor cooperation, local involvement
Regional Economics and Development	Improvement and diversification of economy	The Project	Subsequent planned/spontaneous development	X	X	X		X	X	Resident population and migrants	Long-term	Major	A multi-sectoral, long-term development plan is needed
Land Ownership and Tax Collection	More leasing and sharecropping, demand for cadastral survey and modern land registration, increased land taxes	Intensification of farming	Improved value of land		X			X	X	Beneficiary farmers	Long-term	Major	Unavoidable
Services and Infrastructure	Increased demand for svcs. and infrastructure	Improved economy	Increased population		X			X	X	Resident population	Long-term	Moderate	Unavoidable
Public health	Increased disease vectors	More measurement with irrigation	Lack of vector prevention		X	X			X	Resident population	Long-term	Minor to moderate	Control required
Farm Support Organizations	Increased demand for farmer organizations	Need to operate system			X			X	X	Beneficiary farmers	Long-term	Intensive	Very positive impact

PART II

GAPET DAM PROJECT

ENVIRONMENTAL MANAGEMENT PLAN

The objective of an environmental study is to develop the information necessary for assessing project effects and then to develop a plan to minimize the adverse effects and enhance benefits. Environmental impacts can be considered as falling in two general categories:

1. **Unavoidable Adverse Impacts.** These are effects, such as the loss of habitat to reservoir inundation, that are inevitable with project implementation and do not lend themselves to remedial actions without compromising the project.

2. **Manageable Effects.** These are direct or indirect effects, adverse or beneficial, that lend themselves to some sort of actions to improve the situation. Such actions may lessen the severity of adverse impacts or enhance secondary benefits of the project. Sometimes, a potentially adverse situation can be turned into a project benefit through careful planning, intersectoral coordination, and wise use of financial or other resources.

Types of Actions

The approach to managing an environmental effect varies with the type and degree of effect, its time and place of occurrence, and the stage of project development at which it is recognized. Ideally, the process of environmental impact assessment is a continuous one that permits mid-course corrections in project planning. More often, an environmental assessment is a one time affair, conducted during a pre-feasibility or feasibility study, at a time in project development when only superficial changes in project design are possible. In this project, however, sufficient latitude exists to permit planners to address all of the major environmental concerns.

Mitigation actions may be divided into those directed at changing some aspect of the project, such as design, construction method, or operation, and those directed at changing the environment so as to avoid or lessen a project effect or to increase a benefit. Within these two groups of actions, a further distinction may be made between those that must be imple-

mented during project construction, in order to be effective, and those that take place during project operation.

Impacts to be Managed

The most serious potential environmental problem associated with this project involve conflicting demands on the limited water resource, especially during the dry season. This problem is not new to area residents; under present conditions they find it difficult to find good quality water for domestic purposes and there are inadequate supplies for irrigation.

Proposed Management Plan

Responsibility. As soon as the construction is completed, the management and monitoring plans will be the responsibility of PRIS and BAPPEDA in each district (BAPPEDA, Tk. II). It will be supervised by the Environmental Department of the Ministry of Public Works under Indonesia's Environmental (AMDAL) law. Oversight is provided by the Ministry of Population and Environment. It is recommended that other government agencies be involved in the Management Plan of the project. These agencies include the Extension Services of the Departments of Food Crops and of Livestock, the Departments of Forestry and Health, the National Board of Lands (Badan Pertanahan Nasional, formerly Agraria), the Agrarian Taxation Office (IPEDA/PBB), that part of Public Works responsible for village water supply (Cipta Karya), and regional government (PEMDA) at and below the district level, including the Bupati, Camat, and their delegated staffs.

The Department of Public Works and BAPPEDA should develop a detailed Plan of Action, working together with the sectoral agencies. This would include detailed timing within the annual budget cycle, and detailed budgets from regional (APBD), national (APBN), and to a limited extent, foreign donor assisted funding sources.

Pre-construction Phase

The project should acquire the necessary land before construction commences. There should be no resettlement and little compensation since there are almost no houses located along canal routes, and none at the dam site or within the reservoir area. Land owners owning land at the dam site, reservoir area, borrow areas, along canal routes, office sites, etc., should be fairly compensated.

District government should make guidelines against outside land speculation by limiting land sales to those who will actually live and farm in the area.

Construction Phase

Adverse environmental impacts during construction should be temporary. Increased noise, traffic and dust are unavoidable, although in the case of dust, its effect can be lessened by watering the roads when necessary. Because there will be significant amounts of earth moved, there is always the risk of erosion and consequent sedimentation of the river bed, irrigation canals, and even the service area. The contractor should continuously monitor the situation and take whatever steps necessary to downstream sedimentation.

The contractor should be prepared to supply his laborers with all those necessities that are not readily available from the local villages. In any case, firewood must not be taken from outside those areas that need to be cleared for construction. The contractor must keep the labor camp in a sanitary condition, otherwise pests, disease and hazardous wastes could result. Efforts should be made to minimize the potentially disruptive effect of the presence of up to 850 (mostly) outside, male laborers in the villager over a period of 30 or more months.

Post-Construction Report. A report should be prepared after completion of Project construction. The report should be a detailed description of the future monitoring and mitigation measures required, estimated costs, the status of what has already been implemented and a designation of the responsible agencies for each task. The report, written in the Indonesian language, should be distributed to the implementing agencies with enough lead time to enable them to submit their annual budgets. The plan should be reviewed after a year or two of operating experience, and revised as necessary.

Water Resources

Downstream Water Use: Domestic Water. This project offers the opportunity to substantially improve domestic water quality and availability in the service area without removing a significant amount of water from the irrigation supply. The effect of diversion of the Gapet River on the domestic water supplies in Gapet and Nyerinying hamlets is not currently predictable with any certainty. It is known that well supplies are now just minimally adequate during the dry season. Diversion of the Gapet River for most of the year will probably only make the situation more acute. It is therefore recommended that some sort of mitigative measure be taken to supply a reliable domestic water source to these two hamlets.

The other two hamlets in the service area, Boal Atas and Boal Bawah, also have tight water supplies during the dry season. So does the fifth hamlet of Boal Village (Lamenta), lo-

cated along the eastern edge of the service area. The project, however, will not affect the flow of the Boal Loka or Lamenta Rivers, and therefore no mitigative water supply measures are currently proposed for these hamlets. If water quality monitoring shows that irrigation return flows are polluting the water supply in the area of these other hamlets, then this position will have to be reconsidered. In light of the importance that the Indonesian government places on domestic water supply, and in the interests of equity, it may be desirable to consider supplying Boal Atas, Boal Bawah, and Lamenta hamlets with a piped water supply as an extension of the Gapet Irrigation Project.

The highest quality and best year-round supply of domestic water could be provided by piped water directly from the reservoir to the hamlets of Gapet and Nyerinying. This would be the most reliable from the viewpoint of improved domestic water supplies for the local people. In a 1988 report, Mettana noted that upgrading domestic water supplies is a priority objective of the Indonesian government. Considering the relatively small amount of money required for a piped system (about Rp 90 million), this proposal has the advantage of conferring a significant benefit on the project.

Assuming a tripling of the current population of the two hamlets to a total of 3,300 persons over the life of the system, and an average water requirement of 25 l/c/d (any additional needs such as bathing and washing can be supplied by wells, canals or rivers), the annual domestic demand can be estimated to be 30,110 m^3 (or 0.03 MCM), which is about 0.1 percent of the operating volume of the reservoir. The actual demand on the reservoir would be somewhat less than this because water is also available from local wells. Dedication of this amount of water to domestic use would not affect the operation of the irrigation system.

An alternative and less desirable means to provide domestic water supplies to Gapet and Nyerinying hamlets would be to provide pipes from the secondary (or even tertiary, as the system is now designed) irrigation canal system. Simple steps could be constructed, as well, at the closest access points for the hamlets to the secondary canals, similar to the way that Boal Atas and Boal Bawah are currently served by the canal from the Boal Weir, and Lamenta hamlet from the Lamenta Weir. As the system is currently designed, however, relying only on water from the canals has the disadvantages of possibly not providing water in the dry season in dry years, and of not being particularly convenient since the secondary canals are located some distance from the hamlets.

In order to accomplish construction of the domestic water system for the hamlets of Gapet and Nyerinying, three problems must be addressed: (1) overcoming bureaucratic inertia that resists the multiple-use approach to water development; (2)

funding the design and installation of the water distribution system; and 3) reaching consensus and understanding of the limits to what might be done, among the villagers who will benefit from the project. None of these problems is purely environmental in nature and they require management initiative by those responsible for moving the project forward.

Mettana has included provision for domestic water releases from the reservoir in their preliminary design of the Gapet Project outlet works. Further work at this stage would include a preliminary design and cost estimate for a PVC pipeline system from the dam to water tanks in Gapet and Nyerinying. It remains now for PU NTB to coordinate with Cipta Karya, the Department of Health and local government to review any possible design and arrange for its timely construction. The following points should receive consideration:

1. The system should be sized for peak, rather than average, demand. The domestic water for a day's use is drawn at two times during the day, creating two sharp peaks in demand. If holding tanks (bak) are provided, then water can be provided over the course of a whole day, thus decreasing the size of pipe needed.

2. The locations of village water points should be carefully selected so that a maximum number of people, especially those in the at-risk population, can obtain water without excessive walking. Selection of these sites must be done in consultation with the water users, after public meetings in the targeted hamlets where men, women and children hear about the project from Public Works and LP3ES staff.

3. The design of village water points themselves must be carefully considered. To avoid waste, self-closing outlets are strongly recommended, but it must be one that can be operated by children, since they do much of the water fetching in rural areas. The platform surrounding the outlet must be well drained, to avoid standing water that would provide mosquito breeding sites. It is strongly recommended that some of the construction work be done by the end users to ensure their active participation and understanding of how the water system is to operate and be maintained. CARE has experience in this regard, and is involved in the provision of other piped village water supply systems in Sumbawa. It may be useful to have them involved in the Gapet Project.

4. An educational program should be provided to adults and children alike, stressing the need for water conservation and sanitation. Although the water in the reservoir will be of good quality, villagers

should be urged to continue boiling their drinking water, since the conditions of carrying it are often not sanitary. Periodic water quality testing will be included in the environmental monitoring program.

5. Bathing and laundry steps leading down the banks into the canals, and footbridges over the canals will also help prevent canal bank destruction as well as provide access to freshwater.

Other water supply possibilities include a well drilling program by Public Works, or water trucked from the reservoir in times of need. While both of these options are probably less expensive initially, they are also less reliable in terms of implementation, and supply.

In addition to the need for a piped domestic water supply, there may be some years when it is necessary to provide some minimum flow in the river downstream of the dam, probably for reasons of hygiene. The question of providing a minimum flow may be put to the district (kabupaten) irrigation committee. These discussions should take place over the next two years as an integral part of the preparation of project operation and maintenance procedures. The USAID/Jakarta environmental officer would take an active role in the discussions. Once the project moves into the operation phase, the irrigation committee, assisted by the local water user's association representatives, will evaluate and monitor the adequacy of the minimum river flow.

Livestock Watering. Water for livestock bathing and drinking is a critical necessity in rural Indonesia, and the shortage of water in the dry season causes considerable difficulty for the owners of buffalo and cattle in the Gapet area. The drying of the river bed in the dry season makes the situation difficult for those who depend on river pools for livestock watering; those farmers must be expected to turn to the abundant water in the project canals. In the interests of protecting the canal banks from damage by livestock, a three-pronged program is needed:

1. A vigorous program of education of adults and youth in the farm population to instill respect for the canal system and the realization that damaging the canals is contrary to the interests of farmers and the community. This must be backed up by enforcement, through the water users' associations, with penalties (perhaps in the form of labor or small fines) for violators.

2. Alternative stock bathing places should be provided in the form of basins receiving a small flow of water from the canal. The pools, built to established PU

specifications, must be adequate in number, location, and volume to meet the demand for livestock watering.

3. Some watering troughs should be built, primarily for the benefit of horses, goats and sheep, who would not normally wallow together with water buffalo.

Water Quality. No mitigation program appears needed to maintain water quality at or above present levels, but periodic sampling should be performed (see Monitoring Plan, Part 4) to ensure that degradation to unacceptable levels does not occur.

For those occasions when a portion of the river does go dry, the Monitoring Program may show that it is necessary to release an occasional flow of water from the dam to flush accumulations of drainage water when it is heavily contaminated with fertilizers, pesticides or animal waste products. The agricultural extension unit and the water users' associations should collaborate on a program of farmer training in the proper handling and use of pesticides.

Land Resources

Land Acquisition. About 160 ha of land will be acquired for the reservoir and maybe another 12 ha for primary and secondary supply canals. While the overall benefits to the service area will more than outweigh the loss, the farmers individually affected should be given fair compensation for their land. This will avoid construction delays and generate a positive attitude towards the project.

Reservoir Vegetation Clearing. Concern often is shown for the potential water quality effects of vegetation inundated by a reservoir, especially as the released nutrients might promote the excessive growth of aquatic plants. As noted in the previous chapter, the nutrient problem probably will not occur in the Gapet reservoir. The inundation area is largely open fields, with the only significant trees being in a narrow fringe along the riverbank, so there is not a large volume of plant material.

From the viewpoint of forest resources, however, a good argument can be made for partial clearing. The firewood contained in the area alone might justify some clearing. This could best be determined by the simple expedient of Public Works putting the clearing out for bids. Alternatively, the local population could be allowed to gather domestic firewood while the dam was being constructed. Some restrictions would have to be imposed on the contractor and the general public, however, and strictly enforced:

1. No cutting would be permitted above the high water contour.

2. No roads would be permitted above the high water contour, nor in adjacent valleys. Such roads would encourage later incursions into the watershed.

3. All cut vegetation not removed from the reservoir area must be piled and burned. Failure to do so would result in an accumulation of plant matter at the outlet works entrance.

At a minimum, the larger trees and shrubs along the river should be cut, to improve the aesthetic appearance of the reservoir when drawn down, and to avoid obstructions for possible fishing and recreation activities, if they should develop.

Farming Systems. Improvements in irrigation of the Gapet service area will lead to increased demand for agricultural extension services. The Department of Agriculture (Food Crops) will work together with Public Works, PEMDA, LP3ES and local farmers to shift to cropping patterns that maximize returns with the secure agricultural water supply. The Department of Agriculture should incorporate the need for increased agricultural extension services into its five-year plan (PELITA V). This whole process is likely to require several decades. During this time, it is likely there will also be increased demand for agricultural cooperatives and extension of credit for technical inputs.

Agricultural Chemicals. Although the use of pesticides and chemicals is not projected to significantly harm the general environment, even with increased usage, it would be wise to regularly test for them as part of the recommended water quality monitoring program (see Monitoring Plan). Some of the chemicals can have acute or persistent health effects on the farmers using them. The Department of Agriculture should regulate what chemicals are used and provide training in safe handling and disposal practices.

Livestock Management. The problem of shortage of fodder produced by more intensive cropping was raised at the 1986 scoping sessions for other irrigation projects in Sumbawa. Estimates by the Department of Livestock indicate that there is sufficient plant biomass to sustain the existing livestock. The economics of irrigated pasture should be examined, although at a glance it seems unlikely to compete with crop production. The Department of Livestock should establish an optimum herd size for water buffalo, horses, goats, and Bali cattle, and study ways of obtaining a reduction, if it is justified.

Grazing fees could be implemented and enforced, in order to convince farmers that the keeping of livestock is not without costs, even if that cost is measured in terms of resource consumption. Such fees, which would appear not to have been previously instituted in the region, should be low.

Care must be taken to avoid excessive erosion in the catchment area above the dam in livestock grazing areas. Controlling erosion on pasture land is largely a matter of avoiding overgrazing. Here again, a modest grazing fee would help regulate grazing intensity.

All of these concerns and issues in relation to livestock should be incorporated into an integrated livestock management plan for the area. Definition of such a plan should be carried out with extensive involvement of the local community. Responsibility for plan definition should rest with the departments of Agriculture (Food Crops) and Livestock, through their extension services, and assisted by Public Works and the non-governmental organization LP3ES. Mechanisms for community education and community enforcement of policies should be built into any such integrated livestock management plan.

Biological Resources

Catchment Management. Management of upstream catchment areas should always be a concern in the operation of irrigation systems. Extensive changes in upstream land use can potentially result in increased erosion, siltation of the reservoir and reduced project benefits.

The highest point in the Gapet watershed is slightly more than 800 m, and the catchment contains about 4100 ha. It has almost no potential from the perspective of commercial logging and only a rather limited potential if the area were harvested locally. The Bupati of Sumbawa has recognized the need for forest preservation throughout the district and has prohibited any further forest harvesting of large trees. This has not been a locally popular ruling and there is some pressure on the Bupati to change his ruling.

The catchment is not currently under serious pressure for conversion to agricultural use, except for some pressure to convert land to large pastures. Access is limited to foot traffic beyond the reservoir, and there do not appear to be any significant numbers of shifting agriculturalists present.

Under these conditions, watershed management can be restricted to occasional visual monitoring of the situation, and photographing the area for the record, to ensure that activities in the watershed do not change for the worse.

Pest Management. The longer growing season and higher cropping densities resulting from this irrigation project will encourage increases in pest populations unless adequate control measures are instituted. The Department of Agriculture should work closely with the farmers to improve pest management procedures.

A program of integrated pest management has been successfully implemented elsewhere to control insect populations. Use of biological control and biocides together is the best means of avoiding developed resistance in pest populations. Crop rotation and the use of resistant plant hybrids are also effective measures.

Rats are natural inhabitants of paddy fields and villages. Their numbers can be held in check by a persistent poisoning and trapping program, as well as better storage of grain. Land management, and coordinated planting regimes restricting the types of food available to the rats at any one time, is also effective.

Aquatic plants that grow in canals and drainage ditches can be controlled in various ways. Weeds can be physically removed, and in some cases, weeds such as Hydrilla verticilata and water hyacinth (Eichornia crassipes), can be used as feed for cattle, pigs, ducks, and chickens. Water weeds have also been used as a mulch, and to make paper products. Some species of fish, for instance, grass carp (Tenopharyngodom idella), feed on certain aquatic weeds, and therefore might be raised in the canals. The proper use of herbicides can also help control weed proliferation.

Mosquitoes will breed in the canals and drainage ditches if there is stagnant water. If the canals are kept free of weeds and debris then the flow of the water will make it difficult for mosquitoes to reproduce. Insecticides used judiciously for serious outbreak can also be helpful. In some locations mosquito fish (Aplocheilus panchax) can be introduced into the canals as a control measure.

Aquaculture Development. The question of fresh water provision for coastal aquaculture operations frequently arises when irrigation systems are being planned in coastal areas such as Gapet. Fresh water is needed, particularly in the mid- and late dry season, to maintain pond salinity within an acceptable range. This demand conflicts with irrigation supply for food crops over this period, when the stored Gapet water is being fully utilized for irrigation. A more thorough study might be carried out by the Department of Fisheries, but the actual water allocation to agriculture or aquaculture, assuming the water resource to be finite and the storage capacity of the Gapet reservoir to have been optimized, will require difficult social, economic and development priority decisions.

An additional issue relates to contamination of irrigation return flows by pesticides and fertilizers, and the subsequent impact of use of this water for fish pond supply. The levels of pesticide residues will be very low, due to the rapid degradation of those types in common use, and therefore not an issue. Nutrient levels in the water will be enhanced, but the practical effect of this for fish culture is not clear,

since this water is mixed with ambient coastal water of higher salinity before entering the ponds. Given current conditions of little fish pond activity in the project area, no mitigation is seen as necessary at this time.

Socioeconomic Resources

Water Users' Organizations. Conversion of the service area to operation under one irrigation system will require a higher level of organization than currently exists among local water users' associations. Local farmers will also have to work more closely with local government to operate and maintain the system. The Department of Public Works has contracted the non-governmental organization (LP3ES) to assist in this process.

Land Classification and Land Ownership. With the advent of agricultural intensification upon completion of irrigation construction, it is expected that the irrigated service area land will be reclassified to a higher value. Land values will probably increase even before the irrigation system is completed. It is expected that some farmers will seek to acquire certificate title to their land. The government should organize a special cadastral survey so that the whole service area will be converted to the modern land title system in a systematic and equitable manner.

Since the area currently has a small population and farmers typically own 2 to 3 ha in the service area, it is likely some farmers will be unable to effectively manage these relatively large area and they may sell some land to outsiders. District government should take steps to assure against land speculation and that farmers receive fair compensation.

Land Taxes and Water Users' Fees. The government should expect to receive an increase from land taxes once the value of the irrigated area has been increased. If water users' fees are eventually initiated, the government can expect to receive an increase in operation and maintenance funds from this source.

Public Health. As noted above in the section on Pest Management of Biological Resources, changes in surface water distribution and the attendant possibility of increases in mosquitoes will require a program of malaria and dengue fever prevention on the part of health authorities, if increases in the incidence of the diseases are to be avoided. Any such program should be tied in with a program of public education and local mosquito control. When informed about malaria and dengue fever and given the impetus for action, most rural people respond positively. The additional cash flow in the service area should enhance the ability of people to purchase the inexpensive chemicals needed for mosquito control.

In addition to increased risk of mosquito-borne diseases, the risk of an increase in other water-related diseases will depend on how the population uses water from the canal system. The Department of Health, through its regular PUSKESMAS clinics and its various infant-child health programs should educate mothers, in particular, about the importance of boiling water, basic personal sanitation, and inoculating children against preventable water-borne diseases.

Services and Infrastructure. Improved living standards, more economic opportunity and a larger population will all increase demand for services and infrastructure (schools, health clinics, roads, transport and markets). Some medium- and long-term planning activities are needed if services and infrastructure are to keep pace with irrigation components of the project.

BAPPEDA, Tk II should work together with the Departments of Education, Health and District Public Works to develop local medium- and long-term plans. The Bupati of Sumbawa District and area government (PEMDA) would play an important role in ascertaining the need for and timing of any increases in services and infrastructure, and coordinating various development plans in the Gapet area.

Management Plan Components: Timing and Costs

Public Works will construct the "water resources" mitigating factors, provide any possible clearing of vegetation from the reservoir site, and develop water users' associations. Other government agencies, as mentioned above, will be principally responsible for their own extension programs and ongoing activities. In most cases, the commencement of programs and extension services by other sectoral agencies (see Figure MA-1) should occur by the time the irrigation system construction is completed, which is expected to take about 18 months. By this time, there should be a livestock management plan, a catchment area management plan, and a public health plan in place.

It is expected that any increases in services and infrastructure (e.g., schools, non-project roads, health clinics) will be gradual, and probably occur after 1992. It is expected that changes in land classification, land values, land ownership, land taxes and possibly an initiation of water users' fees will occur after farmers have had several harvests to adapt to intensification. Some land will undoubtedly be sold to "outsiders", but district government should take steps to see this process is not abused.

The organizing of water users' associations and irrigation committees will probably commence in 1991 when the non-governmental organization, LP3ES, begins working with PU staff, local government, and the existing water users' associations.

Table MA-1 summarizes the estimated costs of the mitigating activities. Those costs borne by the Department of Public Works have been factored into the costs of construction of the project. In the cases of costs for other government agencies, most of the recommended mitigating activities should incur no special costs and should come under regular operating costs. The exceptions to this are: 1) catchment management, where it is anticipated that Rp 1 to 2 million be spent every monitoring (see Part 4--Monitoring Plan); and, 2) water quality monitoring twice a year which will initially cost about Rp 15,000,000 annually (see Part 4--Monitoring Plan). Also, if the National Board of Lands decides to commence a cadastral survey and land titling program, there will be special costs, only part of which will be borne by the farmers themselves.

Table MA-1

MANAGEMENT PLAN COMPONENTS
AND ESTIMATED COSTS

Item	Participating Entities	Estimated Cost (Rp)
General Coordination of Sectoral Agencies	BAPPEDA, Tk II, and district government	No Special Cost
Water Resources:		
Domestic Water Supply: provide piped water to Gapit and Nyerinying Hamlets	Public Works, NTB Province	90,000,000 (1)
Bathing and Laundry Steps in Canals (Rp 200,000/unit x 12)	Public Works, NTB Province	2,400,000 (2)
Foot Bridges over Canals (Rp 1,400,000/unit x 8)	Public Works, NTB Province	11,200,000 (2)
Livestock Watering Troughs (Rp 200,000/unit x 8)	Public Works, NTB Province	1,600,000 (2)
Livestock Washing Sites in Canals (Rp 2,000,000/unit x 8)	Public Works, NTB Province; Extension Services of Food Crops and Livestock	16,000,000 (2)
Land Resources:		
Reservoir Vegetation Clearing	Public Works, NTB Province, Sub-contractor and Local Population	No Cost (3)
Farming Systems	Department of Agriculture (Food Crops), with PU assisting	Regular Operating Costs (4)
Land Use: Livestock Management for Establishing pastures/ fodder sources, and number of cattle	Departments of Livestock and Forestry, assisted by PU and LP3ES	No Special Cost (5)

Table MA-1 (cont.)

Item	Participating Entities	Estimated Cost (Rp)
Biological Resources:		
Pest Management/ Preventative Training:		
Agricultural	PU, NTB Provinces, and Department of Agriculture/Extension Services	Regular Operating Costs (6)
Mosquitoes	Department of Health	Regular Operating Costs (7)
Socioeconomic and Cultural Resources:		
Services and Infrastructure	BAPPEDA Tk II, and district government	No Immediate Costs (8)
Land Classification, Land Values, Land Ownership/Sales, and Sharecropping/Rentals	National Board of Lands (Badan Pertahanan Nasional) and Agrarian Taxation Office (IPEDA/PBB), with district government	Special Costs (9)
Land Taxes and Water Users' Fees	Agrarian Taxation Office, National Board of Lands, district government, and Public Works	No Special Costs (10)
Organizing Water Users' Associations	Public Works, NTB Province, Agricultural Extension Services, and assisted by LP3ES	No Special Costs (11)
Public Health	Department of Health	Regular Operating Costs (12)

Notes to Table MA-1:

(1) Public Works plans to install pipes down to the main hamlets of Gapet and Nyerinying, and build two village reservoirs for domestic water supplies. Estimated costs are preliminary pending final design of the irrigation system. Cost will be included in the irrigation system contract.

(2) Estimated costs are preliminary pending final design of the irrigation system. Cost will be included in the irrigation system contract.

(3) Any sub-contractor given permission to clear larger trees and shrubs from the reservoir area would keep monies earned from selling the cut wood. There would be no costs to PU NTB.

(4) Development of new irrigation is usually accompanied by an intensification of agricultural extension services. It is expected that increased staffing by the Department of Agriculture will occur. Funding should be included in the annual budget (DIP) of the Department of Agriculture, and amount should be confirmed by BAPPEDA.

(5) Establishing a land use and grazing policy would be part of the community development activities that would occur while the water user's associations are being organized. Inputs from the Departments of Livestock and Forestry would consist of their field staff attending village meetings.

(6) Unless there is a specific outbreak of an agricultural pest, the Agricultural Extension Services would conduct its normal Training and Visit system, educating farmers in the use of pesticides. If a special problem arose, the Department of Agriculture would have to allocate special funds to meet the problem.

(7) Training in the control of mosquitoes for malaria and dengue fever control is a regular part of the Department of Health's public education program. The Department of Health should monitor the situation and make appropriate changes, if necessary, in its public health training. Any particular worsening of the situation in the area may require the initiation of mosquito spraying control measures. Adequacy of funding in annual Health Department Budget (DIP), to be confirmed by BAPPEDA, Tk. II.

(8) Regional government would be expected to increase the numbers of schools, health clinics and other services as the population increases. No immediate or special costs are envisaged. BAPPEDA, Tk. II, and district government, to determine scheduling and funding.

(9) District government to take steps to prevent land speculation and that fair compensation be paid to any land owners choosing to sell land to "outsiders". A cadastral survey of the land and the necessary administrative costs of providing certificated title to land would partially be borne by the farmers and partially by the respective agencies involved in this task.

(10) Increased revenues from land tax collection would result, but the system for collecting land taxes is already in place. Collection of water users' fees would presumably be shared by the water users' associations and existing tax collecting systems.

(11) Costs for the LP3ES contract with Public Works is covered by GOI/USAID SSIMP project costs.

(12) The Department of Health should monitor developments in this area and adjust their programs and services accordingly.

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PART III

GAPET DAM PROJECT

ENVIRONMENTAL MONITORING PLAN

General Considerations

Environmental monitoring is one of the most difficult components of project development to accomplish. Although continued data gathering is a logical follow-on to the environmental program during planning, design, and construction, and may be mandated by law (as it is Indonesia), operating agencies seldom are receptive to the idea of further studies. The reasons for this reluctance are not difficult to identify:

1. Whereas project design and construction often is funded from exterior sources, the local government bears the burden of operating costs. The local agency rarely is able or willing to allocate funds to what its managers see as an unproductive program.

2. The operating agency usually has its expertise concentrated in the area of its primary responsibility (e.g., agriculture) and lacks expertise in some of the areas required for environmental monitoring.

3. Administrators tend to dislike "open-ended" programs that do not relate directly to the primary mission of their agency.

4. Environmental monitoring programs tend to impinge on the spheres of responsibility of several agencies (e.g., forestry, fisheries, public health), and so tend to inflame inter-agency jurisdictional disputes.

Some of the above factors may be absent in NTB Province and Sumbawa District, but one must anticipate that some parts of the proposed monitoring program will encounter resistance on the part of responsible agencies. The program proposed is a minimal one, however, one that will provide data useful for integrated resource management in the project area.

Proposed Monitoring Plan

Water Quality

Program Objective. The monitoring of water quality will determine the suitability of water in the Gapet system for the various uses to which it is directed. This will be especially important for avoiding adverse health effects that might arise from the domestic use of canal water.

Location. Sample sites that should be considered for this program include:

1. At the intake of the domestic water pipe at the dam.
2. At the piped water supply sources in Gapet and Nyerinying hamlet.
3. In the Boal Weir pool.
4. In the irrigation supply canals where human use is particularly heavy in Gapet, Nyerinying and Boal Atas hamlets.
5. In the rivers where human use is particularly heavy for the Dadap, Gapet, Nyerinying, and Boal Loka Rivers.
6. In the outflow of the Gapet river into Saleh Bay.
7. In at least one well in each of the four hamlets.

If unacceptable water quality is encountered at one of the sampled sites then additional sampling may be necessary to isolate the source of pollution.

Methods and Equipment. A competent water quality laboratory will be needed for analyses. Field meters should be used to measure electrical conductivity, pH, and dissolved oxygen. A hand thermometer will suffice for temperature readings. It would be advisable to establish a staff gauge at each site, in order to obtain flow measurements.

Standardized data sheets must be used for recording all field data, including conditions at each site, flow, and personnel, as well as the analytical data for the sample. Parameters to be analyzed should include total suspended solids, sulfate, nitrate nitrogen, ammonia, phosphate phosphorus, salinity (expressed as chloride ion), alkalinity (expressed as calcium carbonate), and fecal coliform bacteria.

Although pesticides are not forseen as a problem, some testing is recommended due to the significant increase in usage that is anticipated as a result of the project. It may be

necessary to send samples to Java (Biotrop Labs, Bogor) if the analysis cannot be done locally.

An attempt should always be made by PU to determine flow at each site, even if it is only a general estimate. If a staff gauge is present at the site, its reading should be recorded at the time of sampling.

Schedule. Simple water quality tests should be taken during the wet season and the dry season of every year. The sampling should be coordinated with other environmental monitoring (e.g., land use), in order to establish linkages in the system.

Implementing Agency. It is recommended that the Department of Public Works assume primary responsibility for water quality sampling although it may wish to contract out the required testing of water samples.

Land Use

Program Objective. There are two principal reasons for monitoring land use changes. The first, is to detect changes that are caused by the project, especially those that might affect project operation, such as through increased erosion, water quality of runoff, or farming practices. The second, is to detect changes in the condition of the upper catchment area that may affect operation of the irrigation system.

Location. Land use should be monitored periodically throughout the Gapet River catchment, including all tributaries.

Methods and Equipment. At a minimum, four test quadrangles of about 25 ha should be established and visited periodically on foot. No special equipment, other than hand-held cameras will be needed for the field reconnaissance. The field team should note signs of land clearing, new trails or roads, and erosion. The report that is to be prepared should include an overview of change in present conditions compared to past conditions, drawing upon the previous reports and photographs.

Schedule. This survey of land use changes should be conducted annually, with field checking of sample areas more frequently if possible. Reports should be submitted to all interested agencies, including BAPPEDA, Tk II, the Bupati's office, and Forestry and Agriculture.

Personnel. A trained watershed management specialist will be required for this program. It is difficult to retain the same individual for many years on a program requiring only a few weeks of work every three years, but as interest in land use increases in the Forestry and Agriculture Departments, trained specialists may become more readily available.

Implementing Agency. It is recommended that the Planning Section (P3SA, NTB) of Public Works in NTB Province be principally responsible for overall coordination of watershed protection, but that it work closely with the Department of Forestry, and local government (PEMDA).

Biological Resources

Objectives. Monitoring of biological resources will be performed on an as-needed basis, i.e., when a problem of an ecological nature, such as an outbreak of insect, rodent, or bird pests occurs or there is reason to believe that project activities are affecting biological resources. The objective of such a study program would be to evaluate the problem, identify causes, and develop solutions.

Location. Biological resources in any part of the catchment could interact with the irrigation project, but those of the upper catchment are of greater interest from a conservation viewpoint. Pest problems may be expected anywhere in the agricultural production system, from planting to storage and marketing.

Methods and Equipment. Each sort of ecological monitoring problem will require its own methods and equipment. When a problem arises that requires surveillance, the program must be tailored to that problem.

Schedule. Care should be taken that monitoring of a biological resource is not terminated too soon to evaluate the effectiveness of solutions applied to the particular problem.

Personnel. Some ecological problems that may arise will require highly specialized knowledge. Assistance for such problems should be sought elsewhere in Indonesia, or outside the country if no expertise can be found in Indonesia.

Implementing Agencies. It is recommended that the Department of Agriculture and the Department of Health share primary responsibility for monitoring the biological resources as needed. The Department of Forestry is the logical agency to monitor the condition of an endangered species found in the area. BAPPEDA, Tk II should be given copies of all reports and kept appraised of current conditions.

Socioeconomic Resources

Integration of Local and Regional Planning. Any program of environmental monitoring of sociocultural conditions would serve only to supplement the analysis of project effectiveness which will accompany this development on a long-term basis. It is assumed that the Agriculture Department, the subdistrict, and local bodies will monitor agricultural production and support systems so as to ensure project effectiveness and correct

any shortcomings that may arise. The project staff also should be aware of peripheral problems arising from water use, land use changes, or economic changes. The effects of upgrading the agricultural system will be so profound, in terms of income and lifestyle of the target population, that adjustments may have to be made in other sectors of the local economy. The subdistrict and the provincial government must be alert to increased demand for health services, education, and transportation system changes, and the need for electricity at the local level, in order to integrate the irrigation project into regional development. Presumably, BAPPEDA will act as the lead agency in this regard.

No special studies are envisioned to monitor the socio-economic conditions, beyond those already in place among local agencies, but it is hoped that the accumulated data will be examined periodically to evaluate cause-effect relationships among the complex network of social and economic elements. The Department of Statistics in the District can be expected to provide both BAPPEDA, Tk II, and the sectoral agencies with relevant data, although the sectoral agencies can be expected to collect some of the necessary information through their regular monitoring mechanisms.

Table MO-1

MONITORING PLAN COMPONENTS
AND ESTIMATED COSTS

Item	Participating Entities	Estimated Cost (Rp)
Ceneral Coordination of Monitoring Responsibilities	Public Works, NTB Province, and BAPPEDA, Tk II	No Special Cost
Water Resources:		
Water Quality Tests (Rp 6,000,000 x 2/yr)	Public Works, NTB Province, with Department of Public Health, Testing Laboratory (POM-Penyli-dikan Obat dan Makanan), Mataram	12,000,000 (1)
Land Resources:		
Land Use Monitoring	Public Works, NTB Province, Planning Section (P3SA-Proyek Perencanaan Pengembangan Sumber-Sumber Air), and the Bupati, Camat, BAPPEDA Tk II, and Departments of Agriculture and Forestry	3,000,000 Every Year (2)
Biological Resources:		
Monitoring Pests, Diseases, and Other "Ecological" Problems	Departments of Agriculture and Health, NTB Province	No Immediate or Special Costs (3)
Socioeconomic Resources:		
Medium- and Long-Term Local and Regional Planning	BAPPEDA, Tk. II, assisted by Dept. of Statistics and planning sections of Sectoral Agencies	No Special Costs

Notes:

(1) Based on quotations by Mataram University's Analytical Lab (sampling and analytical analysis), and Bogor University's Biotrop Laboratory (pesticide analysis) for 13 parameters at each of 10 locations.

(2) Rp 3 M should be adequate for one month salary of a watershed management specialist to visit the upper catchment area, monitor test quadrangles, take photographs, prepare a map of findings, and prepare a report, along with photocopies of the report.

(3) The Departments of Agriculture and Health should monitor developments in these areas and adjust their programs and services accordingly.