BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR THE PARO VALLEY AGRICULTURAL DEVELOPMENT
IN
THE KINGDOM OF BHUTAN
(PHASE 1)

JUNE 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR THE PARO VALLEY AGRICULTURAL DEVELOPMENT
IN
THE KINGDOM OF BHUTAN
(PHASE 1)

JUNE 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to a request from the Government of the Kingdom of Bhutan, the Government of Japan has decided to conduct a Basic Design Study on the Project for the Paro Valley Agricultural Development and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent to Bhutan a survey team headed by Mr. Yasuhiko Yamamoto, Director, Planning Department, Hokuriku Agricultural Administration Office, Ministry of Agriculture, Forestry and Fisheries from March 29th to April 26th, 1989.

The team held discussions on the Project with the concerned officials of the Government of Bhutan and conducted a field survey in the Paro Valley. After the team returned to Japan, further studies were made and the present report was prepared.

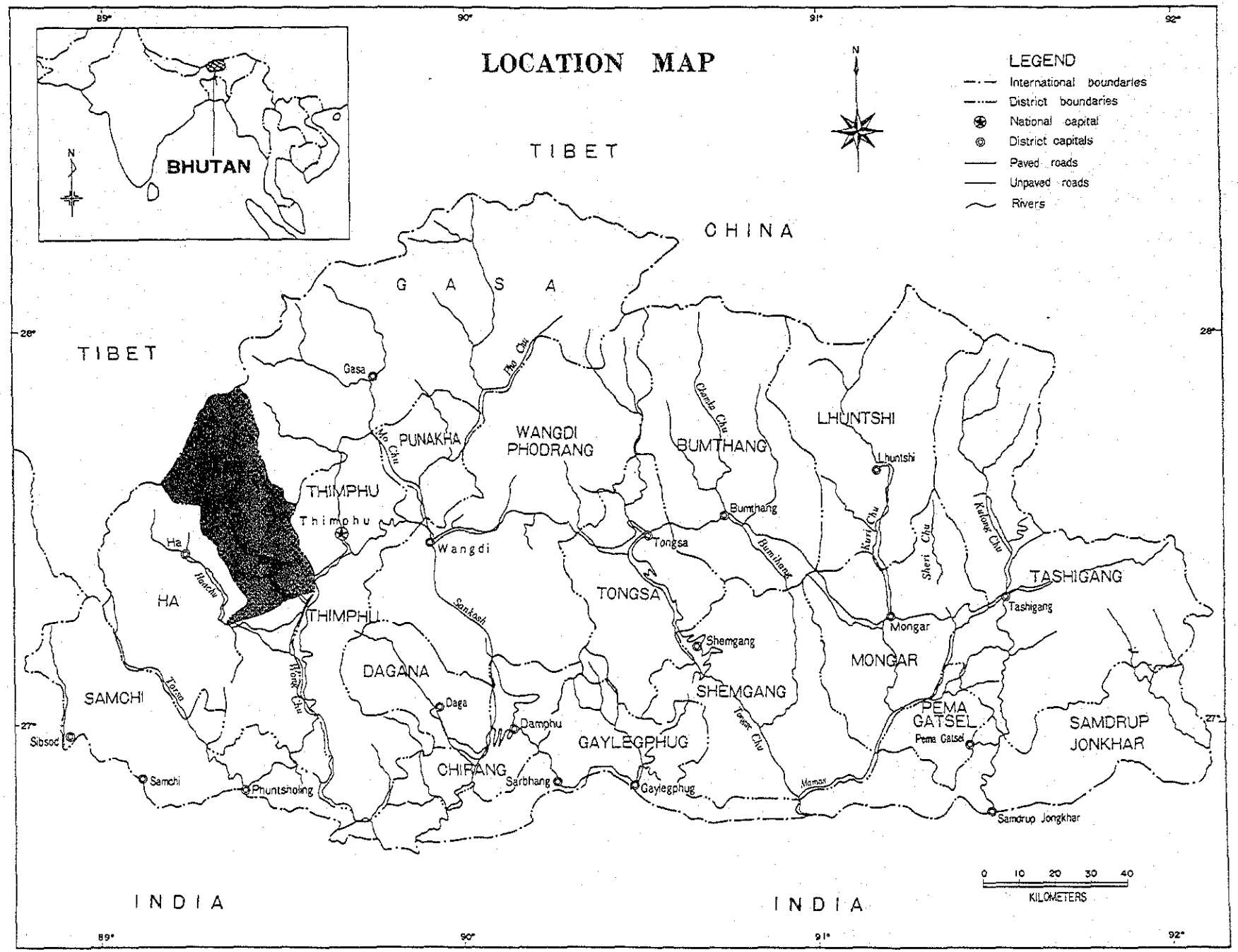
I hope that this report will contribute to the development of the Project and to the promotion of friendly relations between our two countries.

I wish to express my sincere appreciation to the concerned officials of the Government of the Kingdom of Bhutan for their close cooperation extended to the team.

June 1989

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency


LOCATION MAP
BHUTAN
N
LEGEND
International boundaries
District boundaries
National capital
District capitals
Paved roads
Unpaved roads
Rivers
TIBET
CHINA
G A S A
TIBET
INDIA
INDIA
Gasa
Pho Chu
Mo Chu
PUNAKHA
WANGDI PHODRANG
Chamke Chu
BUMTHANG
LHUNTSHI
Lhuntshi
THIMPHU
Thimphu
Bumthang
Kuri Chu
Sheri Chu
Kulong Chu
Ha
Wangdi
Tongsa
Bumthang
HA
Hachu
THIMPHU
Sankosh
TONGSA
TASHIGANG
Tashigang
Mongar
Shemgang
MONGAR
DAGANA
SHEMGANG
SAMCHI
Torsa
Wang Chu
Daga
Damphu
PEMA GATSEL
Pema Gatsel
SAMDRUP JONKHAR
Sibsod
Samchi
Phuntsholing
CHIRANG
Sarbhang
GAYLEGPHUG
Gaylegphug
Torsa Chu
Manas
Samdrup Jongkhar
0 10 20 30 40
KILOMETERS
89°
90°
91°
92°
28°
27°

SUMMARY

The agriculture and livestock industries are the most important industrial sectors in Bhutan, accounting for 41.4 per cent of Bhutan's gross domestic product (GDP) and employing 87.2 per cent of its labor force. There is very little flat land in Bhutan, as most of the country is in the mountainous region of the Himalayas, and farmland accounts for only about 356,000 ha, 8.8 per cent of its land area, of which only 30,000 ha are irrigated. Because of its lack of farmland, coupled with its low productivity, Bhutan is still unable to feed its own people without relying on imports.

The living standard in rural areas, where most Bhutanese live today, has tended to decline due to sluggish growth in wages and rising prices. Thus the Government of Bhutan has tried to raise its rural income by, among other things, raising its productivity in farming and livestock, diversifying its cash crop and implementing development projects. In the 6th Five-Year Plan (1987-1992), Bhutan intends to further promote its agricultural development by allocating 1,142.82 million Nu., about 20 per cent of its capital investment, to agricultural development.

Economic independence is the principal goal of this Five-Year Plan, and to realize it, the less developed areas must be brought up to the level of the more developed areas and each region must contribute to the overall goal of economic independence. With this in mind, the Government of Bhutan has selected five areas as key development areas. The area where the Paro Valley Integrated Agricultural Development Project is being carried out is among the most important of these areas.

In response to a request made by the Government of Bhutan, the Food and Agriculture Organization (FAO-RAPA) carried out in 1987 a preliminary survey in Bhutan. On the basis of this report, the Government of Bhutan asked the Government of Japan for grant aid. The Government of Japan responded by dispatching a preliminary survey mission to Bhutan from November to December 1988. The mission returned and confirmed the

following basic items:

1) If the Dotey Basin is the only area selected for an intensive agricultural development project as suggested by FAO's preliminary survey, the investment cost per farm family may reach a considerable amount and prevent the Government of Bhutan from promoting infrastructural consolidation for development projects in other areas in the future.

2) It is reasonable to include irrigation canals, farm roads, river protection works and farmland consolidation in the development master plan, and it is necessary to study the development needs for each of these components by district. In addition, basic design survey should include the supply of construction machinery and the construction of concrete plants, which are necessary for the project implementation and maintenance.

3) It is especially reasonable to adopt the farmland consolidation into the Project as a pilot scheme.

In accordance with these basic items, a decision was reached to dispatch a basic design survey team. The team conducted a survey for Phase 1 for 29 days, from March 29 to April 26, 1989. In this survey, the present status of agriculture in the entire Paro Valley area was examined thoroughly and the importance of the project under discussion was confirmed. The survey team carried out a survey and discussions in relation to the report on the present status (topographic survey and others) of each component proposed by the Government of Bhutan. The contents of this survey and discussions were placed in order so that they could be incorporated into the Project. A master plan for the entire project was mapped out on this basis, and a basic design survey was undertaken for construction machinery and plants as well as on the improvement of existing farm road for which early implementation will be expected. This report brings together the results of the survey undertaken in Phase 1. In Phase 2, a basic design survey will be carried out on components other than those considered in Phase 1 on the basis of the master plan established in Phase 1.

The project area is agricultural land along the River Paro and its tributary, the River Dotey, in Paro Dzongkhag as south western region of the Kingdom of Bhutan. Climatically, the area belongs to the monsoon zone with a rainy season (June-September) and a dry season (December-February). The annual precipitation is 500-1,000 mm, and the average monthly temperature ranges from 5°C to 25°C. Excluding pasture land, the area utilized as agricultural land is made up of 3,500 ha of land, 43 per cent (1,502 ha) of which consists of wet land, 41 per cent (1,488 ha) of dry land, about 11 per cent (394 ha) of orchards, and the remaining 4 per cent (156 ha) of vegetable gardens. The area has an estimated population of 11,168, with a total of 1,930 farm families.

In the project area, work will be done on a total of 28 irrigation canals, 12 of which derive their water from the River Paro, five from the River Dotey, and 11 from mountain streams. These irrigation canals are generally not equipped with permanent facilities to divert water. Water is drawn from them, as the need arises, by making temporary openings in the separation levees with cobble, sand and other materials found in the riverbed.

As to river protection works, rivers in the area do not have revetments to protect farmlands, with exception of some parts of the Rivers Dotey and Paro. Farmlands located along the River Paro were eroded by the disastrous flood in 1968, but the damaged areas have been still left unrepaired in the condition of the fear of erosion at many places.

Roads in Bhutan can be classified into national highways, feeder roads and farm roads. The project area has only one farm road, and it is in such a poor state of maintenance that it is almost impossible for vehicles to drive along it. This is partly because the two-year period of government observation has expired. There is no farm roads along both side of the River Paro as well as along the right bank of the River Dotey, where agricultural input and its product are transported using man power.

The Paro Valley basin, the site of the current project, is regarded as one of Bhutan's advanced agricultural areas, however, a lack of development in the infrastructures to support agricultural production

has made agricultural mechanization difficult in the area. On the other hand, it was confirmed that the existing facilities have deteriorated largely due to their ages. The project aims to remove the factors impeding growth in productivity by making maximum use of the existing agricultural infrastructure, improving it, and providing irrigation facilities, farm roads and river protection works so that farming in the basin can become more efficient. In this respect, a pilot program will be undertaken to promote the consolidation of farmland.

The master plan is outlined below:

IRRIGATION CANALS

Rehabilitation

- Concrete lining : 5.0 km long (with concrete blocks and job-site concrete)
- Consolidation of earth canal : 9.0 km long (including diversion)
- Replacement of steel flumes : 3.5 km long (Canal No.17)

Construction of Intake Facilities

- Concrete intakes : 4 sites (Canal Nos. 6, 13, 14, 19)
- Wooden mattress : 7 sites (Canal Nos. 1, 3, 4, 8, 11, 12, 15)

FARM ROADS

- Rehabilitation of existing road : Site 1, L= 3.7 km (3.0 m, gravel)
- Construction of new roads :
  - Site 2, L= 6.8 km (- do -)
  - Site 3, L= 9.5 km (- do -)
  - Site 4, L= 1.75 km (- do -)
  - Site 6, L= 1.8 km (- do -)
  - Site 7, L= 3.2 km (- do -)

  Total L= 26.75 km

FARMLAND CONSOLIDATION

(at Changkha-Thang area, one site)

- Irrigation canal : Canal No.8
- Irrigation area : 28 ha
- Number of farmhouses : 30

RIVER PROTECTION WORKS

- New construction : Site 1, L= 3.7 km (Left bank), gabion
  L= 3.7 km (Right bank),gabion
  Site 2, L= 6.8 km, gabion
  Site 4, L= 1.75 km, gabion
  Site 5, L= 2.05 km, riverbed excavation
  Site 7, L= 3.0 km, gabion

  Total L= 21.0 km

The project covers a wide area totalling 3,000 ha of narrow lands along rivers and involves a large amount of construction work. There is also a basic policy that the project be executed with the help of a labor force of farmers thereby to be benefited in the area. Considering the above, it is important for the project implementation that to strictly keep the labor force, and the construction machinery is used effectively. Under the above provision, it is recommended that the Project be implemented in two stages: Stage 1 for areas located in the upstream left bank of the River Paro, including the River Dotey; and Stage 2 for the areas downstream. The implementation period will be 36 months for the Stage 1, and 24 months for the Stage 2.

The implementation schedule will be as follows:

IMPLEMENTATION SCHEDULE

Stage	Year	Main Works
1	1	- The first procurement of construction machinery and plant equipment. - Construction of concrete plants. - Commencement of precast concrete blocks.
	2	- Irrigation canal : Nos. 17, 19, 21 - Farm road : Site 1 - River protection work : Site 2
	3	- The second procurement of construction machinery. - Irrigation canal : Nos. 28, 11, 12, 15 - Farm road : Site 2 - River protection work ; Site 2
2	1	- Irrigation canal : Nos. 1, 14, 8 - Farm road : Sites 3, 4, 6 - River protection work : Sites 4, 5 - Land consolidation : 50 % of the area
	2	- Irrigation canal : Nos. 3, 4, 6, 13 - Farm road : Site 7 - River protection work : Site 7 - Land consolidation : 50 % of the area

Note : Stage 1 : Both sides of the River Dotey and left side of the River Paro, upstream of the confluence of both rivers.

Stage 2 : Right side of the River Paro, upstream of the confluence; and both sides of the River Paro, downstream of the confluence.

In the Phase 1 survey, the basic design was carried out on plants, construction equipments and rehabilitation of existing farm road; and decisions were made on kinds and numbers of machinery and equipment as well as their sizes. Procurement of machinery and equipment, and rehabilitation of the existing farm road shall be executed in stages in accordance with the entire implementation schedule of the Project. Its outline is as follows:

Stage 1.1

CONSTRUCTION EQUIPMENTS

Bulldozer(21 ton)	: 1
(15 ton)	: 4
(3 ton)	: 1
Backhoe(0.6 cubic meter, hereafter cu.m)	: 3
(0.20 cu.m)	: 1
(0.04 cu.m)	: 2
Clamshell(0.6 cu.m)	: 1
Dump truck(11 ton)	: 8
Vibratory roller(10 ton)	: 1
Truck mixer(2.2 cu.m)	: 2
Mortar pump	: 1
Power trowel	: 1
Compressor(7.5 cu.m/min)	: 1
Jack hammer	: 2
Vibrator	: 2
Tamper	: 4
Wheel loader (0.34 cu.m)	: 1
Belt conveyer(7 m)	: 1
Supporting equipment	: 1 set

PLANTS

Crushing Plant(30 t/hr)	: 1 set
Batcher Plant(Forced mixing type)	: 1 set
Precast Concrete Plant	
Block manufacturing equipment	: 1 set
Steam curing equipment	: 1 set
Forklift	: 2
Diesel generator(45 kw)	: 1
Steel-bar cutter	: 1
Water treatment facility	: 1 set

Stage 1.2

REHABILITATION OF EXISTING FARM ROAD

Length	: 3.7 km
Width	: 3.0 m
Design speed	: 30 k.p.h.
Pavement	: Crushed stone

Stage 1.3

CONSTRUCTION EQUIPMENTS

Bulldozer(21 ton)	:1
(15 ton)	:1
Rakedozer(15 ton)	:1
Backhoe (0.6 cu.m)	:1
(0.35 cu.m)	:1
Dump truck(11 ton)	:8
Vibratory roller(10 ton)	:1

The Department of Agriculture under the Ministry of Agriculture will be the implementation agency for the Project. The Agriculture Machinery Centre (AMC) will administer the plants and construction equipments supplied under this Project. AMC will have enough experience and have not technical problem, however, it will be advisable to increase the number of technical staff for machinery maintenance and repair.

If the project components which were studied and proposed within the scope of the basic design survey, are implemented under a Japanese grant aid programme, the Government of Japan will bear the expenses for construction of the plants and incidental facilities, procurement of construction equipments, and rehabilitation work of the existing farm road. The Government of Bhutan will be responsible for meeting the cost of land acquisition for the plants and its ground formation, and provision and installation of electric power facilities to the plants. The procurement of equipments will take 6 months in both first and third years, and that of plants will take 12 months. Rehabilitation of farm road will be continued for 11 months.

Shortage of ordinary labor force and shortage of operators for construction equipments, annual limiting working period, and compensation of land acquisition related to the implementation of farm roads and farmland consolidation are considered as constraints to the project implementation. Results of study and analysis shows that these would not be critical problems.

The project under consideration is one of the key development projects that the Government of Bhutan is actively promoting. At the same time, with their deep awareness of the need and importance of the project, the farmers in the project area have organized the Steering Committee of the Paro Valley Agricultural Development, headed by the Governor and composed of representative farmers. Through this committee the farmers are enthusiastically engaging in activities regarding such matters as the sites to be developed and labor problems.

The implementation of the project will accelerate the agricultural mechanization, which has already started in Bhutan, reduce the burden

of paying wages significantly, and enhance the cash crop production through enlargement of cropping area. This will result in a higher income for farmers and thus help raise their living standard. The project will also serve as a model of regional development, helping the Paro Valley basin to become self-sufficient and to contribute to achieving the national goal. Thus it can be said that the grant aid by the Government of Japan for the Project will make a significant contribution to increasing the well-being of Bhutan's people, and will have a beneficial effect on the economy in the future.

LIST OF ABBREVIATIONS

FAO : Food and Agriculture Organization of the United Nations

RAPA : Regional Office for Asia and the Pacific

UNDP : United Nations Development Programme

IFAD : International Fund for Agricultural Development

BRTF : Indian Border Road Task Force

NUDC : National Urban Development Corporation

FCB : Food Corporation of Bhutan

PWD : Public Works Department

TABLE OF CONTENTS

ANNEX

Chapter 1. INTRODUCTION

The agriculture and livestock industries are the most important industrial sectors in Bhutan, accounting for approximately 41.4 per cent of Bhutan's gross domestic product (GDP) and employing around 87.2 per cent of its labor force. There is very little flat land in Bhutan, as most of the country is in the mountainous region of the Himalayas, and farmland accounts for only about 356,000 ha, 8.8 per cent of its land area, of which only 30,000 ha are irrigated. Because of its lack of farmland, coupled with its low productivity, Bhutan is still unable to feed its own people without relying on imports. The living standard in rural areas, where most Bhutanese live today, has tended to decline due to sluggish growth in wages and rising prices. Thus the Government of Bhutan has tried to raise its rural income by, among other things, raising its productivity in farming and livestock, diversifying its cash crop and implementing development projects. In the 6th Five-Year Plan (1987-1992), Bhutan intends to further promote its agricultural development by allocating 1,143 million Nu., about 20 per cent of its capital investment, to agricultural development.

Economic independence is the principal goal of this Five-Year Plan, and to realize it, the less developed areas must be brought up to the level of the more developed areas and each region must contribute to the overall goal of economic independence. With this in mind, the Royal Government of Bhutan has selected five areas as key development areas. The area where the Paro Valley Integrated Agricultural Development Project is being carried out is among the most important of these areas.

In response to a request made by the Government of Bhutan, the Food and Agriculture Organization (FAO-RAPA) carried out in 1987 a preliminary survey in Bhutan. On the basis of this report, the Government of Bhutan asked the Government of Japan for grant aid. The Government of Japan responded by dispatching a preliminary survey mission to Bhutan from November to December 1988. The mission returned and decided on the following basic items:

1) If the Dotey Basin is the only area selected for an intensive

agricultural development project as suggested by FAO's preliminary survey, the investment cost per farm family may reach considerable amount and prevent the Government of Bhutan from promoting infrastructure consolidation for development projects in other areas, and agricultural production system and social system will be changed drastically. Hence, it is advisable to rehabilitate the existing infrastructures effectively and to make infrastructure consolidation plan in the whole Paro Valley Basin.

2) It is reasonable to take up components of irrigation canals, farm roads, river protection works and farmland consolidation in the development master plan, and it is necessary to study the development needs for each components by district. In addition, basic design survey should include the supply of construction machinery and the construction of concrete plants, which are necessary for the project implementation and maintenance.

3) It is especially reasonable to adopt the farmland consolidation into the Project as a pilot scheme.

In accordance with these basic items, a decision was reached to conduct Phase 1 survey for the present status of agriculture in the whole Paro Valley area as well as basic design survey on construction equipments, plants and on rehabilitation of existing farm road and to examine a master plan for consolidation. In Phase 2, a basic design survey will be carried out on components other than those considered in Phase 1 on the basis of the master plan established in Phase 1. According to this basic policy, JICA dispatched a Phase 1 basic design survey team headed by Mr. Yasuhiko Yamamoto, Director of Planning Division, Hokuriku Agricultural Administration Office, MAFF for 29 days, from 29 March through 26 April, 1989. The team surveyed the present situation of agricultural infrastructure, confirmed the importance of the Project. The survey team carried out a survey and discussions in relation to the report on the present status (topographic survey and others) of each component proposed by the Government of Bhutan. The contents of this survey and discussions were placed in order so that they could be incorporated into the Project. This report brings together the results of the survey undertaken in Phase 1.

Member List of Survey Team, Survey Schedule, Member List of Bhutanese Party and Minutes of Discussions are shown in Annex.

The River Dotey Basin is shown in Photo 1.

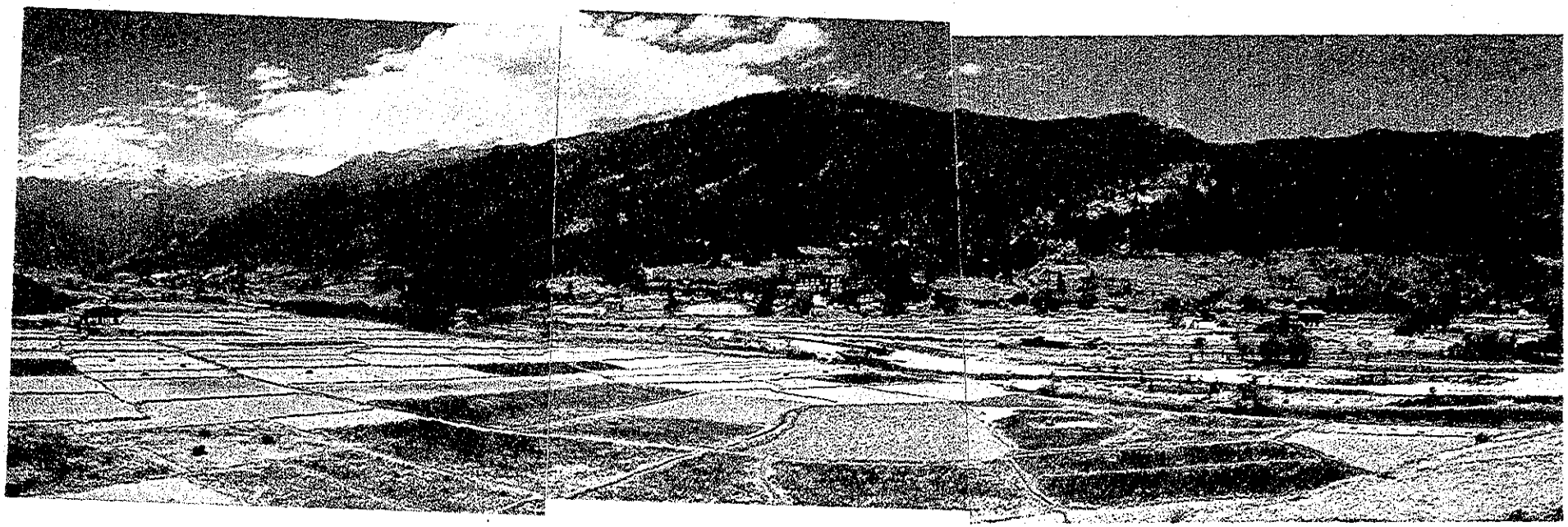


Photo 1 RIVER DOTEY BASIN

Chapter 2. BACKGROUND OF THE PROJECT

2.1 General Condition of Agriculture in Bhutan

Bhutan is a typical agricultural country, where 87.2 per cent of the population are engaged in agriculture and/or livestock industry. The economic growth of the country is basically dependent on the development of its agricultural sector. Since Bhutan's agriculture is small scale and intensive, the key to its development lies in increasing productivity and promoting food processing.

A look at Bhutan's natural conditions reveals that nearly all of it is covered by the steep mountains of the Himalayas. Deep ravines cut into the mountains, no wide plains are found, and small farm villages are scattered throughout the country. Climate changes from a hot humid one in the southern foothills to a severe alpine one of high snow-capped mountains in northern region. As a result, Bhutan's agriculture varies according to the differences in altitude and region.

From a socio-economic viewpoint, the first thing to note is that 87.2 per cent of Bhutan's population are engaged in agriculture, accounting for 41.4 per cent (1986)of the country's GDP, or 1,109.7 million Nu. But agricultural land accounts for only about 356,000 ha, less than 9 per cent of the total area of 4.65 million ha and there is hardly any room to expand the farmland. According to available statistics, the average agricultural land per household is about 0.7 ha, and the average annual income per capita is US $150 as of 1986. The principal products are paddy, wheat, maize and orange. Bhutan's agriculture is of the self-supporting type.

Cultivation in Bhutan is supported mainly by family laborers. But during paddy transplanting and harvesting, farms around cities rely on hired laborers. Animal power is also relied upon, but does not meet the short of labor force. As a way of solving this problem, agricultural mechanization is advancing in certain areas. But rapid spread of mechanization can not be expected because agricultural infrastructures such as farm roads have not been necessarily consolidated.

Since Bhutan is not yet self-sufficient in food, it is forced to rely on imports from abroad to make up for the shortage. The country is about 90 per cent self-sufficient in grain. According to World Development Report, Bhutan imported 18,000 tons of cereals and received 3,000 tons food aid in cereals both in 1986 and 1987.

Taken as a whole, Bhutan's agriculture is still quite primitive, and cultivation lags considerably. Seeds and fertilizers are in short supply. Moreover, neither the distribution nor financial system can claim to be adequate.

2.2 General Condition of Related Plans

2.2.1 National Development Plan

(1) Background

The First National Development Plan was launched in 1961, and five such plans have been completed since. In the 1960s, Bhutan's administrative system was weak and such basic facilities as roads, welfare, communication and education were virtually nonexistent. Consequently, the development plans were focused on public works and educational facilities.

With the advent of the 1970s, development plans were expanded their scope to embrace forestry, electric power, mining and welfare programs. Thus, in the 1970s, a great progress was made in the establishment of the basis for Bhutan's development and in the utilization of its natural resources. The scale of expenditure from the 1st to the 5th development plans reveals that the expenditure for the Fifth Development Plans exceeded that for the first by 43-folds.

The evaluation of the 5th Development Plan (1981/82-1986/87) is as follows:

i) Gross Domestic Product (1986)

- GDP : 2,678.3 million Nu.
- Annual per capita income: US$ 150
- Annual growth rate : 16.4%

ii) Trade Balance

As the table below shows, India is by far Bhutan's biggest trading partner in imports as well as exports, accounting for 96-98 per cent of exports and 82-90 per cent of imports. The only other trading partners of note are Singapore in imports, and Japan, West Germany and the United States in exports.

BALANCE OF TRADE

Unit : US$ million (%)

	1982/83	1983/84	1984/85	1985/86	1986/87
Export					
India	16.3(98.2)	15.2(97.4)	16.8(96.6)	22.1(99.5)	25.0(98.8)
Others	0.2(1.2)	0.3(2.9)	0.5(2.9)	0.2(0.9)	0.2(0.8)
Total	16.6	15.6	17.4	22.2	25.3
Import					
India	56.8(84.5)	58.3(82.3)	61.0(87.9)	65.4(86.4)	74.3(84.4)
Others	10.4(15.5)	12.5(17.7)	8.4(12.1)	10.4(13.7)	13.7(15.6)
Total	67.2	70.8	69.4	75.7	88.0
Balance					
India	-40.5(80.0)	-43.1(77.9)	-44.2(84.8)	-43.3(80.9)	-49.3(78.5)
Others	-10.1(20.0)	-12.2(22.1)	- 7.9(15.2)	-10.2(19.1)	-13.5(21.5)
Total	-50.6	-55.3	-52.1	-53.5	-62.8

Bhutan's international balance of payments is statistically managed by dividing it between with India and with other countries. This is because so much of Bhutan's international balance of payments is with India, as reflected in the fact that, among others, India was Bhutan's sole trading partner until recently and has provided a huge amount of aid in road construction and other development projects.

As the above discussion demonstrates, India occupies an overwhelmingly significant position in Bhutan's foreign trade and provides most of the aids Bhutan receives. But since mid-1970s, other countries' share has increased substantially, with aids from these countries -- including that provided by the United Nations -- beginning to be used in Bhutan's development projects.

The main characteristics of Bhutan's balance of payments, whether with India or with other countries, are its deficit against those countries and a large number of inflow in foreign aids which could countervail the deficit. The scale of the foreign aids to Bhutan now reaches about 17 per cent GDP. Other main income sources of foreign currencies are tourism industry, interest from a reserve in foreign currency, and reimbursement from commodity taxes charged in India.

iii) Finance

To activate Bhutan's economy was the most important reform measure adopted in the 5th Development Plan. The scale of economic activities doubled during the five years. Government revenue increased by 270 per cent. Much of this was due to the tax reform the Royal Government of Bhutan implemented during this period, or 28.7 per cent per annum in average. 69 per cent of the government expenditure was earmarked for development projects(1984/85).

iv) Commodity Price

Since 1981, consumer's price index has risen by 0.7-16.6%; or 8.6% in average per annum.

v) Labor Force

An rate of employment is about 61 % of total population. Percentage of the employment in the first industries, the second and the third is 92%, 3% and 5% respectively. Although disproportionate emphasis on the first industries, majority of which is agriculture, is remarkable, engagement in population other than agriculture rises recently to some extent.

vi) Agriculture

Agriculture and livestock industries are the most important sectors in Bhutan, and agricultural development in the 5th Five-Year Plan was carried out in the following basic policy.

(a) Achievement of self-support status in food supply, in particular grain.

(b) Diversification of agricultural products; in particular a production increase of cash crops which results in leveling up of farmers' income.

(c) Improvement of nutrition condition over the whole nation.

(d) Production increase of high-quality seeds contributing to the food self-support plan.

(2) The 6th National Development Plan

At present the 6th development plan is under progress, and its period is five years and three months from April 1987 to June 1992.

In the 6th plan, various plans and programmes for the socio-economic development of Bhutan have been set out for improving the welfare of the nations. The following nine items are its objectives:

1) Strengthening the administrative capability of the Government.
2) Preservation and promotion of traditional values and ideals.
3) Mobilization of national resources.
4) Increasing income in rural area.
5) Improvement and rehabilitation of farmers' houses.
6) Integration and improvement of development services.
7) Development of human resources.
8) Promoting participation of the people in national development.
9) Promotion of national self-reliance.

Sectorial and yearly allocation of expenditures are as shown in Tables 2.1 and 2.2.

2.2.2 Agricultural Development Plan

(1) Target

The basic policy and target of the 6th National Development Plan is summarized in the three items mentioned below.

1) Increasing self-sufficiency in staple foods.
2) Increasing farmers' income through diversification of cash crops.
3) Improving productivity of land and labor.

In order to achieve the above-mentioned target, the following agricultural development projects are planned.

(2) Agricultural Development Projects

1) Development of Prior Areas

After the selection of high productivity areas, agricultural facilities in the areas are consolidated. Under the condition the agricultural development projects will be implemented. The following five areas have been selected.

a. Chirang Hill Irrigation Project

TABLE 2.1 SIXTH PLAN SECTORIAL ALLOCATION OF EXPENDITURES

Sector	Expenditures (Nu. million)	Percentages (%)
Agriculture/Irrigation	708.16	7.5
Food Corporation of Bhutan (FCB)	86.24	0.9
Livestock	348.42	3.7
Forestry	311.36	3.3
Industry Trade and Commerce	1,613.65	17.0
Public Works Department	1,122.65	11.8
Power	1,135.08	12.0
Transportation Corporation	5.00	0.1
Aviation	48.77	0.5
Telecommunication	256.56	2.7
Post Telegraph and Wireless	81.67	0.9
Information and Broadcasting	99.71	1.1
Education	1,122.84	11.7
Health	400.55	4.2
Urban Development	336.99	3.6
General Development	1,817.63	19.2
Total	9,485.28	100.0

TABLE 2.2 SIXTH PLAN YEARLY ALLOCATION OF EXPENDITURES

Sector	Fiscal Year 1987 /88	1988 /89	1989 /90	1990 /91	1991 /92	Total (Nu. million)	(%)
Agriculture including Livestock and Forestry	251	294	299	309	324	1,476	(15.6)
Telecommunication and Tourism	146	145	76	68	65	500	(5.3)
Trade, Industry and Power	615	1,034	690	291	130	2,760	(29.1)
Social Services	545	583	498	494	526	2,646	(27.9)
Finance	109	121	130	135	136	630	(6.6)
Foreign Affairs	45	38	40	43	46	211	(2.2)
Interior Services	107	98	95	88	86	474	(5.0)
National Urban Development Corporation	66	114	53	53	52	337	(3.6)
Others	137	95	72	73	77	453	(4.8)
Total	2,020	2,521	1,952	1,552	1,441	9,485	(100.0)

Outline of the project :

The increase in the agricultural production will be brought about by utilizing the following procedures, and controlling devastation in the river basin.

(i) Improvement of the existing irrigation facilities.
(ii) Soil conservation and improvement of management in the river basin.
(iii) Strengthening the supporting services for promotion of crop diversification.

Area: Four districts of Chirang Dzongkhang
River basin : 4,400 ha
Farm land area : 2,800 ha
Irrigated area : 1,310 ha
Project cost : US$ 4.35 million
Source of funds : ADB loan US $ 3.48 million, and
local portion funded by the Government of Bhutan, US $ 0.87 million

b. Tashigang-Mongar Area Development Project

Outline of the project :

Rehabilitation of irrigation facilities, execution of improvement works and strengthening of various agricultural supporting services.

Area: Tashigang and Mongar Dzongkhang

Project cost : US $ 6.667 million
Source of funds : UNDP grant: US $ 0.75 million
IFAD loan : US $ 4.75 million, and
local portion funded by G.O.B., US $ 1.167 million

c. Punakha-Wangdi Valley Development Project

Outline of the project :

Rehabilitation of irrigation facilities, execution of improvement works, promotion of agricultural production by strengthening various agricultural supporting services. Soil conservation and environmental protection by the execution of pilot projects for strengthening community forests.

Area: 9 Gewogs in Punakha Dzongkhang,
8 Gewogs in Wangdi Dzongkhang, and
2 Gewogs in Thimpu Dzongkhang.

Project cost : US $ 3.74 million
Source of funds : IFAD Loan : US $ 2.58 million,
UNDP US $ 0.44 million, and
local portion funded by G.O.B., US$ 0.72 million

d. Paro Valley Development Project

The current project.

e. Gaylegphung Area Development Project

Under study and planning.

2) General Agricultural Development Programme

Dzongkhangs and Gewogs which were not designated as prior development areas are scheduled to receive various agricultural supporting services similar to those of the 5th plan by this programme.

3) Strengthening General Agricultural Supporting Services

Providing and strengthening supporting services will be carried out along the following lines:

(i) Technical support for irrigation and land development (study, *design, supervision, etc.*).
(ii) Agricultural research.
(iii) Plant protection services.

(iv) Supply of improved equipment, seeds and plants, fertilizer, tools and agricultural machinery.

(v) Agricultural credit for farmers.

(vi) Post-harvest supporting services.

(vii) Agricultural extension and training services.

2.3 Outline of the Request

The Paro Valley is one of the most advanced agricultural regions in the Kingdom of Bhutan, and this area has played a leading role. The establishment of a modern center for agricultural development in the Paro Valley area in the 6th Five-Year Plan is very meaningful for Bhutan and will contribute significantly to make the country self-sufficienct in food supply.

It is considered that agricultural modernization can be attained through activating the regional economy for which the agricultural mechanization, and consolidation and improvement of the infrastructures are the mainstays. Although agricultural mechanization are starting through Japanese grant aid projects, e.g. AMC, there is urgent need for further improvement and consolidation of the infrastructures. In fact, rehabilitation of irrigation canals, rehabilitation and improvement of farm roads, promotion of river protection works for conservation of farmland are urgent subjects for the agricultural modernization in the Paro Valley area, and making strategy for these objects is requested to the Government of Japan.

In the meantime, the Government of Bhutan requested the study of an agricultural development plan for the Paro Valley area which is one of the five areas included in the national agricultural development plan. In response to this request, the FAO(RAPA) carried out a preliminary survey during the period of September and October, 1987. On the basis of this survey, the FAO prepared a report in which it divided the Paro Valley area into four areas, and designated the River Dotey area as the first priority among these four areas.

On the basis of this report, the Government of Bhutan asked the Govern-

ment of Japan for grant aid. The government of Japan responded by dispatching a preliminary survey mission to Bhutan from November through December 1988. The mission confirmed the following basic items.

1) If the Dotey Basin is the only area selected for an intensive agricultural development project as suggested by FAO's preliminary survey, the investment cost per farm family may reach considerable amount and prevent the Government of Bhutan from promoting infrastructural consolidation for development projects in other areas, and agricultural production system and social system will be changed drastically. Hence, it is advisable to rehabilitate the existing infrastructures effectively and to make infrastructure consolidation plan in the whole Paro Valley Basin.

2) It is reasonable to take up components of irrigation canals, farm roads, river protection works and farmland consolidation in the development master plan, and it is necessary to study the development needs for each components by district. In addition, basic design survey should include the supply of construction machinery and the construction of concrete plants, which are necessary for the project implementation and maintenance.

3) It is especially reasonable to adopt the farmland consolidation into the Project as a pilot scheme.

In accordance with these basic items, a decision was made to conduct a basic design survey in two stages as Phase 1 and Phase 2. In advance of dispatch of the basic design team, the Government of Bhutan submitted detailed appraisal which is shown in next page.

i) Irrigation canals

Name of Gewog	No. of Canals	Canal Length in km	Command Area in ha
Tsento	4	9.92	191.20
Lango	4	11.12	447.37
Shaba	4	8.36	186.23
Wangchang	3	4.926	225.96
Dotey	2	4.86	111.74
Luni	3	7.11	186.45
Shari/Hore	7	18.09	446.14
TOTAL	27	64.386	1,795.09

ii) Farm Roads 64.78 km

iii) River Protection Works 39.3 km

iv) Farmland Consolidation (a) Chankthang 28.3 ha

(b) Dob Damji 30.4 ha

v) Equipment

Construction Machinery

(a) Bulldozer 200HP 15 tons	2
(b) Bulldozer 100HP	2
(c) Pay-Loader 120 - 130HP	4
(d) Backhoe 60HP	2
(e) Backhoe 39HP	2
(f) Backhoe 20-25HP	5
(g) Belt Conveyer	10
(h) Dump Truck 2 cu.m	8
(i) Vibratory Roller 8 - 10 tons	2
(j) Carrier Truck 2.5 - 5 tons	10
(k) Tamper 4HP	5
(l) Power Trowel	5

Supporting Equipment 1 set

vi) Plant (a) Crushing Plant

(b) Precast Concrete Plant

vii) Others

Spare Parts, Cost of Transportation, Installation, Training, etc.

2.4 Scope of the Study

(1) Objective of Study

The objective is to confirm the details of the request and the background, to study the effect of the project and the viability of the project as grant aid, and to make a study on the design necessary and suitable for the cooperation.

(2) Survey Area

An area to be surveyed is Paro Dzongkhang (District) with 25,900 ha land; that is, 8 Gewogs (Sub-District) of Tsento, Lango, Wangchang, Hore, Dotey, Shari, Luni, and Shaba.

(3) Scope

The period for the basic design survey is divided into two, namely Phase 1 and Phase 2 , as described below:

Phase 1

Survey will be carried out on the present situation in the whole Paro Valley area to decide outline of the consolidation programme. At the same time, a basic design survey will be conducted on construction equipments, plants and rehabilitation of the existing farm road required for the whole consolidation works, for which advanced treatment is needed in the course of project implementation.

Phase 2

A basic design survey will be carried out on components other than those considered in Phase 1 on the basis of the master plan established in Phase 1

Detail survey work on both phases will be carried out after the studies mentioned below.

Through data analyses during the preparatory works in the home office as well as discussions with officials of the Government of Bhutan and field surveys, the scope of the plan, the implementation agency and the operation and maintenance of the project will be made clear, as well as suitability as grant aid project considering the effects and benefits.

In home office work, a basic design report will be prepared including design of optimum facility, selection of equipment, cost estimation and plan for operation and maintenance.

Chapter 3. OUTLINE OF THE PROJECT AREA

3.1 Location of the Project area

The project area is an agriculture land located in West Paro Dzongkhag of the Kingdom of Bhutan. The land is situated along the Paro River and its tributary, the Dotey River, located in North latitude 27° 20'- 27° 35' and East longitude 89° 15'- 89° 30'.

The project area covers 8 Gewogs; namely, Tsento, Lango, Dotey, Shari, Hore, Wangchang, Luni, Shaba,as shown in Fig. 3.1.

3.2 Natural Conditions

3.2.1 Climate

The project area belongs to the monsoon climate zone with a rainy season (June to September) and a dry season (December to February). The annual precipitation is 500-1,000 mm and the average monthly temperature varies 5° C to 25° C. Climate data at the Bondey Farm is given on Table 3.1.

TABLE 3.1 METEOROLOGICAL DATA

Year	1987				1988			
Month	Min. Temp. (°C)	Max. Temp. (°C)	Aver. Temp. (°C)	Rain-fall (mm)	Min. Temp. (°C)	Max. Temp. (°C)	Aver. Temp. (°C)	Rain-fall (mm)
January	-3.3	15.7	6.2	4.1	-2.0	16.6	7.3	-
February	-0.4	16.6	8.1	17.8	-0.4	17.6	8.6	13.6
March	4.2	17.2	10.7	28.0	-	-	-	30.0
April	5.6	20.7	13.1	37.8	-	-	-	24.7
May	8.5	22.2	15.4	18.9	11.1	24.0	17.5	36.4
June	15.0	24.3	19.6	90.5	13.8	26.4	20.1	137.8
July	16.1	24.2	20.2	145.0	16.6	24.7	20.7	117.4
August	15.2	22.9	19.1	123.6	-	-	-	181.6
September	15.0	23.4	19.2	107.4	-	-	-	128.2
October	7.9	20.9	14.4	63.9	-	-	-	8.0
November	1.3	20.6	10.9	1.8	1.3	19.4	10.4	11.5
December	-1.7	18.7	8.5	1.2	-0.1	16.9	8.4	16.2
Total Rainfall				640.0				705.4

Source: Bondey Farm

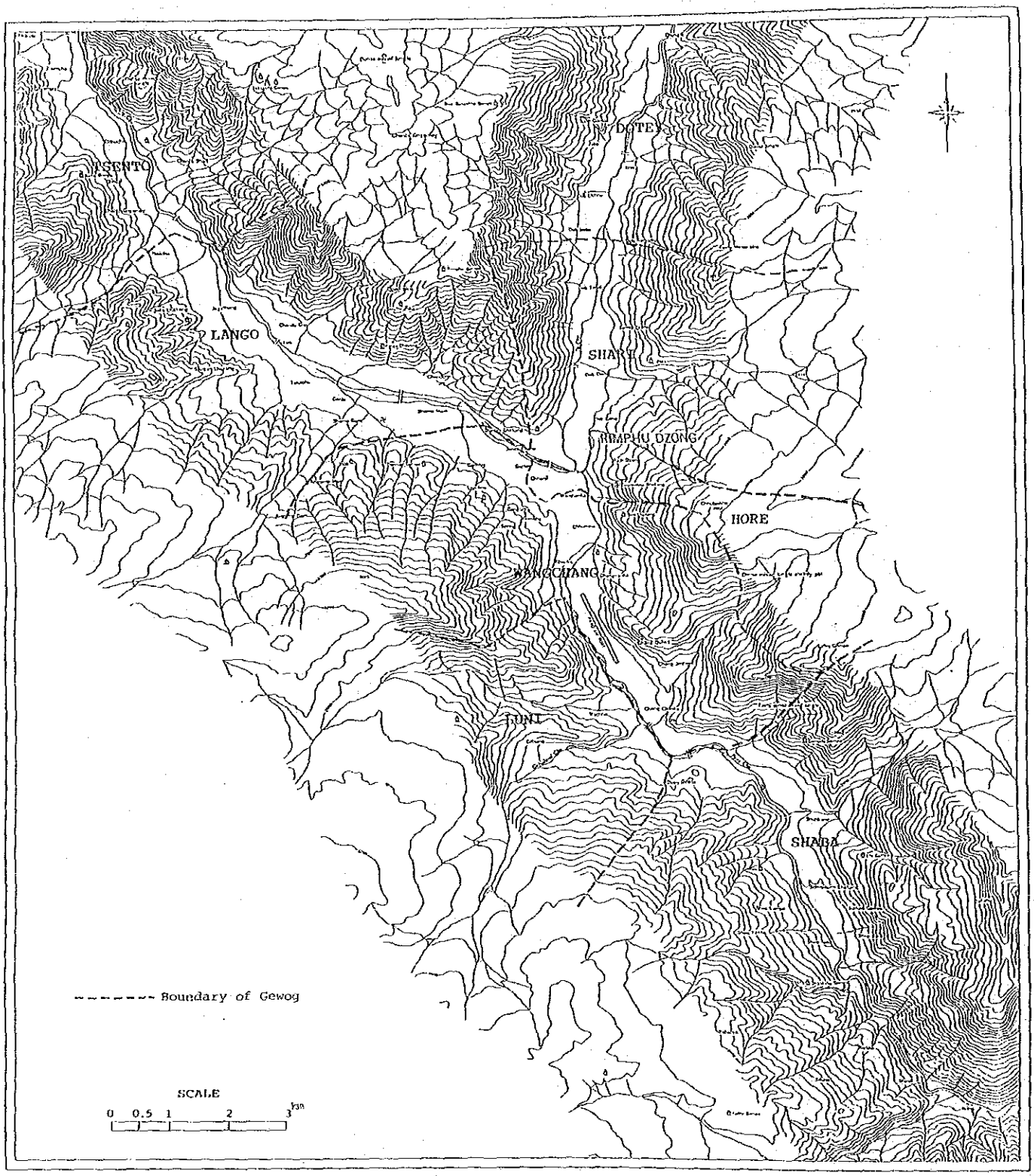


Fig. 3.1 BOUNDARY OF GEWOG

3.2.2 Geology

Geology in and around the project area is composed of gneisses of Precambrian age and covered with overburden consisting of fan deposits, talus deposits and riverbed deposits of Pleistocene to Recent Quarternary age.

Gneisses are of two types: a melanocratic banded gneiss containing a large amount of biotite (garnet bearing) and a leucocratic gneiss consisting mainly of quartz and feldspar.

Weathered zone is seen near the surface. It can be divided into two zones : one is highly weathered zone where rocks are brown colored and some portions of rocks have changed into clay, the other is slightly weathered zone where joints are open and weathering is progressing. The weak weathered zone is around two to three meters thick.

The fan deposits are formed at the places where tributaries flow into the mainstream. They are rich in rounded gravel of gneiss.

The talus deposits are found at the sloping foot of a mountain but their distributed area are small. They consist of silt and subangular gravels which are derived from the highly weathered zone of gneiss.

Riverbed deposits are distributed at riverbeds and mainly consist of cobble to boulder size rounded gravels. Lithology of main gravels are gneiss and others are metamorphic rocks which are Precambrian series origin, such as crystalline schist, marble and quartzite.

3.2.3 Rivers

Main rivers in the project area are the Paro River and its tributary, the Dotey River. The both have rapid streams and flow measurement on the river was commenced in November 1987. Since then, the minimum flow recorded was 4 cu.m/sec in February 1988, while the maximum 68 cu.m/sec in August 1988.

TABLE 3.2 GEOLOGY

Age			Lithological Unit	Rock Faces
Cen-ozo-nic	Qua-rte-rna-ry	Recent	Riverbed deposits	Sand, Gravel
			Talus deposits	Silt,Sand,Gravel
		Plisto-cene	Fan deposits	Sand, Gravel
Pre-cam-bri-an			Gneiss	Garnet bearing Banded biotite gneiss Leucocratic gneiss

3.2.4 Fauna and Flora

Actual survey on animals and plants has not been carried out, so that any inventory on animals and plants has not been prepared. According to an intensive interview survey, it is reported that in the project area and its surrounding mountainous areas the following wild animals are living.

Animals: bear, wild bear, deer, fox, etc.
Birds : sparrow, dove, crow, kingfisher, woodpecker, etc.
Fishes : trout, etc.

Major plants in the area are as follows:
Plants : pine, oak, cypress, willow, rosebay, pear, peach, apple, etc.

3.3 Agriculture in the Project Area

Excluding the pasture land, the project area covers 3,500 ha of agricultural land, consisting 43 per cent (1,502 ha) of wet land, 41 per cent (1,448 ha) of dry land, 11 per cent (394 ha) of orchards, and the remaining 4 per cent (156 ha) of vegetable garden.

The area has an estimated population of 11,168 with a total of 1,930 households. On the average, household has 0.78 ha of wet land and 0.75 ha of dry land.

Cultivation in wet land is entirely done through irrigation, and has crop intensity of 153 per cent. The crop intensity of dry land is currently under 100 per cent; potatoes and wheat are grown in most fields.

Land use block-wise by Gewog and agricultural production Gewog-wise are given in Annex 9 and 10 respectively.

Agricultural mechanization is under progress in the Paro Valley. Almost all of farm works has to rely on human and animal powers due to the present poor situation of agricultural infrastructures. Thus a lack of manpower is a factor preventing increase of productivity.

In the Phase 1 survey, an interview survey was carried out on 25 farm families utilizing questionnaires. The result revealed the actual conditions of farm families in the Paro Valley area, and it is expected to be useful for the basic design. The outline of the survey is described below:

The interview survey was carried out in mid-April 1989. The number of farm families interviewed was 25 in total. The number of Gewogs was five, names of which were Shari, Luni, Shaba, Lango and Wangchang, and numbers sampled were 9, 4, 4, 4 and 4 households respectively.

According to the face-to-face interview survey, it became clear that most farm families in the area earned comparatively higher income than that of national average. In the Paro Valley area, paddy cultivation is the mainstay, and some farm families showing sound management engage in orchard, especially apples. Also potato cultivation can be mentioned in the area. Apart from the above crops, it should be noted that vegetables such as chilies and tomatoes are relatively profitable.

Average annual income derived from paddy cultivation is Nu. 34,000 per household. With regard to fruit, annual income from apples scatters

from Nu. 600 to Nu. 30,000 according to situation of each household. Some households which engage in potato cultivation earn rather high income, and three households earn more than Nu. 10,000. As to vegetable cultivation, it should be noted that three households earn more than Nu.15,000, although 12 families do not engage in vegetable cultivation.

Annual expenditure for farm input is estimated at Nu. 6,000-8,000 per household in the case of paddy cultivation. It is considered that a stable level of income has in general been earned in the area. Its details are shown in Annex 14.

3.4 Infrastructures in the Area

3.4.1 Irrigation Canals

There are 28 irrigation canals to be rehabilitated in the project area, drawing water from three main sources as given below:

(i) River Paro : 12
(ii) River Dotey : 5
(iii) Mountain streams : 11

For the above-mentioned canals, permanent intake facilities have not yet constructed. Therefore, most of canals are unable to supply a sufficient quantity of water. Additionally high operation and maintenance costs and the high construction cost of the facilities are burdens on the farmers. Almost all canals are earth canals, and there have no branch canals, nor turnout to each farm plot.

Many canals which take water from streams having steep gradient are paved with wet masonry. This being deteriorated, leakages were observed. Some areas have not yet faced serious water shortage because of enough discharge of streams, but rehabilitation of the deteriorated sections is required.

The canal No.17 which draws water from the River Dotey was constructed for mini hydro power station, and had been playing its role for a long

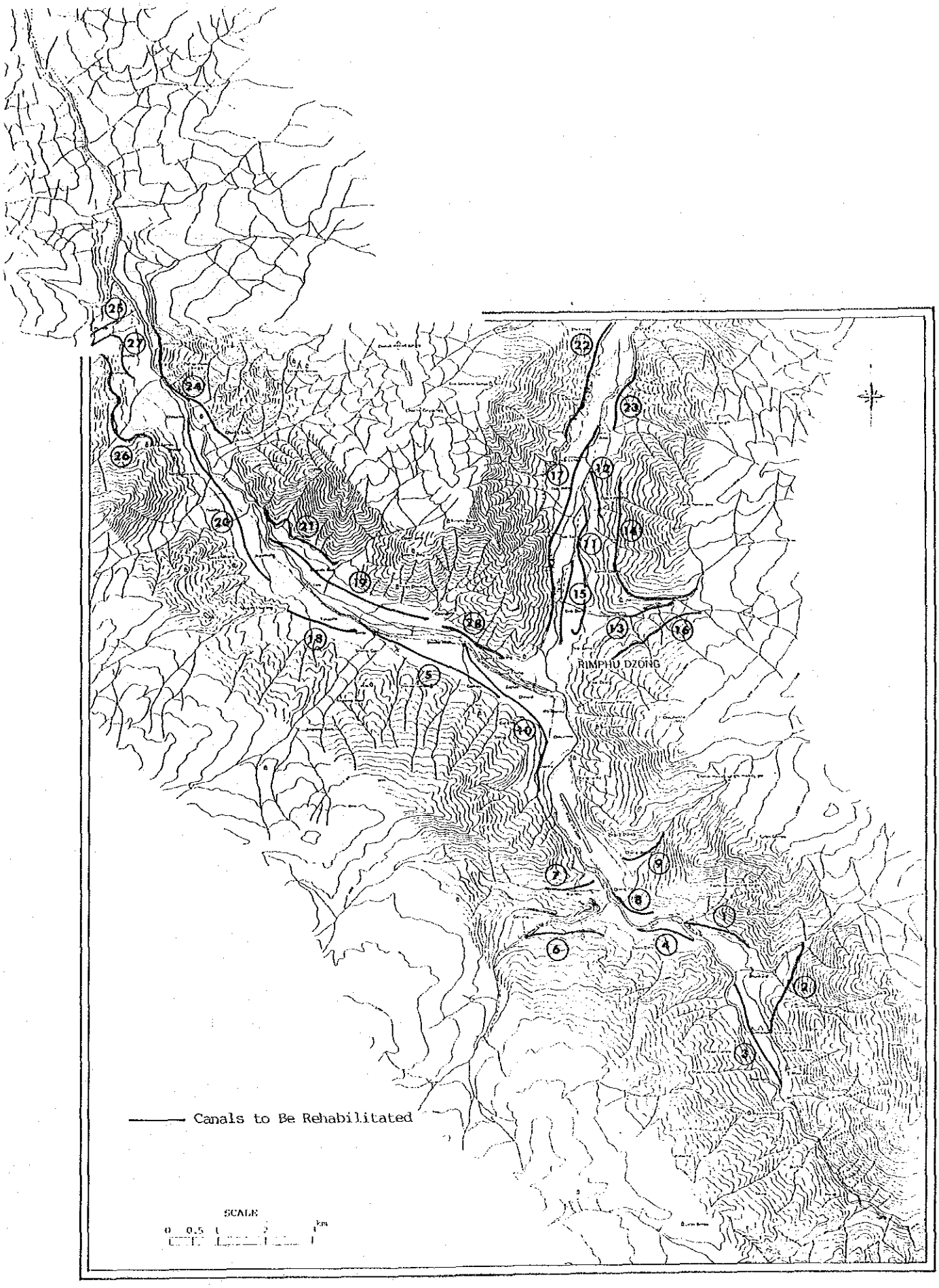


Fig. 3.2 CANALS TO BE REHABILITAED

time. Although it is not utilized presently for power generation due to recent development large-scale power plants and due to the deterioration of the canal, it is still used for irrigation and water supply now. The canal is located along the foot of mountains somewhat distant from farmlands to intentionally keep the necessary head. The canal length in the mountainous section is 3.5km, while total length is 5.8 km. This section was once made of steel plates and when the steel became deteriorated and unable for use, farmers repaired them with tin plates supplied by the Government. However, it was only a temporary measure and further rehabilitation work is urgently required.

3.4.2 Farm Roads

Roads of the Kingdom of Bhutan are classified into Highways, Feeder Roads and Farm Roads. Feeder roads connect the respective Gewog centers. Farm roads are also called district roads. Road distribution by Dzongkhag is shown in Table 3.3.

The road network in the Paro project area is illustrated in Fig. 3.3, and data on construction year, construction agency and maintenance agency are shown in Table 3.4. In the Paro area, the first road was constructed by BRTF in 1962. Since then, major roads have been constructed by aids of India, and the operation and maintenance of these roads has been also carried out by India, for which imported labors are deployed.

Farm roads have been constructed by the government agency, and after operation period of two years, they are handed over to community.

In the area, bridges on which vehicles can pass are the Paro Market Bridge, and the Shari - Ramna Bridge made of reinforced concrete; and the Bondey Bridge made of steel. Traditional wooden bridges like the Dzong bridge are utilized as footbridges. Some suspension bridges are are passable only for humans and animals.
All national highways are paved with asphalt, and others have not been paved at all except for one farm road connecting to Kichu (shown as F8 in Fig. 3.3).

TABLE 3.3 ROAD NETWORK IN BHUTAN, 1987

Dzongkhag	National Highway	District Road	Feeder Road	Total
	(km)	(km)	(km)	(km)
Chhukha	132	37	17	186
Ha	15	11	16	42
Paro	104	51	16	171
Samchi	-	66	13	79
Thimphu	102	-	19	121
Chirang	64	-	24	88
Dagana	22	87	-	109
Punakha	-	12	28	40
Wangdiphodrang	101	-	38	139
Bumthang	122	-	7	129
Galylegphug	106	-	48	154
Shemgang	142	-	-	142
Tongsa	163	-	-	163
Lhuntshi	-	47	-	47
Mongar	177	20	-	197
Pemagatsel	-	23	13	36
Samdrupjongkhar	59	48	5	112
Tashigang	141	45	24	210
Whole Bhutan	1,450	447	268	2,165

Source: Public Works Department

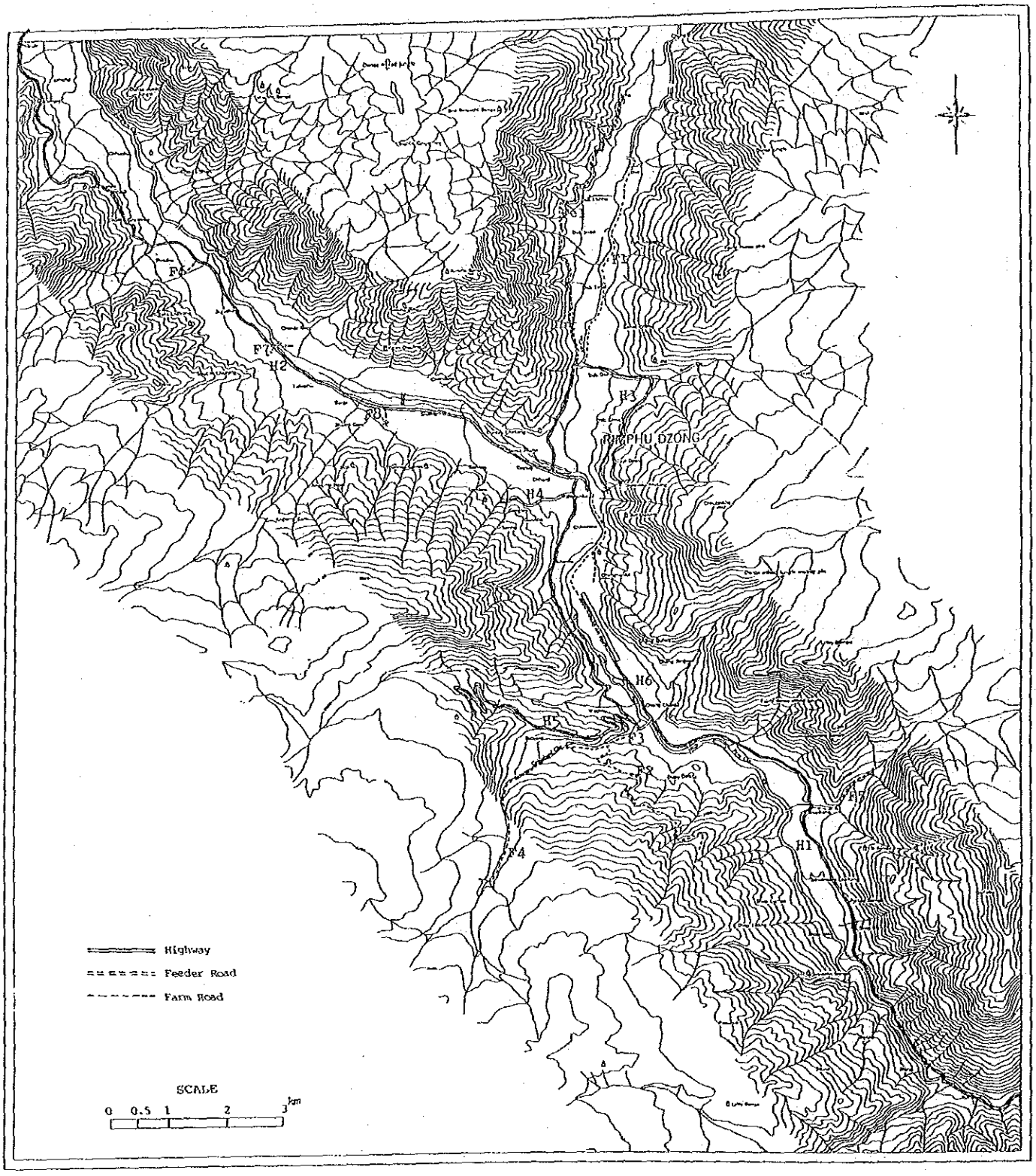


Fig. 3.3 EXISTING ROAD NETWORK

TABLE 3.4 EXISTING ROAD SYSTEM IN PARO, 1989

Route	Year	Construction Agency	Maintenance Agency
Highway			
(1) Confluence - Paro Market	1962	BRTF	BRTF
(2) Paro Market - Drukgel Dzong	1966	BRTF	BRTF
(3) Paro Market - Musium	1976	PWD	PWD
(4) Paro Market - Olathang Hotel	1966	PWD	PWD
(5) Bondey - Chundudingkha	1975	Forest D/BRTF	BRTF
(6) Bondey Bridge - Airport	1967	BRTF	BRTF
Feeder Road			
(1) Shari Ramna Dotey Acho (Bridge) R.B.	1976	BRTF	BRTF
Farm Road			
(1) Shari Ramna Bridge - Jabji Bridge	1977	DZONKHAG	Farmers
(2) Bondey Farm - Pangbina	1974	DZONKHAG	Farmers & AMC
(3) Bondey Village - Bondey Farm	1973	PWD	PWD
(4) Bondey Farm - Gebjana	1976	Forest Contractor	Forest Contractor
(5) Shaba School - Shinagkana	1986	Farmers	Farmers
(6) Nichiphu - Sachan Choten	1976	Farmers	Farmers
(7) Geta Zampa - Lango School	1977	DZONKHAG	Farmers
(8) Plant Site - Kichu	1973	PWD	PWD

Cash crop product is hauled to the highway by man power or by animal force due to lack of farm roads. Agricultural extension service is prevented because access to yield rising inputs is limited due to such hauling conditions. Farm roads appraisal to release this constraint is shown in Table 3.5.

The existing farm roads includes access roads to schools and temple and also forestry road. Actual farm roads are only two routes, one from Shari Ramna Bridge to Jobji Bridge and another from Bondey Farm to Pangbina. The latter is maintained by the AMC, therefore, the road rehabilitation covers only the former.

3.4.3 River Protection Works

The Paro Valley was damaged by disastrous floods in 1968 and 1973. As official records of flood damage were not obtained during the survey period, information was collected through interview. According to these interviews it became clear that the maximum damage occurred at the time of the flood of 5 October 1968, and the next was in 1973. The flood discharge based on traces of water levels in the 1968's flood are given below:

- River Dotey : 330 cu.m/sec
- River Paro upstream of the confluence with River Dotey : 710 cu.m/sec
- River Paro downstream of the confluence with River Dotey : 1,040 cu.m/sec

The area damaged by the floods are shown in Table 3.6. The 1968 flood damage was caused by flooding of the main rivers of Paro and Dotey and by mud flow from the streams. Due to a shortage of construction machinery, about a half of the large-scale damaged areas has not yet been restored to their original state; that is, some former paddy lands remain as wastelands, or have been partly converted to orchards. Even today, in some damaged areas, accumulated sands are still left in the agricultural lands.

TABLE 3.5 FARM ROAD APPRAISAL

Sl.No.	Starting Point	Ending Point	Approx. Length (km)	Covering Beneficiary (Village, Colonies)	Gewog	Remarks
1.	Kasatakha, Dotey (Under Phulumbha)	Ramna, Shari	8.4	Atsho, Chubha, Jabji Chasampa, Leechu, Jiba, Ramna.	Shari & Dotey	Right bank of Dotey River. Along with protection work
2.	Tshokhona, Dotey (Opposite of Attso Chuba)	Changsima & Hore	8.0	Akshi, Kutiphu, Pachu Damji, Cahngsima	Dotey, Shari & Hore	Left bank of Dotey River. Connecting to (a) Farm road under consolidation plot & (b) Farm road of Rimdo-Tsekha and Richukha. Along with protection work
3.	Ruchukha, Shari	Rimdo-Tsekha, Shari	1.8	Kempa, Rotogang, Bichukha, Tshekha, Chimsarp, Delikha.	Shari	Covering most advanced area. Highest density of powered machinery distribution.
4.	Namdu-Thangguto, Cahng-Nangka	Domna & Tsokapang, Chang-Nanka	2.3	Wangthangka, Dungkha, Shina, Gyechunka, Tak-Chorten, Tsokapong	Wangchang	
5.	Changkha-Thang,	Jangtena	1.5	Chang, Rongna, Jangtena, Nangka	Wangchang	Sample road on slope.
6.	Degolo, Khangku	Taju	2.2	Hydro-Office, Chimina, Uchuka, Chamithangka, Khangkhu	Wangchang	
7.	Gartsang, Woochu	Confluence of Paro River and Woochu stream.	0.9 x 2 = 1.8	Kashi-Tsawa, Woochu	Luni	Both left/right bank, Along with protection work

(Continued)

Sl.No.	Starting Point	Ending Point	Approx. Length (km)	Covering Beneficiary (Village, Colonies)	Gewog	Remarks
8.	Bondey-Lhakang	Gebji, Drugye-Dingkha and connection to Panbesa road.	5.0	Bondey, Bondey-Gom, Drugye-Dingkha, Panbesa	Luni/ Shaba	
9.	Bamdoley, Chendo-Chukha	Jyangsa Phaka	8.0	Rema, Chendo-Chukha, Bamdeley, Chendona.	Shari, Lango	Left bank of Paro River, Along with protection work
10.	Sa-Tsam Chorten	Tsento-Mitsi	12.0	Ngaymay, Zamsa, Gynanjey, Juser, Chunjey, Mitsi.	Tsento	Following alignment of old Phari Trade route, for covering maximum area of Farm land, and villages.
11.	Sa-Tsam Chorten	Taju (or Geptey)	9.5	Nyemjyo, Geptey, Shomo, Ganjyu, Chunka, Jagathang, Nichiphu.	Wangchang Luni Lango Tsento	Major connecting road to highway. (a) Kichu-Lhakang 4 km from Market. (b) Lango-School and Lango bridge, 7 km from Market.
12.	Chorten-Sarpa,	Deankha, Shaba	4.2	Bara, Serina, Chonni, Tankha, Chazam-Zampa bridge.	Shaba	Along with land protection work.

TABLE 3.6 AREA DAMAGED BY 1968 AND 1973 FLOOD

GEWOG	Village	Area Demaged (ha)	Stream/River
Tsento	Mitshi	1.6	
	Chunjey	2.0	
	Phando	4.0	
	Chento Shari	6	
Lango	Chendo Gon	2	Tom Chena
	Chendo Gon	4.4	Paro River
	Chendona	4	"
	Jagathang	1.2	
	Shamo Gom	3.2	
	Shamo Hom	8	Mapepu Chu
Dotey	Whole area	4	Dotey River
Shari/Hore	Ramna, Juka Zingkha	200	Shari Rongchu
	Thachukha, Bara, Juka, Damji, Shari	8	Dotey River
Wangchang	Chhumina	30	Paro River
	Chong Chanke	4.8	
Luni	Woochu	4.0	Paro River
	Woochu	20.2	Woochu
	Bondey	80.9	Gebiolumi Chu
Shaba	Dugeydingkha	8	Paro River
	Shengo	12	"
	Gangi	4	"
	Tilikesa	6	"
	Bara	16	"
	Shingkana	2	"
	Nephu	1.5	"
	Jalungpa	8	"

Note: Serious farmland damages such as inundation, sand and cobbles erosion were caused by the flood.

Some river revetments have been constructed along the national highways which have been maintained by BRTF. In the vicinity of the Paro Airport, river protection works have been constructed taking into account of flood damages of 1968. At present, however, they have been constructed only on the left bank of the river Paro where the airport is located, hence, total river training is not yet carried out and right bank is apt to be damaged.

Riverbed was excavated as a foreign aid project from the Paro Market Bridge up to the confluence of the River Paro with the River Dotey, after 1968 and 1973 floods, which was not followed thereafter. The Government of Bhutan normally supplies material of gabion and supports for farmers to build gabion except for concrete revetment constructed in the Shaba area. State of river protection works differs in each village, some area, e.g. along the river Dotey, is protected carefully and other area is not protected well. Farmers install gabion close to center of the river trying to enlarge their farmland. Flood discharge is easy to overflow due to reduced river section. Totally balanced river protection plan shall be established considering the discharge capacity of the river.

State of the river protection works is shown in Fig. 3.4. River bank condition of the Shaba area is shown in Photo 2.

Details of the river protection works appraisal is shown in Table 3.7.

3.4.4 Other Public Facilities

The National Bondey Farm in the Paro area plays an important role as a centre for agricultural extension and agricultural mechanization. It is anticipated that the AMC in the area will play a central role for training operators of constriction machinery necessary for the project implementation.

Regarding an educational sector, facilities has not been sufficient. These facilities are unable to accommodate students increasing in number and the double-shift system has been practically applied at some

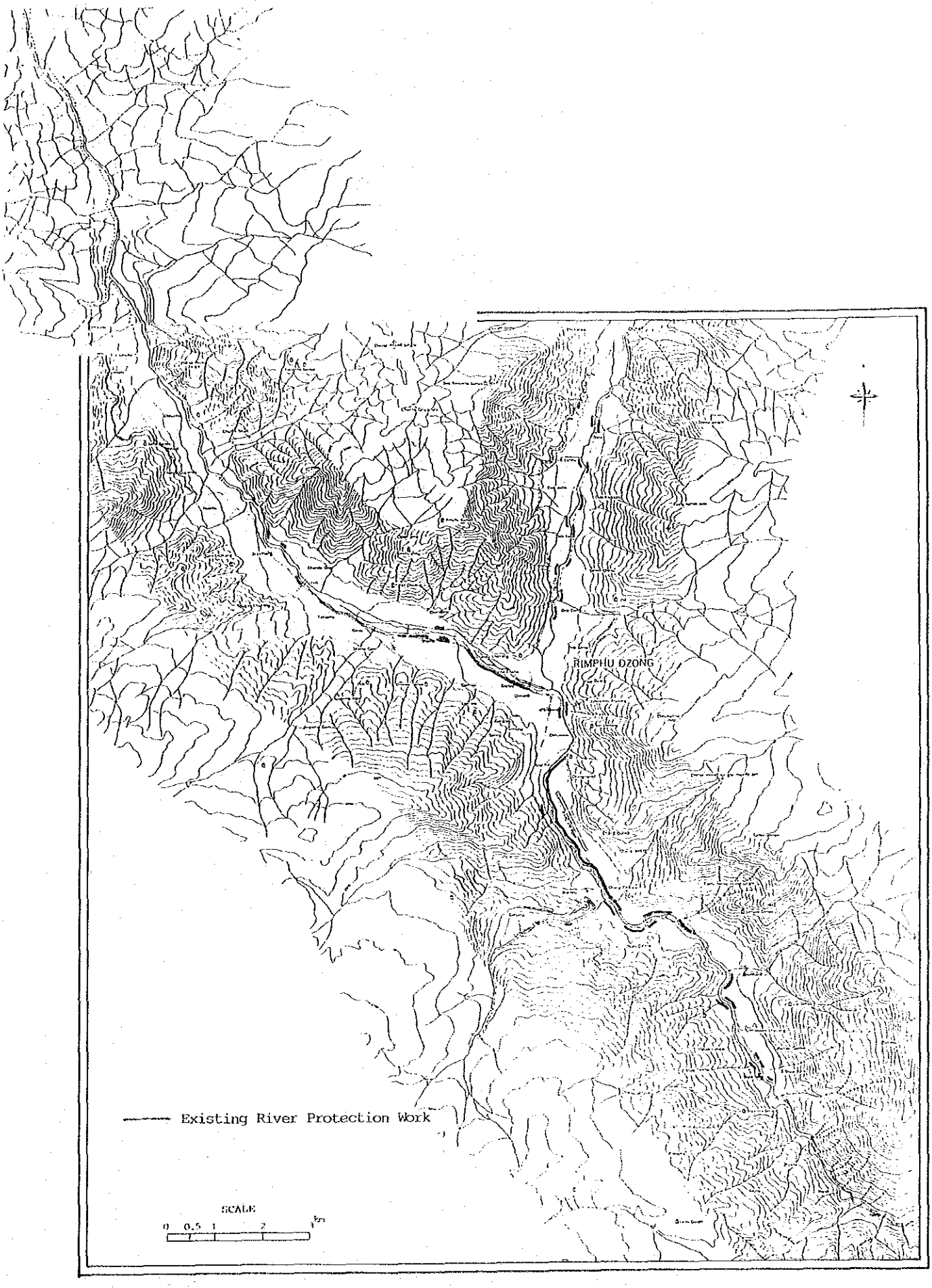


Fig. 3.4 EXISTING RIVER PROTECTION WORKS

TABLE 3.7 RIVER PROTECTION WORK

Sl.No.	Name of River	Embankment Left/Right	Location From	Location To	Length (km)	Passing Through	Remarks
1.	Dotey River	Left	Tsokhona (Dotey)	Changsima (Hore)	8	Chukha, Pachu, Kutiphung, Kempa, Damji-Dozam, Consolidation Plot, Changshima.	Farm road
2.	Dotey River	Right	Chuba & Atso (Dotey)	Jhangsa (Shari)	8	Jabji, Chasampa, Lichu, Jiba, Jhangsa.	Farm road
3.	Paro River	Left	Bamdoley (Tsento)	Jangsa (Shari)	8	Bamdoley, Tsento-Chukha, Chendona, Rema	Farm road
4.	Paro River	Left	Sengo-Tsekha (Shaba)	Chorten Sarpa (Shaba)	6	Bathumu, Serina, Chonni, Tanka, Chazam-Sampa, Shengo.	Farm road
5.	Paro River	Right	Nyemi-Zam (Wangchang)	Khangku (Wangchang)	2	Khangku, Woochuka, Wangthagka.	
6.	Paro River	Right	Suspension Bridge (Opposite of Dantak Camp) (Shaba)	Drugye-Dingkha Tseka (Shaba)	1.5	Dugye-Dingkha	
7.	Paro River	Right	Kesa (Shaba)		1.5	Kesa, Tilikha	Protection of Pumping Site
8.	Woochu River	Left	Gartsang (Luni)	River Confluence (Luni)	0.9	Woochu, Kashi-Tsawa	Farm road
9.	Woochu River	Right	Gartsang (Luni)	River Confluence (Luni)	0.9	Woochu, Kashi-Tsawa	Farm road
10.	Gyebjana Rongchu	Right	Changchu-Lhakang(Luni)	River Confluence (Luni)	2.5	Bondey, Gyebjana	Tail point right&left (Both side needed)

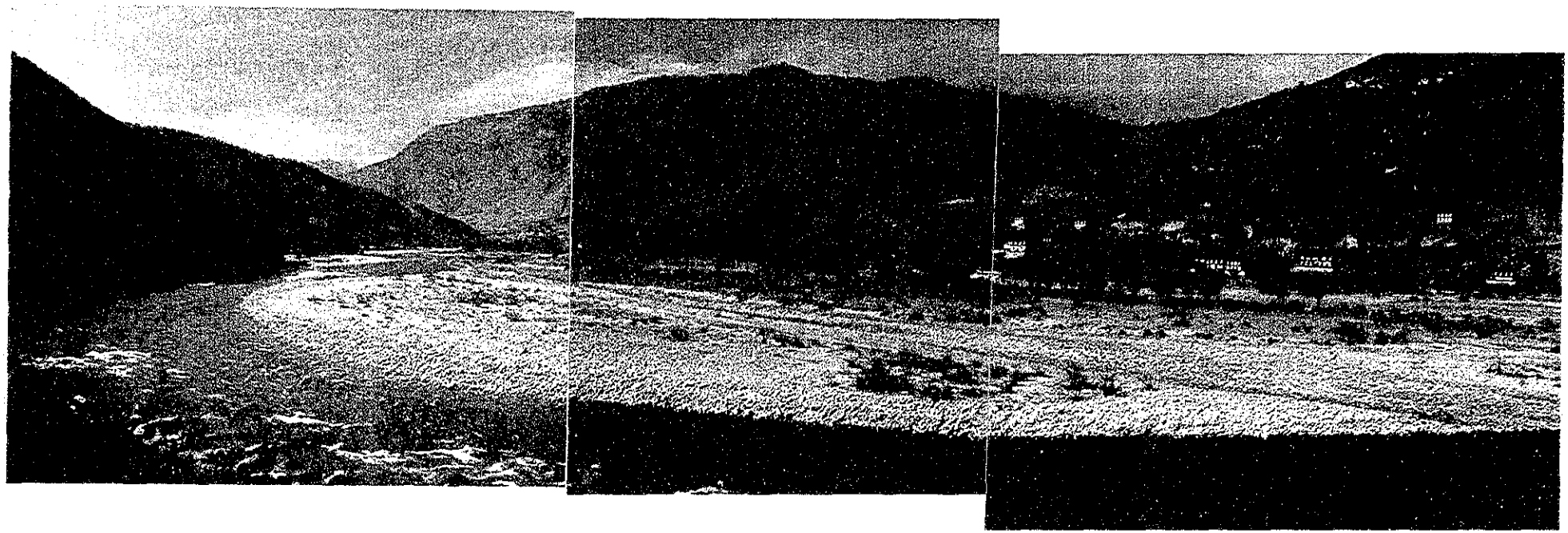


Photo 2 SHABA AREA

schools. The list of public facilities in the area is shown in Table 3.8, and their location in Fig. 3.5.

3.5 Construction Equipments

AMC, Bondey Farm, has Hire Service Division which lent construction machinery with operators and mechanics for the government development projects. List of machinery under the Hire Service and list of machinery operators are shown in Annex 12 and 13 respectively. As private contractors are still under development and number of their machinery is limited, AMC will not be able to deploy its machinery for the Paro Valley Agricultural Development Project without interrupting progress of other projects. Therefore, the Government of Bhutan requested construction equipment and plants to implement this project. These list are shown in Table 3.9 and 3.10 respectively.

TABLE 3.8 PUBLIC FACILITIES IN PARO, 1989

Facilities	Number	Location
1. Agriculture		
a) Agriculture Extension Centres	6	/1
b) Agriculture Research Station/Farm	1	Bondey
c) Agriculture Machinery Workshop	1	Bondey
d) Agriculture Machinery Training Centre	1	Chundudingkha
e) Food Processing Unit	1	
f) Seed Production/Processing Packing Centre	1	
g) Tissue Culture Laboratory	1	Bondey
2. Animal Husbandry		
a) Veterinary Hospital	1	Namey Zampa
b) Livestock Farm(Piggery/Poultry)	1	Khanku
3. Food Corporation of Bhutan		
a) Sales Depot	1	Paro (Tshongdu)
b) Horticulture Storage Godowns (50/100 MT)	3	- Jagathang - Bondey - Dob Damjhi
4. Forestry		
a) Range Office Logging	1	Paro (Tshongdu)
5. Education		
a) Teachers' Training Centre	1	Nemey Zampa
b) Junior High School	2	- Gawpay - Jalumpa
c) Primary School	6	/2
6. Health		
a) Hospital (2 doctors)	1	Paro (Tshongdu)
7. Power		
a) Electric Sub-station	1	Geptey
b) Electricity		- All gewongs covered
8. Communication		
a) Telephone Exchange	1	Taju
b) Post Office	1	Tshongdu
c) Wireless Station	1	Nemey Zampa
d) Bus Service		/3
e) Airport		

(continued)

Facilities	Number	Location
9. Bank	1	Taju
10. Industries		
a) Saw Mill	1	Shaba
b) Wood Handicraft/Furniture Factory	1	Wuchu
11. Other		
a) Petrol Pump	1	Paro (Tshongdu)

Note: /1 - Drukgyel Dzong
- Jagathang
- Bondey
- Dob Damjhi
- Bjabjee
- Jalumpa

/2 - Namey Zampa
- Drugyel
- Wuchu
- Jagathang
- Bjabjee
- Chupacha (up to Class 4)

/3 - Parto to Thimphu - Twice daily
- Parto to Haa - Twice weekly
- Paro to Phunlsholung - Twice weekly

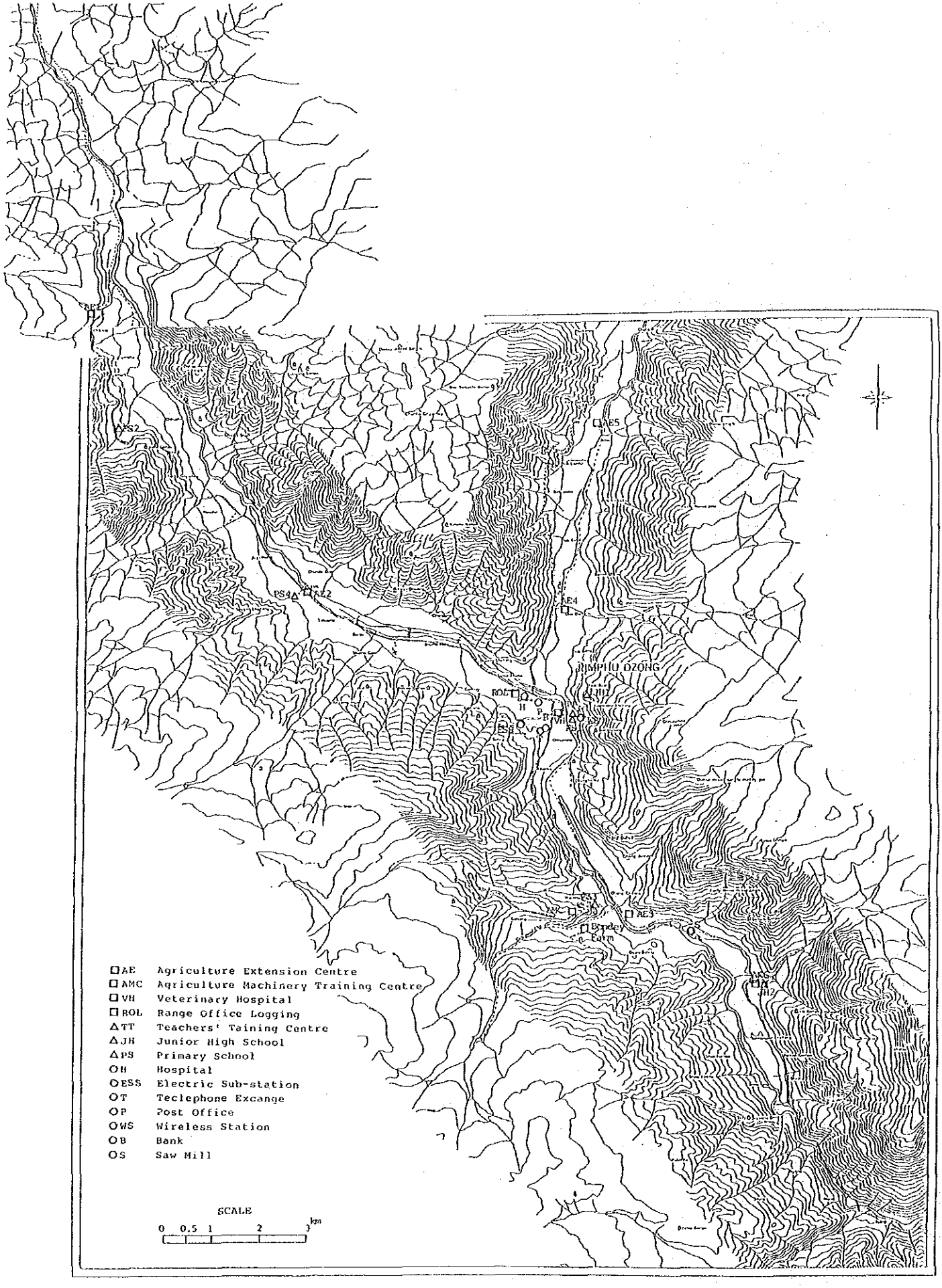


Fig. 3.5 EXISTING INFRASTRUCTURES

TABLE 3.9 EQUIPMENT APPRAISAL

No.	Description	Main Attachment	Quantity
I.	Earth Moving Equipments:		
1.	Bulldozer 200 HP 15 ton pull, Draw bar.	ROPS canopy, ripper, angle dozer angle-Ranke-dozer, back hoe	2
2.	Bulldozer, 100 HP	- do -	2
3.	Pay-loader 120-130 HP	Bucket 2.0-2.5m^3	4
4.	Excavator 60 HP, Cabin type	Clamshell, side cutter, narrow cutter bucket, breaker, extensio extension arms, ejector bucket, V-shape, slope finishing bucket	2
5.	Excavator 39 HP, Cabin type	- do -	2
6.	Excavator 20-25 HP, Cabin type	Blade, back hoe	5
7.	Belt-conveyer with electric-motor, 7000x450-550 mm 35-40 mm	Distribution-box, extension-wire generator (55 KVA) for emergency stand by with wheel	10
8.	Dump-truck/tipper 2 m^3		8
9.	Road roller, Vibratory, 8-10 ton		2
10.	Carrier truck-chain type with tipper arrangement 2.5-5 ton	With crane 2 tone capacity	10
11.	Tamper, 4 HP petrol engine 600-900 kg tamping force		5
12.	Petrol Engine operated power trowel 0.8 m blade dia		5

(Continued)

No.	Description	Main Attachment	Quantity
II.	Supporting Equipments:		
1.	Self-loader trucks cap. 18 t, Hydraulically controlled winch	Tipping outrigger, Ramps, wooden truck bed, winch	1
2.	Rough Terrain cane truck, 10-12 ton at 5m load center telescopic boom minimum 20m length		1
3.	Mobile workshop with tools equipments		1
4.	Concrete pump vehicle 20m³/H, Horizontal 190-250m, Vertical 30-40m		1
5.	Truck-mixer (dry-type) 2-3m³ drum cap. with vehicle		2
6.	Transport truck, 6x6 ton capacity 11 ton	With crane	2
7.	Supervision vehicles. 4x4 pick up double cabin, 4000cc displacement		4
8.	Service Vans with tools/equipment 4x4 type		2
9.	Motor bikes 185cc with spare like sprocket, chain etc.		20
10.	Oil tanker for oil distribution 7000 litter capacity		1
11.	Drafting equipments with blue print etc. and other office equipments		1
12.	Building for precasting plant, Prefabricated.		1
13.	Project Office, Prefabricated, 250m² floor area with toilet, kitchenette, 4 rooms		1

TABLE 3.10 PLANT APPRAISAL

No.	Description	Main attachment	Quantity
I.	Stone Crusher Plant, Portable:		
1.	Primary crushinf unit, Secondary crushing unit, Diesel generator with wire, control pannel, conveyers, etc. washing arrangements, screens 30-40 ton/H, Material handling equipments, Pay-loader etc.		2
II.	Pre-Casting Concrete Plant:		
1.	Cement butching plant		1 unit
2.	Pre-casting concrete plant		
3.	Steam curing unit with boiler, Compressor.		
4.	Sprinkler unit with pump, delivery hose pipe, Diesel engine.		
5.	Water treatment plant with chemical treatment and related equipments.		
6.	Material handling equipment	Pay-loader, Fork-lift etc.	
7.	Steel rod processing unit		
8.	Casting mould, 1 lot	(including channel, edge block, slab, tetrapod etc.)	

Chapter 4. OUTLINE OF THE PROJECT

4.1 Objective

In Bhutan, 87.2 % of the population are engaged in agriculture or its related industries. However, Bhutan is still unable to feed its own people without relying on imports. Rice, their staple food, was imported to supply 15% of their needs in 1986. In order to improve this situation, the government of Bhutan plans to promote three major items of agricultural development in the sixth Five-Year Plan. They are : an increase of the rate of food self-sufficiency, an increase of farmers' income by employment of cash crops, and an improvement of the productivity of land and the labor force.

The Paro Valley area, the project area, is considered an advanced area of agriculture, however, infrastructures related to agriculture production are still under-developed, as mentioned in the former chapter. Hence, the current project aims to rehabilitate the existing infrastructures effectively, considering present situation, in order to eliminate the hindrance and to raise farm work productivity. Consolidation of infrastructures is planned to show the Government of Bhutan a model of promoting rehabilitation in other areas in the future without changing production and social situations drastically.

4.2 Study on the Request

4.2.1 Examination of Project Components

The Government of Bhutan requested the following four components:

- Irrigation Facilities
  - Irrigation Canals
  - Pumping Station — Kesa, Tilikha, Shaba Gewog
- Farm Roads
- River Protection Works
- Farmland Consolidation

1) Irrigation Facilities

In some areas, it takes about one month to transplant paddy due to lack of water supply capacity of canals. Indigenous paddy varieties are major crops, however, high-yielding varieties with long duration of a crop will be cultivated widely after rehabilitation of irrigation facilities to enable effective crop management. Hence, it is reasonable to rehabilitate irrigation canals.

Pumping station is proposed at Tilika, where cash crops are cultivated very generally but main portion of agricultural lands is terraced paddy lands on the steep slope. The installation of the 40 m head pumping station to irrigate cash crops is not evaluated to be reasonable as project component because of difficulties in operation and maintenance by the farmers.

2) Farm Roads

The development of motor road network was initiated from the first road completion, 1962. The road network is not enough in length as well as in quality. Due to this situation it is reasonable to construct new farm roads. The vehicle bridges are installed only at the highways and others are suspension bridges which are passable for humans and animals. It is desirable to make road network plan with bridge installation, promoting the local economic activity and communication.

3) River Protection Works

The River Paro and River Dotey flow in the Paro Valley keeping steep gradient with coarse riverbed material and cobbles, changing riverbed shape with strong erosion during flood. Flat agricultural land is limited to terraces in alluvium which is composed of erodible sand and gravel. Hence, it is reasonable to request river protection works for farm lands.

4) Farmland Consolidation

Farmland consolidation is proposed at terraces in alluvium, where cobbles and gravels shall be removed during consolidation. Lowered foundation shall be banked using hauled soil. It is less reasonable in present stage to consolidate in large-scale due to high construction

cost, however, it is reasonable to show pilot scheme of farmland consolidation.

4.2.2 Priority of Project Components

(1) Irrigation Canals

The irrigation canals requested by the Government of Bhutan are scattered in eight Gewogs and are 28 canals, and their combined length is 64.234 km, including the additional canal lost in the appraisal.

All the above canals were surveyed with the assistance of farmers living in the areas that will benefit from the Project, and at the same time they were interviewed about water supply conditions. As a result, it became clear that canal No.17 requires complete rehabilitation on 3.5 km (67% of its total length), and most of the other canals need partial rehabilitation totaling 200 - 300 m each.

The survey revealed that intake facilities for the canals which drew irrigation water from the River Dotey as well as the River Paro had not been constructed, and new construction of intake facilities was required for almost all of canals.

Priority of each canal was decided using the following criteria:

a. Water supply conditions of canals in areas to be benefited.

i) Severe shortage of water (more than 20%).....A1
ii) Short of water B1
iii) Somewhat short or sufficient (less than 10%).....C1

b. Cause of Water Shortage and Countermeasures

i) There are some defects in system of which improvement work is too hard for farmers to cope with in respect to technology and investment cost..... A2

ii) Although some defects are found, farmers are able to repair provided far as materials for repair are supplied..... B2

iii) Repair is not necessary on the whole..... C2

Taking into account urgency and importance, the criteria on priority are classified into A, B and C. As a general rule, for A rehabilitation works will be conducted; for B materials for repair will be supplied; and for C no repair works will be done.

A: A1, A2
   B1, A2
B: A1, B2
   B1, B2
C: Others

Evaluated priority for 28 canals is shown in Table 4.1.

(2) Farm Roads

Due to a shortage in the labor force the demand for agricultural mechanization has increased among farmers. The number of agricultural machinery owned by farmers is shown in Table 4.2. As seen in the Table, during the past 1.5 years the number of power tillers has almost doubled from 35 to 67. Due to deficiencies in the existing road network and inappropriate distribution of farmlands and farm roads, the shortage of farm roads is the most important factor in slowing agricultural mechanization.

Farm roads will be hand over to farmers after two years observation period. Hence, considering operation and maintenance, the project excludes the routes which are evaluated to have small traffic volume in the future.

Regarding the route connecting between Degolo and Taju in Wangchang Gewog, the plan has been changed to utilize the construction road for river protection work along the River Paro through the discussion with the Government of Bhutan.

TABLE 4.1 IRRIGATION CANAL

No.	Canal	Gewog (District)	Source of Water	Canal Length (km)	Command Area (ha)	Priority A	B	C	Main portions imporved
1.	Shaba-Shengo	Shaba	Paro River	1.77	10.1	o			Intake weir
2.	Sing-kana	Shaba	Stream	2.30	48.6		o		Provision of material Pipe - 30 x 5 = 150 m
3.	Bathumu	Shabe	Paro River	2.31	49.0	o			Intake weir
4.	Dujey-Dinkha	Shaba	Paro River	1.78	78.6	o			Intake weir
5.	Mayu-Nemjo	Luni	Paro River	3.93	63.0			o	
6.	Serekha	Luni	Stream	2.10	66.8	o			Intake weir Rehabilitation 300 m
7.	Jimtshe	Luni	Stream	1.08	56.7			o	
8.	Tshechukha	Wangchang/ Shaba	Paro River	1.10	93.2	o			Intake weir. Pipe line (Proposed Land Consolidation)
9.	Lungkha	Wangchang	Stream	0.69	89.7			o	
10.	Jachey (Khangkhu)	Wangchang	Patro River	3.13	43.1			o	
11.	Kampa-Thangyul	Shari	Dotey River	1.86	24.3	o			Intake weir
12.	Gisi-Chawa	Shari	Dotey River	1.50	101.3	o			Intake weir
13.	Sharimo-chu	Shari	Stream	1.23	60.8	o			Intake weir (Same Richu) pipe line system
14.	Richu	Shari	Stream	2.38	24.8	o			Intake weir (Sharimo-chu) up-stream pipe line
15.	Damte-Yuwa	Shari Horey	Dotey River	2.64	162.0	o			Intake weir
16.	Thachukha	Shari Horey	Stream	1.80	16.2			o	
17.	Jangasa (Min. Hydro)	Dotey Shari Horey	Dotey River	5.264	88.7	o			3.5 km U flume or pipe
18.	Gonju	Lango	Stream	2.5	142.8			o	

(continued)

No.	Canal	Gewog (District)	Source of Water	Canal Length (km)	Command Area (ha)	Priority A	B	C	Main portions imporved
19.	Chendo-Chukha	Lango	Paro River	3.0	102.3	o			Intake weir (concrete) Division Structures
20.	Guyamey-Jagathang	Lango	Paro River	3.7	121.5			o	
21.	Bamdoley	Lango	Paro River	1.92	81.0	o			Up-stream length renovation (insufficient section)
22.	Doshom-Menchu	Dotey	Paro River	3.3	47.0		o		Several portion leakage 7 x 30 = 210 pipe provided.
23.	Tshokona	Dotey	Paro River	1.56	64.8		o		Rehabilitation of 200m lining. Material supply
24.	Chento-Shari	Chento	Paro River	2.77	32.4			o	
25.	Damphu	Chento	Stream	1.70	28.4			o	
26.	Shhezi	Chento	Stream	3.8	110.2			o	
27.	Gnyamjay	Chento	Stream	1.65	20.4			o	
28.	Rema Thangyo	Lango	Paro River	1.47	64.78	o			
	Total:			64.234	1,892.48				

Priority	Canal length	Command Area
A	30.324 km	1,007.68 ha
B	7.160	160.4
C	26.75	724.4
Total:	64.234 km	1,892.48 ha

TABLE 4.2 PRIVATE OWNERSHIP OF FARM MACHINERY AND EQUIPMENTS AS OF 31ST MARCH, 1989 IN PARO VALLEY

Sl No.	Gewog	Tractor	Power Tiller	Power Thresher	Water Pump	Rice Mill	Winnower
1.	Luni	7 (7)	11 (7)	4 (4)	1 (1)	15 (13)	18 (17)
2.	Dotey	3 (3)	(-)	- (-)	- (-)	11 (10)	5 (5)
3.	Wangchang	3 (3)	12 (5)	2 (2)	1 (-)	15 (11)	7 (7)
4.	Shari	4 (1)	19 (11)	3 (1)	4 (2)	17 (14)	10 (10)
5.	Lango	4 (2)	11 (6)	3 (3)	4 (1)	23 (20)	7 (5)
6.	Tsento	- (-)	2 (2)	2 (2)	- (-)	14 (10)	3 (3)
7.	Doagar	2 (2)	- (-)	- (-)	- (-)	9 (7)	- (-)
8.	Hore	1 (1)	2 (-)	- (-)	- (-)	3 (2)	- (-)
9.	Shaba	1 (1)	9 (4)	- (-)	2 (2)	4 (4)	6 (5)
10.	Naja	- (-)	- (-)	- (-)	- (-)	3 (3)	- (-)
	Total	25 (20)	67 (35)	14 (12)	12 (6)	114 (94)	56 (52)
Total in Project Area		23 (18)	67 (35)	14 (12)	12 (6)	102 (84)	56 (52)

Note: Number in parenthesis denotes number of machinery as of 30 September, 1987.

Route connecting Bondey with Gebji as well as Panbesa, 5 km long, has been limited with mutual understanding of the Government of Bhutan to route connecting Bondey with Gebji only, 1.8 km long, considering overlapping with existing farm roads.

Priority of farm roads was evaluated using the following criteria:

(a)	Benefit area (per 1 km)	above 30 ha.....	A1
		.....	B1
		below 17 ha	C1
(b)	Number of houses (per 1 km)	above 10 family.	A1
		...	B2
		below 9 family.	C2
(c)	Gradient of farmland (%)	below 5%	A3
		.....	B3
		above 15%	C3

As a general rule the following criteria were applied.

A: - Two or more of A, and not including C3,
or,
- one of A, and others of B.

B: - Two of B, and others of C but not including C3.

C: - Including C3.

Total length of farm roads requested was 64.7 km, however, the actual length necessary for improvement was reduced to 45.35 km as a result of the survey. Priority of the farm roads is shown in Table 4.3, and their locations is shown in Fig. 4.1. Total length by priority is given below.

A: 26.75 km
B: 6.80 km
C: 11.80 km

Table 4.3 PRIORITY OF FARM ROAD

No.	Length (km)	Benefit Area (ha)	Area/L (ha/km)	No. of Houses	N.H./L (No./Km)	Gradient of Farmland (%)	Priority
1	3.7	118	31.9	34	9.2	10	B
2	3.7	108	29.2	73	19.2	10	A
3	1.8	41	22.8	19	10.6	7	B
4	0.5	19	38.0	5	10.0	less than 5	C
5	1.3	33	25.4	20	15.4	27	C
6	1.75	43	24.6	38	21.7	less than 5	A
7	1.3	35	28.9	18	13.8	20	B,C
8	1.8	50	27.8	20	11.1	11	A
9	6.8	116	17.1	95	14.0	10	A
10	10.0	111	11.1	69	6.9	20	C
11	9.5	310	32.6	174	18.3	7	A
12	3.2	50	15.6	32	10.0	less than 5	A

(3) River Protection Works

Damaged area was reported to be 445.8 ha in the 1968 and 1973 flood, of which 111.9 ha, about quarter, was caused by the main rivers Paro and Dotey and others by deposits from small streams. 1973 flood was induced by the exclusive track of Cyclone. Therefore, the possibility of future damage by flood deposits of sand gravel is considered to be small. Hence, river protection works against inundation and erosion was planned for the main rivers.

The conditions of the sites for the river protection works are described below (see Table 3.7):

Nos. 1 and 2:

On both sides of the River Dotey, existing revetments are relatively satisfactory, but due to the meandering of the rivers, the flow capacity is insufficient in some parts. Erosion is in progress on farmlands of the right bank and on farm roads on the left bank.

No. 3:

It is judged that due to the adequate width of the River Paro, sufficient flow capacity can be achieved by training the river course. There is a section extending about one km in which the vertical section

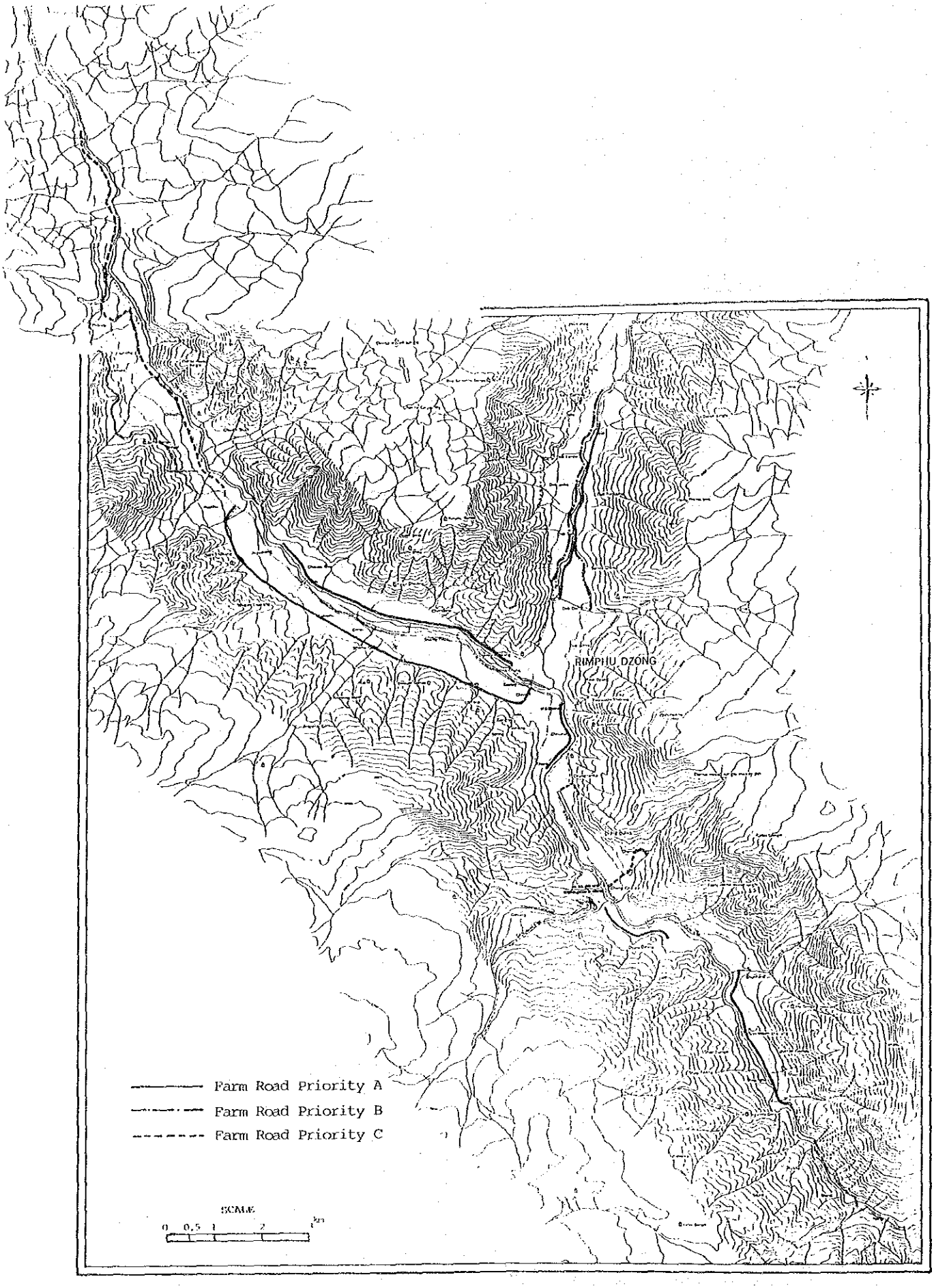


Fig. 4.1 PROPOSED FARM ROADS

of erosion is visible and a countermeasure is needed urgently. In Shendo Gon and Chendona, farmlands of 4.4 ha and 4.0 ha respectively were washed away by the 1968 flood, and they have not rehabilitated so far. It is evaluated that farmers will not be able to rehabilitate them.

No. 4:

This site has not recovered completely from the 1968 flood. There are places where the cross-section of the river has been reduced by construction work of gabion and are apt to be flooded. Therefore, further study will be required on river run-off analysis.

No. 5:

Flood damage may occur in the future, because the opposite side was already protected by river revetment for the airport. Accordingly, river protection work will be required.

No. 6:

Sand deposited during the 1968 flood still remains. The river section at this site has been reduced compared to that of upstream. Accordingly, the section shall be enlarged.

No. 7:

Farmlands were washed away by the 1968 flood, and they have never been rehabilitated. It is evaluated that farmers will not be able to rehabilitate them.

Nos. 8 and 9:

River gradient, at upstream of the national highway, are unstable due to the presence of large rocks. Riverbed excavation will be required to keep discharge capacity of the river.

No. 10:

Due to sediment discharge during the 1968 flood, the river course has changed. The discharge capacity must be increased by increasing the width of the river. Road elevation must be lifted by embankment at some part of the existing farm road.

As for priority of the above 10 sites, the following criteria were applied.

A: - Possibility of erosion on farmland is high,

or,

- Farmland development can be executed by farmers at their own expense, if the area damaged is protected by river revetments,

or,

- The river section is narrow, and inundation is apt to occur.

B: - The river section is wide, and possibility of inundation is small,

or,

- Flood areas where the possibility of farmland development is high.

C: - Flood areas where the possibility of farmland development is low,

or,

- Relatively stable section of river.

Total length of river revetments requested was 39.3 km. However, based on the survey the length finally decided was reduced to 25.53 km. Priority of river revetment with length is given in Table 4.4, and their locations in Fig. 4.2. Total length by priority is given below.

A: 15.20 km
B: 7.03 km
C: 3.30 km

(4) Farmland Consolidation

As candidates for the project implementation, two sites have been selected. They are: i) the Changkha - Thang area on the left bank downstream of Bondey Bridge in Wangchang Gewog, and ii) the Damji and Jukha area in Shari Gewog on the left bank of the River Dotey.

i) Changkha - Thang Area

This is a 28 ha area bounded by the mountain and the national highway located on the left bank of the river. In this area, flat farmlands extend widely, and one irrigation canal covers the whole area. Sediment from mountainous areas caused by the 1968 flood still remain in

TABLE 4.4 RIVER PROTECTION WORK PRIORITY

Sl.No.	Name of River	Embankment Left/Right	Starting Point	Ending Point	Length (km)	Priority	Remarks
1.	Dotey	Left	Tsokhona	Changsima	3.7	A	Farm Road
2.	Dotey	Right	Chuba & Atso	Jhangsa	4.3	A	
3.	Paro	Left	Bamdoley	Jangsa	1.0	A	Eroded Farmland
					5.5	B	Enough River Width
4.	Paro	Left	Sengo-Tsekha	Chorten Sarpa	3.0	A	High Potential
					0.63	B	Low Potnetial
5.	Paro	Right	Nyemi-Zam	Khangku	1.75	A	Farm Road
6.	Paro	Right	Suspension Bridge	Drugye-Dingkha	0.9	B	Protection 400m Excavation 500m
7.	Paro	Right	Kesa		1.5	C	Farmland was almost washed away
8.	Woochu	Left	Gartsang	River Confluence	0.9	C	
9.	Woochu	Right	Gartsang	River Confluence	0.9	C	
10.	Gyebjana Rongchu	Right	Changchu-Lhakang	River Confluence	2.05	A	Riverbed Excavation
				Total	26.13		

the area. Some sediments have been collected and piled at some places, but only in 5% of the entire area. The area is shown in Photo 3.

ii) Damji Jukha Area

This area was badly damaged by sediment discharges from small streams flowing from mountainous areas during the 1968 flood. About one-third of the proposed farmland consolidation with 30 ha land area is still covered by the sediments, and presently no crop is cultivated there. This area is irrigated by three canals, and the farm fields have relatively sharp slopes towards the mountains. The national highway passes through this area, connecting it to the museum.

In selecting areas for farmland consolidation, the following criteria were applied.

(i) Farmlands are flat in general.
(ii) Irrigation systems are not overlapped.
(iii) The proposed area is relatively independent.
(iv) The location is good for demonstration.

According to the above criteria, it was judged that Changkha - Thang area should be selected, and in regard to Damji - Jukha area, attention should be given to rehabilitate the damaged farmland by removing sand and gravel.

(5) Concrete Plant

The concrete plant originally requested by the Government aimed to manufacture concrete blocks for irrigation canals and river revetments, however, the field reconnaissance confirmed that it was better to use gabions for river revetments instead of concrete blocks. The gabion can be make of boulder stones available in sufficient quantity on the local riverbeds. This method is effective and popular in the country.

Irrigation canals, on the other hand, are not maintained well and leak in many points. It causes water shortage in the area. Consequently, it is proposed that a concrete plant be constructed to manufacture precast

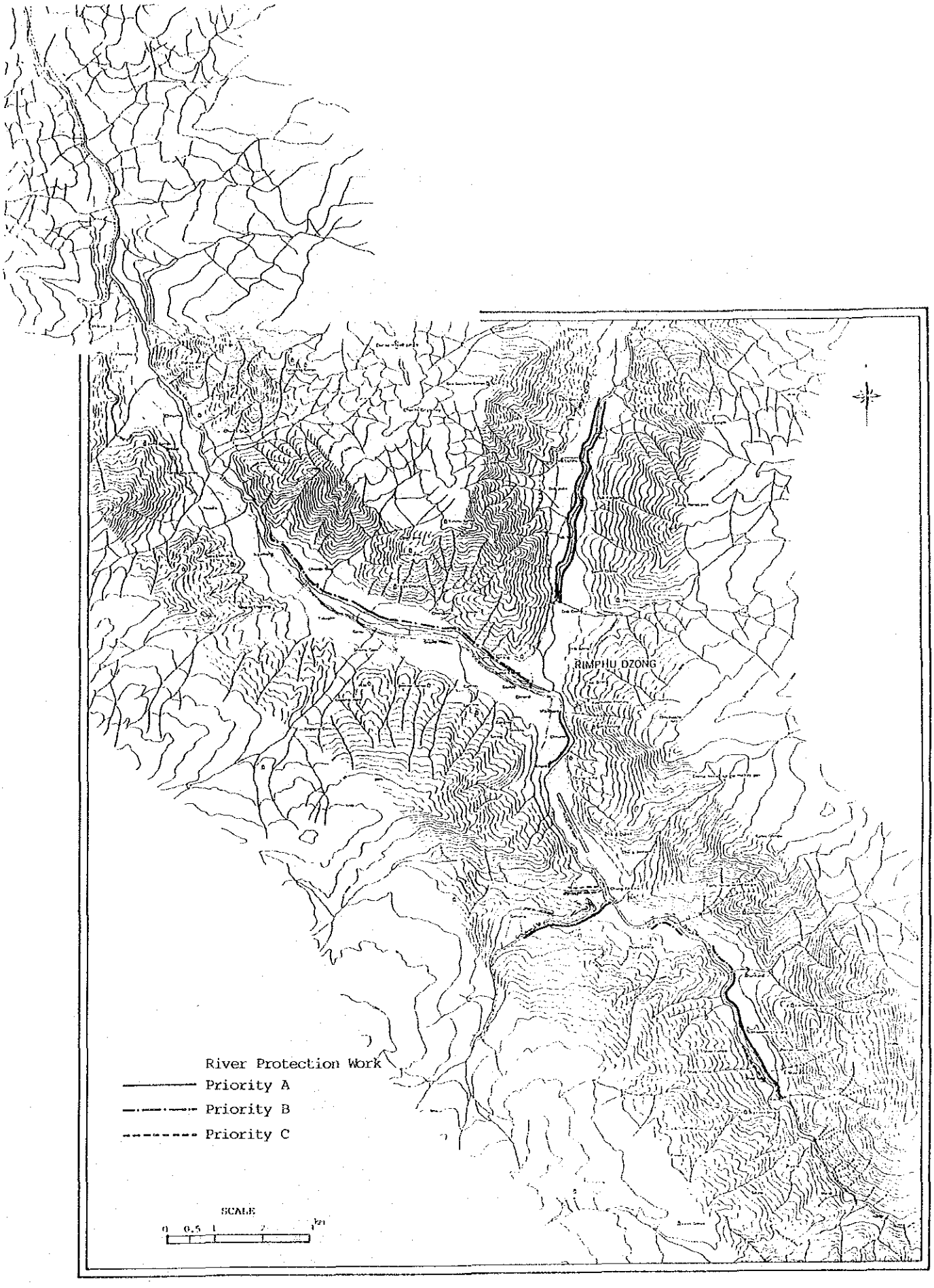


Fig. 4.2 PROPOSED RIVER PROTECTION WORKS

concrete products such as U-shaped blocks, which are superior in installation and cost for canal consolidation. In addition, it is also necessary to construct a stone crushing plant to supply aggregate for concrete and crushed stones for farm road construction.

(6) Construction Machinery

The supply of construction machinery has been requested by the Government of Bhutan for the construction of irrigation canals, farm roads, river protection works and farmland consolidation, which will be executed in the project.

In Bhutan the national highways, one of the main infrastructures, are maintained by BRTF, and the government agencies have not enough machinery. Private contractors are still under development and number of their machinery is limited. Equipment requested by the Government of Bhutan are evaluated, considering construction quantities for the components of the master plan as well as construction period.

Earthwork equipments are selected in consideration of balance of loading machines and hauling equipments. Numbers and sizes of the equipments are estimated using construction plan of Critical Path Method based on the combination of Backhoe 0.6 cu.m with Dump Trucks 11 tons. Details are shown in 6.1 "Equipments and Plants"

(7) Borrow Area

The site for the borrow area proposed by the Government of Bhutan was Chundudingkha in Luni Gewog. This site is located about 10 km downstream of the confluence of River Paro and River Dotey. In view of the large amount of construction work, the collection of soils at this site would not always be economical, and for improving of farm roads, which requires the hauling of a great amount of soil, an appropriate borrow area should be selected near the proposed farm roads. Through the confirmation on the available amount of soil by a hand-auger (as shown in Photo 4), soil classification by the visual method, and survey on the possibility of land acquisition, the appropriate sites for borrow area were confirmed as shown in Fig. 4.3.

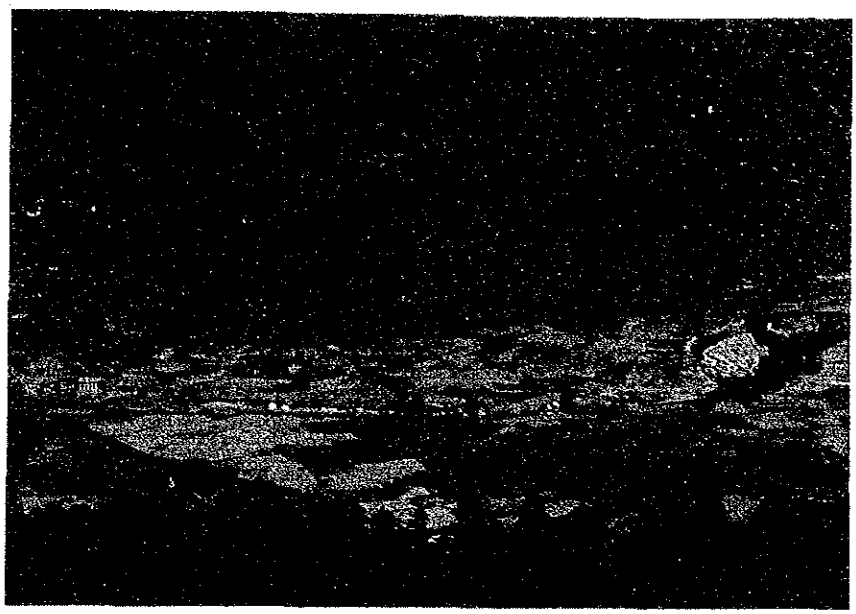


Photo 3 PROPOSED FARMLAND CONSOLIDATION AREA

Photo 4 HAND-AUGER SURVEY

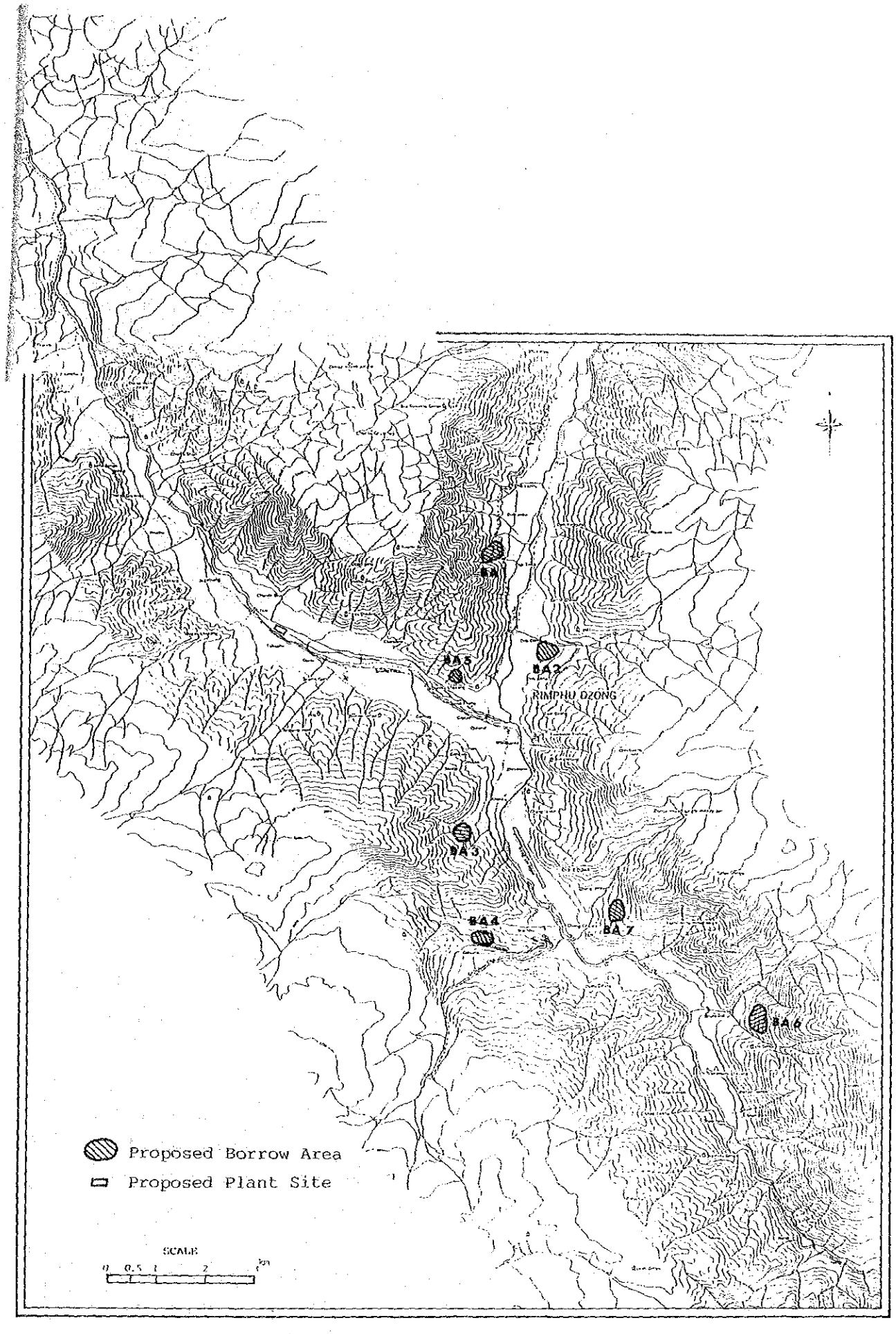


Fig. 4.3 PROPOSED BORROW AREA

The proposed borrow area of Juka Zingkha in Shari Gewog is an area damaged by the 1968 flood. This site was selected taking into account that the area could be restored to farmland by removing the accumulated deposits as material for farm roads embankment.

Soil materials are less found in the lower portion and proper soil materials are found mainly in the higher portion, 40 - 50 m high from the existing roads. Soil balance should be taken between excavation and embankment except farm roads accompanied by the river protection works.

(8) Quarry Site

In the plan prepared by the Government of Bhutan a quarry site was proposed at the steep foot of the mountainous area along the national highway in the Shaba Gewog. Based on the survey, it was concluded that boulders, riverbed material from the River Paro and the River Dotey should be utilized as raw materials for crushed stones. The reason is described below.

(i) The proposed site is located about 20 km downstream of the confluence, and further downstream than the farthest downstream site proposed in the Paro Valley area. In view of the long hauling distance, this site is considered uneconomical.

(ii) The proposed quarry site is located at a nearly vertical mountain slope along the national highway. The national highway will have to be closed in the case of blasting. In order to facilitate the regular passage of vehicles, enormous expenditure would be required.

(iii) Rocks from this site need to be broken down to suitable size for the crushing plant. The rocks are judged to be uneconomical in view of high percentage of waste fines due to the weathered zone contained.

(iv) There is a temple near the crest of the mountain, and the surrounding area is designated as a sacred precinct. By quarrying in the area, the national environment would be affected.

Riverbed rocks in the Paro were brought to Japan and tested, the result of which is given in Annex 7. The rocks were judged to be of a suitable quality.

4.2.3 Constraint to Project Implementation

Shortage of ordinary labor force and shortage of operators for construction machinery, annual limiting working period, and compensation for land acquisition in related to the implementation of farm roads, and farmland consolidation are considered as constraints to the project implementation.

(1) Labor Force

In Bhutan the shortage of labor is serious. Furthermore, at the meeting with the Ministry of Agriculture, it was strongly requested that the Project also promote mechanization. About 200 foreign labors under the control of India were employed for repair and pavement work on the national highway, and for the construction of runway extensions at the airport, showing the seriousness of the labor shortage.

As for mobilizing the the labor force for this project, the following method is planned by the Government:

(i) Farmers living in the beneficial area.
(ii) Labor force to be mobilized through the entire country by the National Work Force.

According to the study on the possibility of farmers' participation through discussions with members of the Steering Committee for the Paro Valley Agricultural Development Project, it was suggested that participation of laborers of about one-tenth of the total farmers on an average during the construction period of October to around May was possible. In this connection, the number of families in the eight Gewogs in the Paro Valley is 1,930.

The Ministry of Agriculture has a plan to recruit labors under the

National Work Force when required. In fact, according to the survey, it was found that during the construction period of the Punkha Wangdi Valley Development Project, 80-90 labors recruited under the National Work Force had been engaged in the construction works. Considering the above matters, it is expected that disturbances caused by the shortage of labor would be relatively small as long as mechanization is promoted.

(2) Operators for Construction Machinery

The employment of foreign laborers within the country has been strictly limited by the Government of Bhutan. Therefore, during the project period the operators must be planned to be Bhutanese. The Bhutanese operators who have been trained in the AMC are listed in the Annex 13. As seen in the list the total number is 41. Considering that some operators will be engaged in other projects, about 30 operators will participate in this project. In view of construction period and amount of construction work, the shortage of operators may be an obstacle to construction, therefore, an increase in the number of operators through training prior to the project implementation is necessary.

(3) Construction Period

The annual rainfall in the project area is about 700 mm, and the climate is divided into a rainy season (June to September) and a dry season (October to February). Rainfall during the rainy season is 120 - 200 mm monthly, and the total amount of rainfall during the four months occupies about 80 per cent of the total annual rainfall. Therefore, as for the main construction period, the dry season of October to May shall be effectively utilized. It is considered adequate that the annual working period is to be about eight months for irrigation facility works. Actual working days during eight months will be about 165 days, which is taking into account 60 days for Sundays and festival days, about 20 days for busy days for farming, about 25 days reserved for rainfall and so on.

The earth work is affected by rainfall and temperature. An average working days are 293 days annually, calculated from the climatic data at the Bondey Farm. However, considering holidays, annual working days

is planned to be 252 days for the project.

(4) Compensation for Land

As for compensation for lands utilized in agricultural development projects, the government does not participate at all, rather, it is conducted by mutual cooperation among farmers concerned.

This is a method in which all farmers living in an area that will benefit from an agricultural development project compensate equally to farmers who own land that has been used for that project. Also in the case of the current project, the compensation of lands will be conducted based on the above system. This matter has been confirmed through discussions with members of the Steering Committee, and with farmers concerned.

4.3 Similar Project

During the survey period, a site survey on road construction work of the Punkha-Wangdi Valley Development Project was conducted. It is included in the 6th Development Plan (1987-1992), and the construction work of roads was commenced five years before. The construction work was initially started by the Ministry of Agriculture, however, due to a shortage of construction machinery in the Ministry, the work was transferred to the PWD for continuation. In accordance with change of policy on foreign labor force, 80-90 labors per day are employed at present, instead of the former 130 imported labors.

It was confirmed that land acquisition was not paid when the route passed through the existing farmland, and that farmland ownership was adjusted among farmers.

Construction work is continued during rainy season, however, maintenance is main work during that season. Due to poor balance between equipments, slopes excavated without excavator are left to be vertical and apt to be damaged during rainy season.

Construction machinery actually being utilized is listed below:

Bulldozer	: 1
Portable compressor	: 1
Jackhammer	: 2
Dump truck	: 2
Roller (8 tons)	: 1

PWD has more construction equipments compared to the Ministry of Agriculture, however, its equipments are not judged to be enough for big construction works.

Chapter 5. MASTER PLAN

5.1 Basic Policy

In order to make maximum use of the existing agricultural basis whose main components were previously decided in the direction of agricultural promotion, the master plan for the current project is to improve and maintain the agricultural basis and thereby secure water for agricultural use, introduce effective farming methods and preserve the farmlands. With regard to irrigation canals, farm roads and river protection works, a comprehensive plan of rehabilitation and consolidation should be formulated. Moreover, with respect to farmland consolidation, a pilot farm will be set up in the project area with a view to benefiting not only the Paro Valley area but also numerous other areas.

Through the implementation of the project, it is hoped that the importance of providing and maintaining a sound agricultural basis will be recognized nationwide, and that the project will be serve as a model for promoting active farmer participation. Implementation schedule of the project shall be established on the basis of the priority examination. Construction work should be mechanized as much as possible to effectively realize it.

5.2 Implementation Agency

The project is to be carried out by the Department of Agriculture, a subordinate organization of the Ministry of Agriculture, Bhutan.

During and after the project implementation, management of construction equipments and plants is to be done by AMC in Paro. AMC has a Hire Service Division, which has their own budget to procure spare parts and will have enough ability to maintain the procured equipments in the future. AMC also has the Agricultural Machinery Training Centre, where training of operators for construction equipments will be carried out as the six months course for the implementation of this project.

5.3 Implementation Schedule

After examining the validity of the grant aid project - especially its urgency, importance, total project cost and the number of years for implementation - on the basis of the priority plan for the various components examined earlier in preparing the master plan, a decision was reached to divide the entire project into Stage 1 and Stage 2; implementing Stage 1 in three phases and Stage 2 in two phases. Detail of the implementation schedule will be re-evaluated in Phase 2 Basic Design Survey. The implementation schedule, which was made based on the present information and will be re-evaluated in detail at Phase 2 Basic Design Survey, is shown below:

IMPLEMENTATION SCHEDULE

Stage	Year	Main Works
1	1	- The first procurement of construction machinery and plant equipment. - Construction of concrete plants. - Commencement of precast concrete blocks.
	2	- Irrigation canal : Nos. 17, 19, 21 - Farm road : Site 1 - River protection work : Site 2
	3	- The second procurement of construction machinery. - Irrigation canal : Nos. 28, 11, 12, 15 - Farm road : Site 2 - River protection work : Site 2
2	1	- Irrigation canal : Nos. 1, 14, 8 - Farm road : Sites 3, 4, 6 - River protection work : Sites 4, 5 - Land consolidation : 50 % of the area
	2	- Irrigation canal : Nos. 3, 4, 6, 13 - Farm road : Site 7 - River protection work : Site 7 - Land consolidation : 50 % of the area

Note : Stage 1 : Both sides of the River Dotey and left side of the River Paro, upstream of the confluence of both rivers.

Stage 2 : Right side of the River Paro, upstream of the confluence; and both sides of the River Paro, downstream of the confluence.

- As the works of irrigation canals will be placed heavily in Stage 1, some parts are scheduled to be transferred to Stage 2.
- Construction machinery will be procured mainly in Stage 1.1; and others for farmland consolidation in Stage 1.3.

5.4 Project Components

5.4.1 Irrigation Canals

Based on the results of the examination of the project components presented in 4.2.2, countermeasures for priority A, including construction of new facilities, is to be formulated and implemented. The major work for the 14 irrigation canals to be implemented in the project is as follows:

Rehabilitation of canals :

- Concrete lining : L = 5,000m
- Earth canal rehabilitation : L = 9,000m
- Steel flume (No.17) : L = 3,500m

Intake facilities :

- Concrete intake : 4 sites
  (Irrigation Canals 6, 13, 14, 19)
- Wooden mattress : 7 sites
  (Irrigation Canals 1, 3, 4, 8, 11, 12, 15)

Location of the major works is shown in Fig. 5.1.

5.4.2 Farm Roads

(1) Traffic Volume

Of all the road routes requested by the Government, those classified under Priority A will have traffic of less than 100 transporting vehicles per day. Cash crops, principally potatoes and apples, are the main items for transport, as nearly all of the paddy is consumed by the

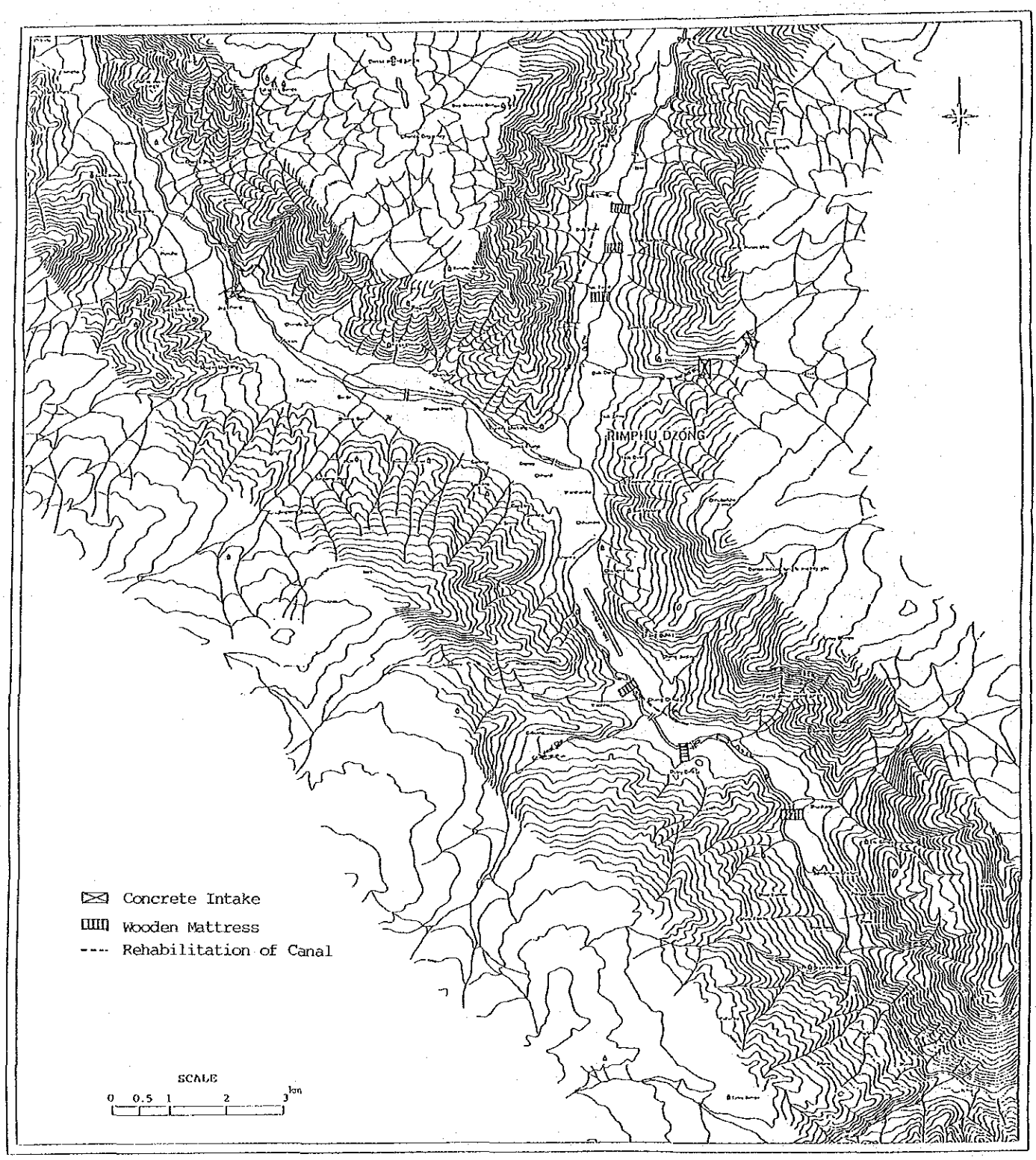


Fig. 5.1 IRRIGATION MAIN WORKS

farmers themselves. The traffic volume by route is estimated in the following table. Since farmers in Shaba Gewog live in houses located higher than the national highway, paddy is counted in the traffic volume in the case of the Chorten-Sarpa-Deankha route.

Traffic Volume Estimate

(Unit : ton)

Route	Potatoes	Apples	Paddy
Left bank of Dotey River	659	360	-
Upstream left bank of Paro River	366	325	-
Sa-Tsan Chorten-Geptey	398	327	-
Downstream of Dzongkhag Bridge	265	-	-
Bondey-Drugye-Dingkha	324	197	-
Chorten-Sarpa-Deankha	202	-	231

The above volume is estimated on the basis of the current output. The crop intensity is expected to rise as a result of brisk cash crop cultivation made possible by the new or improved farm roads.

In Kesa area, Shaba Gewog, has no access road to the highway in the appraisal, where cash crop productivity is high. Their product is hauled using small suspension bridge. In Chendo Gon area, Lango Gewog, the proposed farm road will connect with the Paro Market area, however, delivery of farm inputs and hauling of product will be carried out more effectively if new bridge is build instead of the existing Jagathan suspension bridge. Hence, the possibility of new bridges will be evaluated for two sites in Phase II Study.

(2) Agricultural Mechanization

The cropping intensity and the percentage of tractor and power tiller ownership are shown in Table 5.1. In Shari and Luni Gewogs, the rate of ownership of principal agricultural machines (tractors and power tillers) is relatively high, 10.8 percent in Shari and 9.1 percent in Luni. The rate in other Gewogs is 5 percent or lower. In Shari and Luni, farming will be further mechanized as new farm roads are

constructed. Lango, Wangchang and Shaba show high crop intensity, but mechanization has not progressed because of the imperfection of farm roads. Thus they can be regarded as areas where construction of farm roads will clearly promote the agricultural mechanization.

Table 5.1 Crop Intensity and Agricultural Machines

Gewog	Cropping Intensity (%)		Ownership (%) of Tractor and Power Tiller
	Wet Land	Dry Land	
Tsento	139	90	0.7
Lango	162	102	4.7
Wangchang	161	98	4.3
Hore	150	96	1.6
Dotey	143	92	3.0
Shari	149	99	10.8
Luni	146	100	9.1
Shaba	160	113	3.9
Total(Average)	153	99	4.7

5.4.3 River Protection Works

River protection works, given Priority A, will be constructed in the same stage and phase as the farm roads. River protection works are proposed below:

RIVER PROTECTION WORKS

- New construction : Site 1, L= 3.7 km(Left bank), gabion
  " , L= 3.7 km(Right bank), gabion
  Site 2, L= 6.5 km, gabion
  Site 4, L= 1.75 km, gabion
  Site 5, L= 2.05 km, riverbed excavation
  Site 7, L= 3.0 km, gabion
  Total L= 20.7 km

5.4.4 Farmland Consolidation

According to priority evaluation, farmland consolidation is planned for the Changkha - Thang area, where is irrigated by the canal No.8 and has benefit area of 28.3 ha and 30 households as beneficiaries.

(1) Lot Layout

The size and shape of a standard lot for farming will be determined by use of small and medium-sized farm machines, such as tractors and power tillers currently spreading in the Paro Valley, and by taking into account the fact that even in the flat areas, a single lot of a farmland is today 0.05 ha or smaller. Thus in the project area the minimum standard lot will be designated at 0.1 ha. One block will consists of eight lots, and the two blocks will be one unit for farming, as shown in Fig. 5.2.

The shape and arrangement of the farmlands were decided according to the following conditions:

a) The farm work plan for the farmland will be based on a system of medium- and small-sized machinery.

b) Intensive farming will be carried out for paddy and cash crops, and some secondary crops.

c) In principle, water for irrigation and drainage shall be completely separated to facilitate water management. Main and branch irrigation and drainage canals will be arranged to this end.

d) It will make it easier for farmers to go to their farmlands. It should be possible to operate water for irrigation and for drainage independently for each farming lot or block.

e) Farm roads will be arranged along the main or branch irrigation and drainage canals.

f) In the grading plan of excavation and banking, an effort shall be

made to minimize the total earth volume.

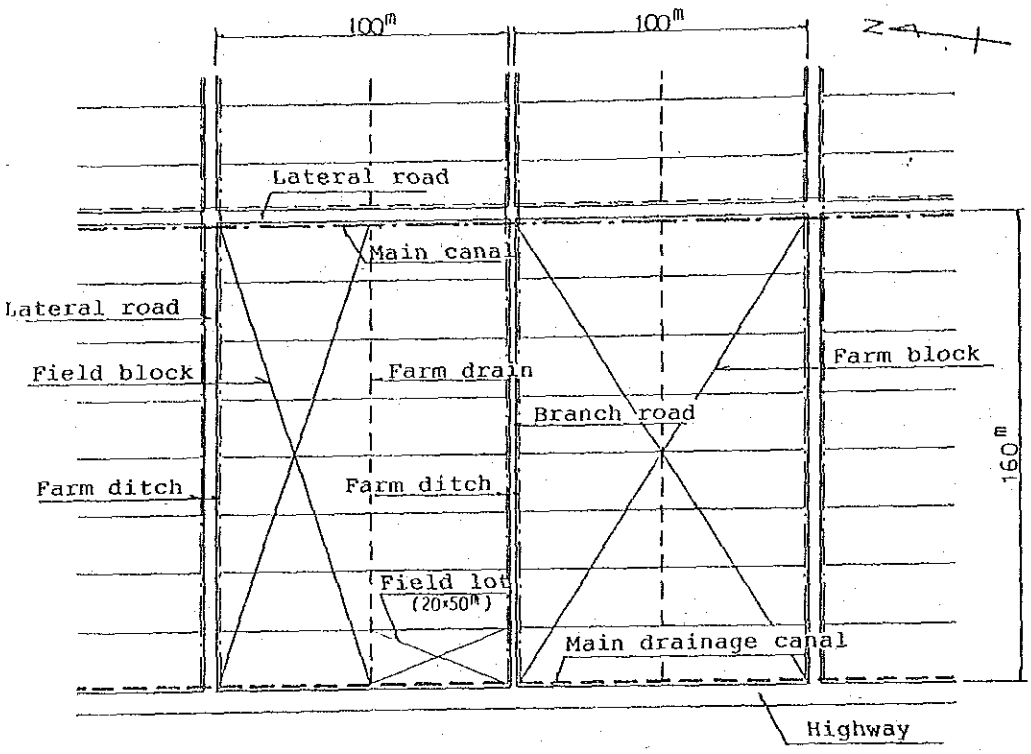


Fig. 5.2 STANDARD LOT

(2) Irrigation and Drainage Canals

1) Irrigation Canals

Canals will be planned to be open channels composed of concrete U-shaped blocks which are to be manufactured in the scope of the project. The section of the blocks will be designed so that water can pass through it at peak flow. In the case of small irrigation canals, the section at the upper reaches will be the same as that of the lower reaches. An intake gate will be installed on the side of the upper reaches along the branch canals. The gates used shall be ready made ones, and easy to operate.

Field ridges filled with earth shall be arranged along the border lines of each field lot. The section will have a upper width of 30 cm and a height of 30 cm. Its sectional shape will be a trapezoid with 1:1 slope.

2) Drainage Canal

The drainage canals will be of trench type. The section will be designed for maximum drainage of surface water.

(3) Topsoil Treatment

The farmlands in the project area have a relatively thin effective layer of topsoil. The subsoil are different from topsoil in their characteristics, hence topsoil shall be removed and pushed to the field edges with a bulldozer. After the base of the subsoil is leveled, the topsoil is returned. In this case, thickness of the topsoil will be as deep as the present surface soil, or 15 centimeters at the maximum.

Small stones in the subsoil should be removed at the ground-leveling stage of execution.