THE KINGDOM OF BHUTAN

MINISTRY OF AGRICULTURE AND FORESTRY

FEASIBILITY STUDY ON THE LHUNTSHI AND MONGAR INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT

MAIN REPORT

JANUARY, 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

No.

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国際協力事業団 18859	

PREFACE

In response to a request from the Royal Government of Bhutan, the Japanese Government decided to conduct a feasibility study on the Lhuntshi and Mongar Integrated Agricultural Development Project and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to the Kingdom of Bhutan a study team headed by Mr. Takayoshi YAMAZAKI, Nippon Koei Co., Ltd., twice during the period from December 1987 to September 1988.

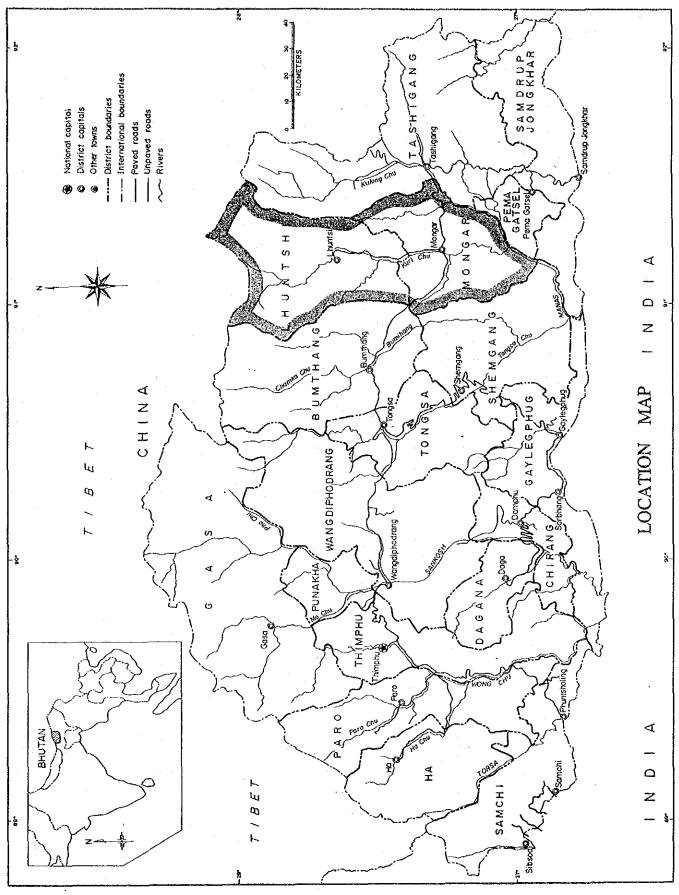
The team exchanged views with the officials concerned of the Royal Government of Bhutan and conducted a field survey (in Lhuntshi and Mongar Districts). After the team returned to Japan, further studies were made and the present report was prepared.

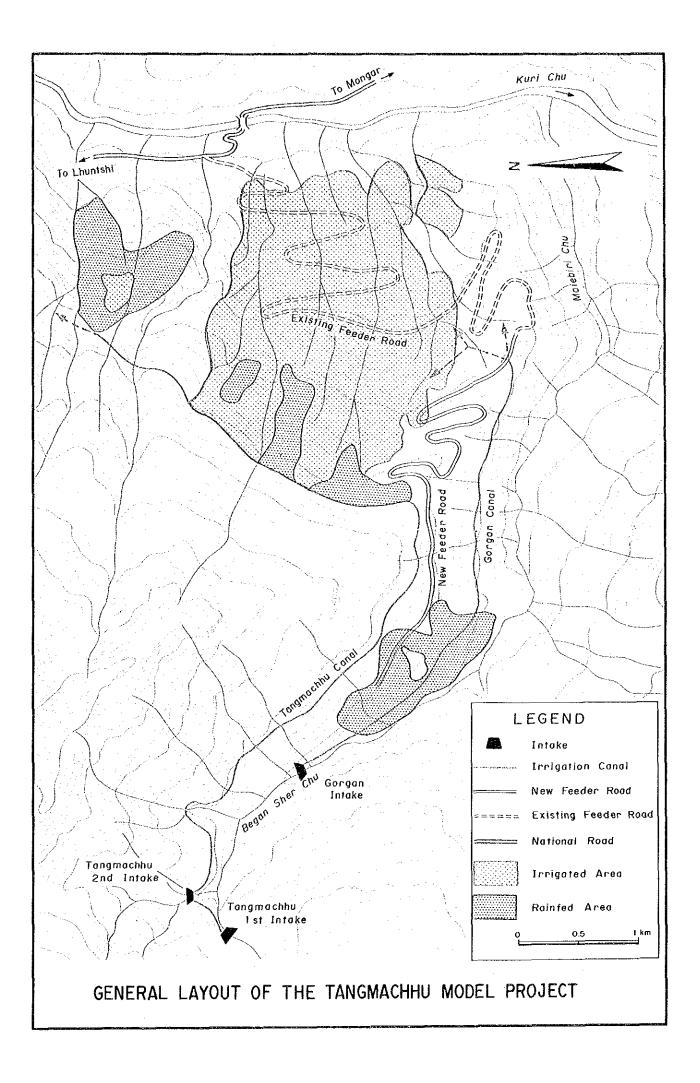
I hope that this report will contribute to the development of the Project and further to the promotion of friendly relations between our two countries.

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

January, 1989

Kensuke Yanagiya President Japan International Cooperation Agency

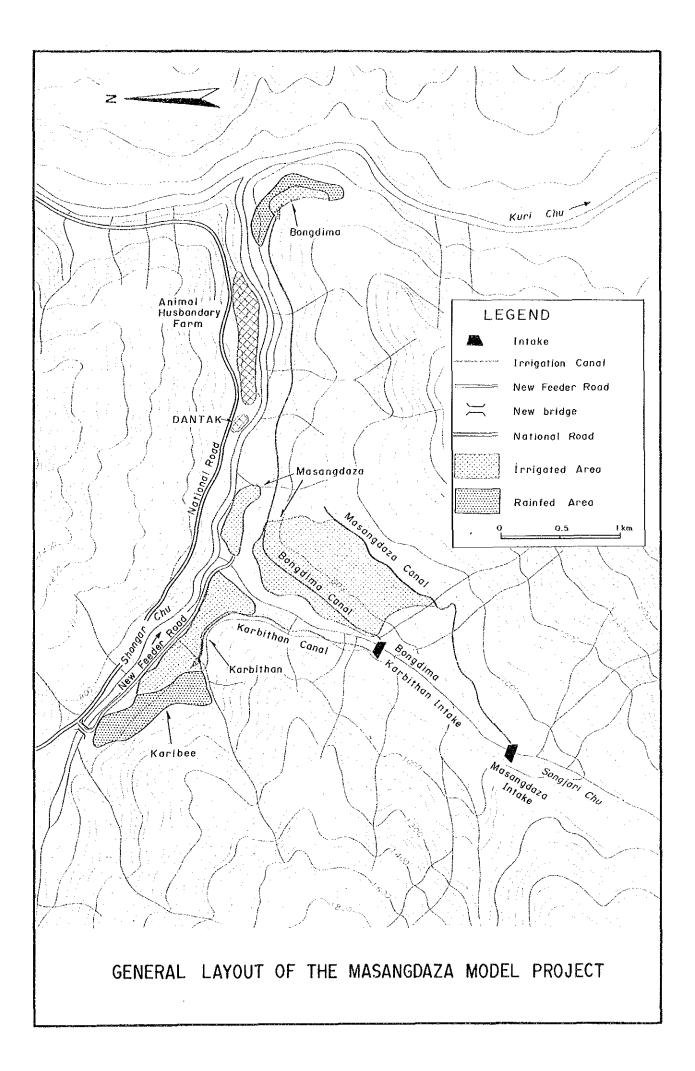




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BASIC DATA OF BHUTAN

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		opulation	(1986)			•	million	• .	
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			5 - 14			22.1	8		
			15 – 54 55 and ove	er		50.9 9,4			
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	· · · ·								
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						·		•	10 P
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· · · ·						. '			
			EXCHAN	IGE RAT	ES (Nu/US	\$).			
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	1.00 0.0	0 2.40	10.10	11.50	12.57	12.01	12.72		
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	· . · · ·		8.3 millid		-	PAYMENTS	(1986/87)	Nu 323	.0 million
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SUMMARY

INTRODUCTION

1. This is the "Final Report" for the Feasibility Study on the Lhuntshi and Mongar Integrated Agricultural Development Project (hereinafter referred to as "the Study") which is drawn up in accordance with the "Scope of Work" agreed upon between the Royal Government of Bhutan through the Ministry of Agriculture (MOA) and the Japan International Cooperation Agency (JICA) on July 26, 1986.

2. The study was conducted from December 1987 to November 1988. The objectives of the study were to formulate the Integrated Agricultural Development Plan in Lhuntshi and Mongar Districts, and to access the technical soundness, economic and financial viability of the identified projects.

3. The study area covers the Lhuntshi and Mongar Districts including sixteen (16) existing or proposed small irrigation areas along the Kuri chu which flows through the study area.

BACKGROUND

4. The Kingdom of Bhutan is a small landlocked country with an area of 46,500 km². Because of the rugged mountain country, flat land is scarce and small valley basins are dispersed throughout the country. The population is estimated at about 1.3 million with a low density of 28.2 persons/km² in 1986.

5. The main industry of the country is agriculture and 90% of the population is engaged in the agricultural sector. The economy is based primarily on subsistence oriented communities. Total estimated GDP in 1986 amounted to Nu 2,678 million at current prices, in which agricultural sector accounted for almost half (51%) of GDP. Per capita income was estimated at US\$160 in 1986.

6. Agriculture is intensively practised to produce mainly staple foods of rice and maize on small fields scattered on the steep mountain slopes. However, self-sufficiency in these basic cereals has

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not been achieved yet, resulting in the import of more than 28,000 t of cereals a year from India.

7. To overcome this situation, the Royal Government of Bhutan has launched the 6th Five Year Development Plan, in which the target for the agricultural sector is national self-sufficiency of staple foods and an increase in farmers' income. Furthermore, for equitable distribution of social welfare throughout the Kingdom, development of the remote eastern region, where development has been behind in comparison with other regions, is being emphasised.

8. The Royal Government of Bhutan, therefore, requested the Government of Japan to extend technical cooperation for the feasibility study for the Lhuntshi and Mongar Integrated Agricultural Development Project in August 1985. In response to the request, the Government of Japan agreed to provide the technical cooperation and entrusted the project to JICA.

PRESENT CONDITION OF THE STUDY AREA

9. The study area is the two contiguous Districts of Lhuntshi and Mongar from north to south in the eastern region of Bhutan. The maximum north-south distance and east-west distance of the study area are 125 km and 50 km respectively.

10. The study area slopes from north to south, with the altitude ranging from over 4,000 m in the northern part to about 300 m of the Kuri chu level at the southern edge of the area. The study area is generally classified into two climatic regions i.e. (i) the hot and humid subtropical area of the southern foot hills, and (ii) the cooler region of the inner Himalaya.

11. The population of Lhuntshi and Mongar Districts is estimated at 42,100 and 77,20 respectively, and have 53 and 119 villages covered under 8 and 11 blocks.

12. Total area of the study area is about 5,600 km^2 consisting of 3,400 km^2 in Lhuntshi and 2,200 km^2 in Mongar. The following present land use in the study area is estimated using the latest Landsat data:

	Lhunt	shi	Mong	ar	Tot	al
Item	(ha)	(%)	(ha)	(%)	(ha)	(%)
Paddy field	1,700	(1.5)	1,300	(0.7)	3,000	(1.0)
Upland and pasture	12,100	(11.0)	22,200	(11,5)	34,300	(11,3)
Bare land	1,300	(1.2)	3,500	(1.8)	4,800	(1.6)
Sparse forest	11,400	(10.3)	18,800	(9.7)	30,200	(9.9)
Dense forest	84,000	(76.0)	147,500	(76.5)	231,500	(76.2)
Total	110,500	(100.0)	193,300	(100,0)	303,800	(100.0)
Total study area	340,000		220,000		560,000	

13. Agricultural land is classified into three categories i.e. wet land, dry land, tsheri land. Wet land is terraced and bounded and usually cultivated for paddy under irrigation but often rainfed condition. Dry land, usually sloping fields and not terraced, is permanent fields for the cultivation of upland crops under rainfed condition. Tsheri land is under shifting cultivation and used for upland crops once every five to six years.

14. At present, less than 15% of the cultivated land has been assured by irrigation water, and agricultural production largely depends on the monsoon. The irrigation water is taken from the small tributaries of the Kuri chu, and conveyed to the paddy field by open canal system in all schemes. Most of the irrigation systems are not functioning fully and not secured with adequate water supply due to no permanent intake structure and no canal protection facilities.

15. The main cereal crops are paddy, maize, wheat, millet and barley. Paddy is cropped on the terraced land under irrigation at altitudes lower than 2,000 m. Maize is the dominant crop on dry and tsheri lands at middle hill (800 - 1,600 m) and foot hill (lower than 800 m). Wheat, barley and buckwheat are the main crops on dry land at upper hill (higher than 1,600 m).

16. Generally, unit yields of main crops are lower than those of the country average. The low yields of the crops are caused by various factors on irrigation water supply and farming practices. While shortage of water is the present most serious reason.

17. Farming practices have changed very little, retaining labour intensive practices and using only limited modern technologies. Farming practices are usually carried out by family labours, but most

of farm households provide and exchange labours, as well as draught power.

18. Field surveys have shown that most of the farmers are owner operators. The average farm size of owner operators is 1.7 ha in Lhuntshi and 1.1 ha in Mongar. Limited farm and non-farm cash incomes are mostly spent on the living expenses and the net reserves are negligibly small.

19. Extension works in the field are carried out by agricultural extension workers appointed at each block of the district. There are no any agricultural research and experiment stations except the animal husbandry farm at Lingmethang, Mongar. Agricultural support activities are limited to only extension matters.

20. The surplus of basic grains, mainly paddy and maize, is traded within villages and/or with neighboring villages and sometimes bartered for the other agro-product with other farmers. Cash crops other than basic grains are potato, soyabean, dry chill, orange, apple and vegetables. The main market for cash crops from the study area is Samdrup Jongkhar which is the border town in the eastern part of Bhutan.

21. The east-west national road linking Thimphu and Tashigang goes through Mongar District. Lhuntshi District is solely connected to the district capital from Mongar along the Kuri chu. Other feeder roads are steep and narrow foot paths. Electrification is limited to a few specific areas. Rural water supply beneficiaries are still less than 20% of the total population.

BASIC INTEGRATED AGRICULTURAL DEVELOPMENT PLAN

22. The physical and economic environment in the study area is in no sense fabourable for industrial development. On the other hand, the large majority of the rural inhabitants is engaged in agriculture and has acquired a certain level of techniques to increase production and to exploit their farm lands. Therefore, the prospects for development will heavily rely on agricultural development.

23. Mitigation of the agricultural development constraints is naturally required in order to accelerate the regional development to:

- 1) expand the regional economy through increasing agricultural production, and
- improve the farmers' present subsistence situation, together with adaptation or smooth transfer to a monetary economy.

The basic principles of the development correspond exactly to the agricultural development policy given in the Sixth Development Plan. Considering the absolute limitation of the physical resources, the possibilities for intensification of agricultural production basically lie in better utilization of existing land and water. The following basic integrated agricultural development plan has been conceived for the achievement of these objectives:

(1) Land Use

Owing to the limited land suitable for agriculture, agricultural land use should be planned taking following matters into consideration:

- Expansion of wet land
- Maintenance or improvement of soil fertilityConversion of tsheri land into dry land

(2) Agricultural Development

Increasing agricultural production will be attained by the following approaches, in combination with improvement and/or construction of irrigation facilities as well as promotion of agricultural mechanization:

- Increase of unit yields through introduction of suitable varieties and improvement of cropping system and farming practices
- Increase of cropping intensity through expansion of double cropping on wet land
- Encouragement of farmers to move into higher value crops e.g. promotion of cash crops

In order to increase agricultural production through the measures above, it will be essential to strengthen the agricultural support services such as research and extension in national, regional and project basis.

(3) Irrigation and Drainage Development

The following general priorities shall apply to the development of irrigation and drainage projects in the study area:

- In order to obtain the maximum benefits from project implementation and to secure the irrigation water supply instantly and constantly, existing facilities shall be renovated first.
- Operation and maintenance must be organized on a sound basis to maintain the facilities satisfactorily and for smooth operation.

 Any new irrigation and drainage development projects which have technical and economical advantages should be implemented.

(4) Other Rural Facilities' Development

The basic development plan for the other rural facilities was formulated as follows:

- Acceleration of agricultural mechanization
- Promotion of small scale agro-industry
- Establishment of workshop (a branch of AMC in Paro)
- Improvement of agricultural extension center

In addition to the above, the improvement of infrastructure such as roads, power and water supply will have an important impact in improving the living conditions of rural inhabitants as well as in increasing agricultural productivity. Thus it may be argued that improvement of the social infrastructures is urgently required.

APPROACH TO THE DEVELOPMENT

24. In view of the shortage of development funds and of trained personnel, full-scale implementation of the basic plans throughout the study area in the short-term is considered to be an impractical development approach. Hence the approach should be directed to the long-term, and step by step.

The following strategies for integrated agricultural development of the area are therefore recommended:

- Selection of priority project areas which have relatively large development potentials and which will spread effects to the other areas.
- Expansion of these project areas according to the availability of funds and personnel taking development experiences in the priority projects into consideration.

DEVELOPMENT PLAN OF MODEL PROJECT AREA

25. Selection of Model Project Area

Sixteen (16) project areas have been evaluated according to the criteria for selection of model project areas. Tangmachhu project area in Lhuntshi District and Masangdaza project area comprising of Karibee, Karbithang and Masangdaza including Bondima in Mongar District were selected for the model project area.

26. Present condition of the project areas is basically same as those in the study area. The present demographic and land use conditions in the project areas were summarized as follows:

Item	Tangmachhu	Masangdaza
I. Demography 1. No. of Local Villages 2. Population 3. Family Size	20 2,427 9.6	5 498 5 - 7
<pre>II. Land Use (ha) 1. Irrigated land 2. Rainfed land 3. Tsheri land 4. Others Total</pre>	220 114 95 <u>49</u> 478	30 81 3 <u>9</u> 123

27. The farm water requirement was assessed on a 10-day basis, deducting the effective rainfall from crop water requirement. The peak unit diversion requirements for each crop were estimated as follows:

Crop	Peak Uni Diversio	n Period nt 10-day	<u>Masangdaza Int</u> Peak Unit Diversion Requirement (1/s/ha)	Period
Paddy	1.49	Jun. 3rd	2.85	Aug. 2nd
Wheat	1.32	Nov. 2nd	0.95	Nov. 3rd
Mustard	0.85	Dec. 2nd	0.76	Mar. 2nd

The irrigable areas for respective crops guaranteed by the drought discharge at the lower proposed intake site were estimated as follows:

		(Unit:	ha)
Crop	Tangmachhu Area	Masangdaza	Area
Paddy Upland crops	221 334	148 473	

28. The following future land use plan were made on the basis of the above irrigable area, topographic conditions of the areas, and labour force availability:

		a dha an an 1977 an san <u>an</u>
Description	Without project Condition (ha)	With project Condition (ha)
Tangmachhu area		· · · · · · · · · · · · · · · · · · ·
irrigated land	170	220
(non-irrigated)	(50)	
rainfed land	114	114
tsheri land	. 95	0
others (rainfed)	49	144
total	478	478
Masangdaza area		· .
irrigated land	30	80
rainfed land	81	31
tsheri land (rainfed)	3	0
others (rainfed)	9	12
total	123	123

29. The following anticipated crop yields were estimated under assured irrigation system as well as proper water management with improved farming practices:

Irrigated Crops		Rainfed Crops	
Paddy Wheat Mustard	5.0 t/ha 1.8 t/ha 0.9 t/ha	Maize Soyabean Wheat Mustard Chilli (dried)	1.5 t/ha 0.5 t/ha 1.2 t/ha 0.6 t/ha 2.0 t/ha

The future crop production were estimated as follows:

	······		(Uni	<u>t: t)</u>	
	Tangma			Masangdaza	
Crops	Without	With	Without	With	
			· · · · · · · · · · · · · · · · · · ·		
Irrigated land					
Paddy	374	1,100	45	400	
Wheat	-	- 99		36	
Mustard	· -	50	· -	18	
Rainfed land					
Maize	183	85	44	47	
Soyabean	17	29	-	16	
Chilli	2	114	~		
Wheat	2	35	3	10	
Mustard	1	17	1	5	

30. The model projects have been formulated in line with the strategy of providing basic integrated agricultural development. The following components were selected for priority development:

(1) Irrigation and Drainage Development

The existing irrigation facilities are to be improved or new irrigation facilities to be constructed in order to improve the availability of intake water and the efficient water conveyance and water distribution as much as possible. The following main irrigation facilities are proposed for the model projects:

(a) Tangmachhu Area

- New construction, intake Tangmachhu 1st intake Tangmachhu 2nd intake	1	No. No. No.
Gorgan intake - Renovation, main canal Tangmachhu canal	8.6	
Gorgan canal	4.0	
-, New const'n secondary canal Tangmachhu secondary canal	0.4	km
(2 secondary canals to be combined)		
- Renovation, secondary canal Ngunmaling secondary canal Tangmachhu 2nd secondary canal	0.3 0.2	

(b) Masangdaza Area

- New construction, intake	Masangdaza intake Bongdima, Karbithang intake	1 No. 1 No.
(Existin - Renovation, main canal	g 2 intakes to be combined) Masangdaza canal	3.3 km 4.5 km 0.7 km
- New const'n main canal - New const'n, secondary canal	Karbithang canal	0.9 km 0.2 km

(2) Feeder Road Development

The following feeder road development plans aim to (i) improve convenience for traffic and the communication systems generally, (ii) solve transportation difficulties for agricultural inputs and outputs and (iii) minimise operation and maintenance costs.

(a) Tangmachhu

	- Route ;	Heli-port - Nebi village (Connected to the existing feeder road up to the
	- Length ;	Heli-port) 5.4 km
(b)	Masangdaza	
	- Route ;	National road - near the river mouth of the Songjari chu
	- Length ;	2.4 km

(3) <u>Others</u>

The following development plans would aim to (i) promote cash crop production, (ii) reduce farm labour requirements through mechanized farming, (iii) promote improved farming practices, and (iv) strengthen O&M activities for feeder road and irrigation facilities:

(a) Agro-processing Facilities

Location	;	Tangmachhu	· · · ·	
Facilities	;		No	Capacity
		Building	1	95 m ²
	1997 - 1992 - 1993 - 19	Mustard oil unit	· · · <u>1</u>	100 kg/hour
		Chilli powder unit	1	20 kg/hour
		Multi-purpose dryer	1	5 m ³ /day

- (b) Agricultural Mechanization
 - Objective Area ; Tangmachhu, Masangdaza
 - Equipment ; Improved tools and machinery
- (c) Branch Office of Agricultural Mechanization Center (Workshop)
 - Location ; Mongar District
 - Facilities ; Branch office building with repair tools and machines Mobile Workshop O&M equipment
- (d) Agricultural Extension Center
 - Location

Extension Center ; Lingmethang (Near Masangdaza) Demonstration Plots ; Tangmachhu (5 plots) Masangdaza (3 plots) - Facilities ; Extension center building (Lingmethang) Tools and machinery for demonstration and trial

CONSTRUCTION PLAN AND COST ESTIMATE

31. The construction works of the projects comprise the following four items; (i) construction of intakes, (ii) construction/ rehabilitation of canals, (iii) construction of feeder roads, and (iv) construction of buildings. In order to solve the difficulties of labour recruitment and to take the early benefit from the project, the minor mechanized construction method using mini-size equipment has to be considered for the construction planning.

32. Before the commencement of the construction works for the irrigation facilities, access road will have to be provided to the sites. The access roads will consist of new feeder roads and temporary construction roads.

33. Financial project cost comprises the costs for construction, land acquisition, procurement of equipment, administration and engineering, and physical and price contingencies. The financial project cost was estimated at Nu 120.2 million as follows:

			r\c		Total
Project Area	Nu 10 ⁶	(%)	Nu 10 ⁶	(%)	Nu 10 ⁶
Tangmachhu Masangdaza Total	50.1 37.4 87.5	(69) (78) (73)	22.3 10.4 32.7	(31) (22) (27)	72.4 47.8 120.2

ORGANIZATION AND MANAGEMENT

34. Ministry of Agriculture (MA) (Department of Agriculture (DOA)) will be responsible for the implementation of the Lhuntshi and Mongar Integrated Agricultural Development Project in close coordination with other relevant ministries. DOA will be responsible for execution of the project in consultation with the Steering Committee. DOA will also have to establish a Project Construction Office which will transact the day-to-day business of the project execution.

PROJECT EVALUATION

35. The project evaluation has been made on the model project based on an assessment of project feasibility in view of economic, financial and socio-economic aspects. The economic analysis was made for the irrigation development schemes as follows:

			(Unit: Nu 10 ³)
	Net Product	ion Value	Development
Area	Without	With	Benefit
	(I)	(11)	(II)-(I)
Tangmachhu	405	2,593	2,188
Masangdaza	51	943	892

(1) Economic Irrigation Benefit

(2) Economic Cost

		(Un:	it: Nu 10 ³)
Item		Tangmachhu	Masangdaza
Total economic cost	(Nu 10 ³)	40,131	19,170
Project Area	(ha)	220	80
Economic cost per ha	(Nu 10 ³ /ha)	182.4	239.6

The economic internal rate of return (EIRR) of the irrigation development schemes were calculated from the economic project benefit and cost flows for each project area. EIRRs in Tangmachhu and Masangdaza project areas are 4.6% and 3.8% respectively.

(3)

(4)

It is concluded that these irrigation developments are not suitable for the International Funding Agencies. Nevertheless, the farmers of the areas are eager for these developments which are based on Basic Human Needs (BHN). It is recommended that these projects would be implemented under concessional term aid from the international institutions.

36. After the implementation of the projects, drastic increase of net reserve can be expected in each farmer classified. The net reserve of each farmer will be expected to be more than Nu 500 in the future with project condition. Future land and labour productivity on irrigated land may be expected to be more than three (3) times as much as the present on average.

37. In addition to the direct benefits counted in the economic and financial evaluations, various secondary and intangible benefits and/or favourable socio-economic impacts may be expected by the implementation of the projects as follows:

a) Activation of regional economy

b) Expenses saving and export earning

c) Spreading effects to other area

d) Effective utilization of available labour force

e) Enhancement of farmers' organization

f) Improvement of livestock production

g) Improvement of dietary life and social welfare

RECOMMENDATION

38. The two model projects have been shown to be technically sound, and indispensable for the regional development. It is strongly recommended that the necessary arrangements for early implementation of these projects should be made as soon as possible.

39. In order to ensure realization of the expected benefits of these projects, systematic and effective operation of the project components will be indispensable. Considering the present staff limitation of DOA, it is recommended that technical assistance should be considered. The experts required at the minimum are an agronomist, a water management specialist, and an agro-mechanical engineer.

40. The agricultural support service activities should be strengthened and expanded especially on (i) research activities for paddy as well as upland crops, (ii) extension activities including the training of farmers and extension workers, (iii) marketing system for agricultural products and inputs, and (iv) agricultural credit.

41. Such social infrastructure as water supply, electrification and health services in the study area are all undeveloped. It is recommended that these social infrastructure be improved step by step according to a long term national plan.

42. After completion of the model projects, it is recommended that other projects be chosen mainly from the existing irrigation schemes for successive development. It is further recommended that the necessary arrangements for implementation of the new projects should be taken as early as possible.

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LHUNTSHI AND MONGAR INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT FINAL REPORT

MAIN REPORT

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1)	Organization	
	Bhutan	
	АМС	Agricultural Mechanization Center
	BGTS	Bhutan Government Transport Service
	вни	Basic Health Unit
	cso	Central Statistical Organization
	DAC	Druk Air Corporation
`	DAH	Department of Animal Husbandry
	DOA	Department of Agriculture
	DOP	Department of Power
	DOS	Department of Survey
	FCB	Food Corporation of Bhutan
	моа	Ministry of Agriculture and Forestry
.'	NASEPP	National Seed and Plant Program
	PWD	Public Works Department
	RICB	Royal Insurance Corporation of Bhutan
	STC	State Trading Corporation
	UTB	Unit Trust of Bhutan
	International	
	FAO	Food and Agricultural Organization of United
· .	7000	Nations The International Bank for Reconstruction and
•	IBRD	Development (World Bank)
	Helvetas	Swiss Association for Development and Cooperation
÷.,,	IMF	International Monetary Fund
	IFAD	International Fund for Agricultural
		Development
	JICA	Japan International Cooperation Agency
	UNCDF	United Nations Capital Development Fund
	UNDP	United Nations Development Program
	UNICEF	United Nations Children's Fund
2)	Others	and the second of the second second second
	Dzong	Fortified monastery housing both civilian administration and monastic institution
	Dzongdag	District Administrator
	Dzongdag Wagma .	Deputy District Administrator
•	Dzongkhag	District
	Dzongrab	Assistant District Administrator
· . ·	EL	Elevation above mean sea level
·	Gup	Head of Block
	Mang Gup	Head of Village
÷	Tsheri	Shifting cultivation

ABBREVIATIONS OF MEASUREMENTS

÷						
1.0	. ¹ . 1.	7.5		Volume		
	Lengt	h		lit.	=	liter
1.1	mm		millimeter	cm ³	=	cubic centimeter
	cm		centimeter 0.39 in.	m ³	=	cubic meter 1,000 lit.
	m	== ==	meter = 1.09 yd. 3.28 ft.	MCM	n u	million m ³ 1x10 ³ m ³
	km		kilometer = 0.62 ml.	ft ³	1. 1	cubic feet = 0.028 m ³ 28.32 lit.
	in. ft.		inch = 2.54 cm foot = 30.48 cm	ac-in.	=	acre inch = 88.05 m^3
	yd.		yard = 91.44 cm	ac-ft.	=	acre feet = $1,234$ m ³
· ·	ml.	-	mile = 1.61 m	Weight		
	Area			g		gram
1.1	cm ²	=	square centimeter	kg	. 11 - I	kilogram
· · .	m ²	1 .1	square meter	t	17 B.	metric ton = 1,000 kg
· ·	km ²	=	square kilometer 100 ha	1b		pound = 375 g
	ha	=	hectare = 0.01 km^2	Time	*** ***	2011년 전 2012년 2
			2.5 ac	sec		second
	ac	=	acre = 0.41 ha	min	-	
		=	4,050 m ²	ĥr	1.1	hour = 60 minuits 3,600 seconds
•	ft ²		square feet 0.03 m ²	day		24 hrs = 1,440 minutes 86,400 seconds
5	$mile^2$. === .	square mile = 2.59 km^2	yr		year
	· · · · · ·				197	

				144		

Elect;	rical Measures	Deri
kW	= kilowatt = 1,000 watt	m ³ /s
MW `	= megawatt = $1,000$ KW	
GW	= gigawatt = $1,000$ MW	ft ³ /
 kV	= kilovolt = 1,000 volt	

Oth	er	Measures
		A 4 4 4

olo	. .	percent		
0		degree	: 	
T	-	minute		
u	<u>=</u>	second		
°C	· ==	degree	in	Celsius
lakh	• =	105	1. j.	

Derived Me	asures
m ³ /sec =	cubic meter per second (Cumec)
ft ³ /sec =	cubic foot per second
	(Cusec)

- 1.5	1.1	4 1		
			ry	

US\$ =	US dollar
¥ ==	Japanese yen
Rp =	Indian rupee
Nu =	Bhutan ngultrum
	(1 Nu = 1 Rp)

1. INTRODUCTION

1.1 Authority

This is the "Final Report" for the Feasibility Study on the Lhuntshi and Mongar Integrated Agricultural Development Project (hereinafter referred to as "the study") which is drawn up in accordance with the "Scope of Work" agreed upon between the Royal Government of Bhutan through the Ministry of Agriculture and Forestry (MAF, now renamed as the Ministry of Agriculture : MOA) and the Japan International Cooperation Agency (JICA) on July 26, 1986. Scope of work of the study is shown in ATTACHMENT 1.

1.2 Project History

The Kingdom of Bhutan is a small landlocked country with the area of 46,500km². The country is entirely covered with rugged mountains of the Great Himalaya Range. Because of this physiographical constraint, flat land is scarce and small valley basins are dispersed throughout the country. The population is estimated at about 1.3 million with a low density of 28.2 persons/km² in 1986, and is distributed unevenly over the lower altitude areas.

The main industry of the country is agriculture and 90% of the population is engaged in the agricultural sector. The economy is based on small primarily subsistence oriented communities. Per capita income was estimated at US\$160 in 1986.

Owing to the rugged terrain, agriculture is practised intensively to produce mainly staple foods of rice and maize on small scale terraced fields scattered on the steep mountain slopes. However, self-sufficiency in these basic cereals has not been achieved yet, resulting in the import of more than 28,000 t of cereals a year from India.

To overcome this situation, the Royal Government of Bhutan has formulated and launched the 6th Five Year Development Plan (1987/88-1991/92), in which the target for the agricultural sector is national self-sufficiency in staple foods and an increase in farmers! income. Furthermore, for equitable distribution of social welfare throughout the Kingdom, development of the remote eastern region, where development has been behind other regions, is being emphasised. The Royal Government of Bhutan, therefore, requested the Government of Japan to extend technical cooperation for a feasibility study on the Lhuntshi and Mongar Integrated Agricultural Development Project in August 1985. In response to this request, the Government of Japan agreed to provide the technical cooperation and entrusted the project to JICA, the official agency responsible for the implementation of technical program of the Government of Japan.

Based on the above "Scope of Work" agreed between the Royal Government of Bhutan through the Ministry of Agriculture and Forestry (MAF) and the JICA on July 26, 1986, JICA dispatched the feasibility study team (hereinafter referred to as the "study team") twice to Bhutan namely the First Phase Field Survey from December 1987 to March 1988 and the Second Phase Field Survey from July to September 1988.

1.3 Outline of the Study

1.3.1 Objectives

The objectives of the study were to formulate an Integrated Agricultural Development Plan in Lhuntshi and Mongar Districts, and to examine the technical and economic feasibility of the identified projects.

1.3.2 Study Area

The study area covered the Lhuntshi and Mongar Districts which are both in the eastern region of Bhutan.

The project areas are located at sixteen (16) existing or proposed small irrigation areas along the Kuri chu which flows through the study area.

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1.3.3 Activities of the Study Team

The work schedule for the study is shown in Fig. 1.3.1.

During the first phase study (Dec. 1987 - Jan. 1988), the study team did field and home office works in accordance with the minutes of meeting on the Inception Report shown in ATTACHMENT 2. The principal activities during the first phase study were as follows:

 Data collection and review of reports and documents related to the study;

la an seo seo

- 2) Field reconnaissance;
- 3) Field survey and investigation comprising:
 - a. natural resources surveys including topographic surveys, meteorological and hydrological surveys, land use and soil surveys,
 - b. rural facilities' surveys including irrigation and drainage facilities, and other rural facilities such as roads, electricity supply, schools, health centers, communications;
 - c. social and economic surveys, and
 - d. installation of water level recorders and rainfall gages both in Lhuntshi and Mongar Districts.
- Preparation of the "Progress Report" on the results of the field surveys and investigations;
- 5) Formulation of the basic concept for integrated agricultural development in the study area based on the results of field findings and the minutes of meeting on the Progress Report shown in ATTACHMENT 3,
- Selection of model project areas namely: Tangmachhu from Lhuntshi District; and Masangdaza including Karbithang and Karibee from Mongar District;
- 7) Preparation of the "Interim Report" as the results of the First Phase Study.

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The Second Phase Study started in July 1988 as scheduled. The meeting on the "Interim Report" was held on July 11, 1988. After confirmation of the minutes of meeting on the "Interim Report" shown in ATTACHMENT 4, the study team carried out the following field investigations necessary for the feasibility study of Tangmachhu and Masangdaza model project areas during July to September, 1988:

- Meteorological and hydrological surveys by utilizing water level recorders and rainfall gages, necessary for estimation of available water resources on irrigation;
- (2) Irrigation and drainage surveys necessary for estimation of irrigation efficiency and irrigation water requirements, making layout plans for irrigation and related structures, and formulation of operation and maintenance plans,
- (3) Agricultural and agro-economic surveys necessary for formulation of agricultural development plans and financial and economic evaluations of the projects,
- (4) Land use and soil surveys to assess land resources in the project areas utilizing land cover maps prepared by processing Landsat data;
- (5) Construction materials and cost surveys, and
- (6) Topographic surveys necessary for making preliminary designs for the principal irrigation facilities and feeder roads.

The study team made further studies in Japan during September and October and submitted the "Draft Final Report" to MOA, Bhutan in the middle of November, 1988. This "Final Report" was prepared taking the minutes of meeting on the Draft Final Report (ATTACHMENTS) and the comments from MOA into consideration.

Members of JICA study team and counterpart personnel are shown in ATTACHMENT 6.

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2. BACKGROUND

2.1 National Economy

The Kingdom of Bhutan is an agriculture oriented country with about 90% of the labour force engaged in agricultural sector. The rural economy is based on small, primarily subsistence-oriented communities.

Total estimated GDP in 1986 amounted to Nu 2,678 million or about \$212 million at current prices. Per capita GDP against the total population estimate of 1,312,700 is Nu 2,040 or about \$160. The agricultural sector accounted for almost half (51%) of GDP. During the 1981-1986 period, the annual growth rate of GDP was estimated at 6.3% on average and the growth rate of agriculture, livestock and forestry was 5.8%, 6.3% and 19.0% respectively.

The country has close economic links with India. Trade with India in 1986/87 amounted to 99% of total exports (Nu 323 million) and 84% of total imports (Nu 1,126 million). The trade balance deficit was accelerated, rising from a deficit of Nu 414 million in 1981/82 to Nu 803 million in 1986/87, largely due to the growth of imports. Foreign aid has contributed to offset the current account deficit and the overall balance of payments has increasing since 1981/82.

Major export commodities to India were cement, timber and agricultural products, especially fruits, cardamon and potatoes, which accounted 73% of the total export amount (Nu 270 million) in 1985. Imported goods from India varied from consumer goods like food, fabrics, etc. to capital goods like machinery, trucks, etc. mainly due to the promotion of national development.

Bhutan is an agricultural country, yet self-sufficiency of food supply has not been achieved. In terms of basic cereals, selfsufficiency rate is about 70%. The country has been importing cereals through the government and private channels. The cereals imported through the government channel have been increasing in recent three

- 5 -

years and reached about 28,000 t in 1986. The main reasons for the increase in cereals' import are assumed to be as follows:

- Increase in food demand for foreign construction labour for road and other public facilities, and domestic nonagricultural population such as government and private employees,
- Increase in rice and wheat demand of rural inhabitants substituting for maize and minor cereals, and
- 3) Unstable production of domestic cereals, and underdeveloped inter-regional and regional marketing channels for domestic cereals.

2.2 National Development Policies for Agriculture

The Sixth Plan during 1987/88 to 1991/92 was finalized in 1987 by the Planning Commission. Development objectives in the agricultural sector are (i) the achievement of self-sufficiency in staple foods, (ii) an increase in farmer's income through an increase in land and labor productivity, and (iii) the contribution to the GDP and export earnings.

An area-based development approach is taken as the master strategy in the Sixth Plan by the Ministry of Agriculture. Based on the existing geo-physical features, north to south road system and regional economic linkage, the Ministry recommends water-shed linked area development consisting of the four regions. Agricultural development programs during the Sixth Plan will take a more areafocused approach than before, in accordance with the decentralization policy. The following new development efforts will be carried out under the Sixth Plan along with all on-going activities:

- 1) Promotion of new integrated area development projects.
- Promotion of rehabilitation of small scale irrigation systems.

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- 3) Strengthening of the functions of the Center for Agricultural Research and Development (CARD) at Wangdiphodrang with the establishment of a new agricultural training center.
- A varietal testing and farming systems research program on maize.
- 5) Assessment of fertilizer effect on the yield increase.
- Improvement of centralized collection system of meteorological and hydrological data.
- 7) Re-structuring and reviewing of the activities of the Food Corporation of Bhutan.

2.3 Agricultural Development in Bhutan

2.3.1 Agricultural Production

Bhutan is mountainous and rugged land country. About 28,400km² or 70% of the total land surveyed by remote sensing in 1983 is covered by forest. Only about 3,560 km² or 9% is used for agricultural purposes.

Agricultural land is divided into five (5) categories based on the land features and crops cultivated. Wet land is terraced and bounded and usually cultivated for paddy under irrigation but often rainfed condition. Dry land, usually sloping fields and not terraced, is permanent fields for the cultivation of upland crops under rainfed condition. Tsheri or pangshing land is under shifting cultivation and used for upland crops once every five to six years. The other land categories are kitchen garden and orchard including plantation. Most of the agricultural land is in the wet and dry land categories which are about 24% and 52% of the total area respectively.

Crop productivity is usually low such as paddy of 2.1 t/ha, wheat/barley of 1.1 t/ha and maize of 1.5 t/ha mainly due to

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traditional farming with local varieties, and little development of farm land and irrigation facilities.

Cropping intensity is estimated at 123% on the basis of the total agricultural lands of 1,266 km² and the total harvested area of $1,562 \text{ km}^2$.

2.3.2 Agricultural Development

(1) Central Programs and Projects

The central programs and projects aim at nationwide promotion of agricultural support services such as research, extension, marketing and credit under the planning, execution and monitoring of the Department of Agriculture (DOA), Thimphu. During the Sixth Plan, these support services by DOA will be strengthened for the achievement of selfsufficiency in staple crops and the increase of farmers' income by introducing cash crops. The details on the central programs and projects are summarized in Table 2.3.1.

Neither the DOA nor the district offices have enough trained staff at present, hence several programs do not function satisfactorily throughout the country. Manpower development and training programs have been planned for the promotion of the central programs.

(2) Integrated Area Development Project

Department of Agriculture will continue the integrated area development projects from the Fifth Plan forward, on the basis of the water-shed linked area development concept keeping in view the need for equitable development of the nation. The projects comprise integrated and packaged components which will improve local constraints on social and economic conditions. These projects conform to the decentralized development concept which should improve and balance capabilities in local communities. Details of the integrated area development projects are summarized in Table 2.3.2.

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(3) <u>Dzongkhag (District) Schemes</u>

Central programs and projects of the agricultural support services of the Department of Agriculture are implemented at district level as Dzongkhag Schemes and called the General Agricultural Program. Dzongkhag schemes under each district administration usually consist of the components not covered under the integrated area development projects and are coordinated with the area development projects. For the achievement of the government decentralization policy, the Dzongkhag schemes will be strongly promoted during the Sixth Plan period.

Support services under Dzongkhag schemes are provided to the farmers through the network of extension centers located at the gewog (block) level. Dzongkhag Schemes usually cover (i) supply of improved farm inputs, (ii) execution of irrigation development support services, (iii) execution of plant protection services, (iv) extension of improved farming methods for basic cereals and promising cash crops, (v) construction of compost sheds and supply of fertilizers, and (vi) terracing of irrigable land, conversion of tsheri land into permanent fields and contour bunding of dry land slopes. The nationwide agricultural support system is shown in Fig. 2.3.1.

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3. PRESENT CONDITION OF THE STUDY AREA

3.1 Location

The study area is the two contiguous Districts of Lhuntshi and Mongar from north to south in the eastern region of Bhutan. The study area is bordered by the Tibet region of China in the north, Tashigang District in the east, Bumthang and Shemgang District in the west, and Pema Gatshel District in the south-east. The maximum north-south distance and east-west distance of the study area are 125 km and 50 km respectively.

The town of Mongar, the capital of Mongar District, is located about 150 km east of Thimphu, however, the road distance from Thimphu to Mongar is about 470 km, and it takes almost two days driving. The town of Lhuntshi, the capital of Lhuntshi District, is located at about 50 km north of Mongar, and road distance between Lhuntshi and Mongar is around 70 km and three to four hours driving.

The project areas of sixteen (16) existing or proposed small irrigation schemes, including the two (2) model project areas, are sporadically situated over the study area, mainly along the Kuri chu except for two areas located in the Sheri chu basin. Administratively, seven (7) project areas are located in Lhuntshi District, and nine (9) project areas are located in Mongar District.

3.2 Topography and Geology

3.2.1 Topography

The study area is situated in the eastern part of the Himalayan ranges, the so called as High Himalaya and Inner Himalaya, and has generally rugged mountainous topography such as undulating steep slopes and deep valleys. The study area slopes from north to south, with the altitude ranging from over 4,000 m in the northern part to about 300 m in the Kuri chu at the southern edge of the study area. The Kuri chu flows from north to south through the central part of the study area and joins the Manas river at the south-eastern edge of Mongar District. The average river gradient in the study area is about 1/100 and the river length in the study area is about 134 km. The Sheri chu flows in a south-easterly direction in the middle of the eastern part of the study area and joins the Manas river at the middle-eastern edge of the Mongar District.

Because these two main rivers and their tributaries have been dissecting and eroding the valleys so deeply for a long period, the valleys sometimes are more than 1,000 m deep and the lower part of valleys is very steep. However, the middle to upper parts of valleys have generally gentle slopes or terrain compared with the lower slopes. Also, the direction of the slopes affects steepness. Slopes facing south have been affected more by solar radiation, wind, and weathering processes and show steeper slopes than in other direction.

Sixteen (16) project areas are situated at gentle slopes, on mountain ridges or terraces of the mid-slopes or river diluvium at altitudes of between 500 m and 2,200 m, however, the dominant topographic feature of the project areas is gentle slopes at the middle elevation of the mountains.

3.2.2 Geology

According to previous reports on the geology of Himalayas, the geological conditions of the Bhutan Himalaya are classified into four zones i.e. (i) the Sub-Himalayan zone : belt of molasse, (ii) the Lower Himalayan zone : sedimentary of late Precambrian age exposing metamorphism, (iii) the High Himalayan zone : crystalline sheets, and (iv) the Tibetan Himalayan zone (Tethys Himalaya) : crystalline sheets from Precambrian to Eocene.

Out of the above four geological zones, the study area is mainly covered by the Lower and High Himalayan zones. The Lower Himalayan zone covers the Kuri chu basin, which dominant rock is micaceous schists associated with metabasic rocks.

3.3 Climate

At least, three major climatic regions in Bhutan can be recognized: the hot and humid subtropical area of the southern foot hills, the cooler (microthermal) region of the inner Himalaya and the tundra region of the great Himalaya.

The inner Himalayan ranges have microthermal climates and can be dividend into the lower and upper zones, extending to about 4,500 m that is the upper limit of agriculture and natural tree growth. Winter ranges from moderately cool to severe and summer varies from warm to cool and is rainy.

The climate of the project area is classified as that of the lower zone of the microthermal Himalayan climates. The climate of Lhuntshi area varies from temperate to severe to some extent. Mongar area is characterized with the typical climate in the lower zone of the microthermal Himalayan climates.

(1) Rainfall

The project area is located in monsoon region. The climate is characterized by two distinctive seasons, wet and dry, according to the seasonal distribution of rainfall. During the period from November to March, the monthly rainfall is very little in almost all stations. The rainfall increases from April and is concentrated during June to September. An annual mean rainfall is about 830 mm and 980 mm in Lhuntshi and Mongar area respectively. The mean monthly rainfall for both areas is shown below:

		· .								(Uni	t : mm)
Feb.	Mar.	Apr.	Мау	Jun.	Jul,	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
0.0	55.3	79.4	70.7	130.6	169.8	109.8	116.8	74.5	10.7	5.0	825.7
30.5	43.2	83.9	73.8	169.3	200.1	133.5			9.7	10.2	977.6
	0.0	0.0 55.3	0.0 55.3 79.4	Feb. Mar. Apr. May 0.0 55.3 79.4 70.7	Feb. Mar. Apr. May Jun. 0.0 55.3 79.4 70.7 130.6	Feb. Mar. Apr. May Jun. Jul. 0.0 55.3 79.4 70.7 130.6 169.8	Feb. Mar. Apr. May Jun. Jul, Aug. 0.0 55.3 79.4 70.7 130.6 169.8 109.8	 Feb. Mar. Apr. May Jun. Jul. Aug. Sep. 0.0 55.3 79.4 70.7 130.6 169.8 109.8 116.8 30.5 43.2 83.9 73.8 169.3 200.1 133.5 168.9 	Feb. Mar. Apr. May Jun. Jul, Aug. Sep. Oct. 0.0 55.3 79.4 70.7 130.6 169.8 109.8 116.8 74.5	Feb. Mar. Apr. May Jun. Jul. Aug. Sep. Oct. Nov. 0.0 55.3 79.4 70.7 130.6 169.8 109.8 116.8 74.5 10.7 30.5 43.2 83.9 73.8 169.3 200.1 133.5 168.9 52.7 9.7	(Uni Feb. Mar. Apr. May Jun. Jul. Aug. Sep. Oct. Nov. Dec. 0.0 55.3 79.4 70.7 130.6 169.8 109.8 116.8 74.5 10.7 5.0 30.5 43.2 83.9 73.8 169.3 200.1 133.5 168.9 52.7 9.7 10.2

Rainfall (1985-1987)

Source: Department of Agriculture, Hydrometeorology Division

The mean temperature in Lhuntshi area is about $16^{\circ}C$ over the year with the highest mean monthly maximum of $24^{\circ}C$ in June and the lowest mean monthly minimum of $5^{\circ}C$ in January. In Mongar area, the mean temperature is about $20^{\circ}C$ over the year, having the highest mean monthly maximum of $28^{\circ}C$ in June and the lowest mean monthly minimum of $9^{\circ}C$ in January.

. . . .

Air Temperature (1985-1987)

							·					(Unit :	OO .
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Ave.
Lhuntshi	1 1 ²	i en tran	÷ .		1. A 1		1.1		5 - C. J.	t est.	: "		
Max	13.8	15.3	17.3	20.6	21.8	23.8	22.8	23.7	22.6	21.1	18.1	14.7	19.6
Min.	5.0	7.6	10.3	12.5	14.9	18.7	19,1	19.5	18,3	15.9	9,9	6.7	13.2
Mean	9.4	11.5	13.8	16.6	18.4	21.3	21.0	21.6	20.5	18.5	14.0	10.7	16.4
Mongar													
Max.	19.6	20.9	22.7	25.2	26.7	28.2	27.2	28.1	27.0	25.6	22.8	20.4	24.4
Min.						20.9							15.2
Mean	14.2	15.5	17.5	20.4	22.1	24.5	24,0	24.6	23.4	20.5	17.2	14,9	19.8
· · · · · · · · · · · · · · · · · · ·													

Source: Department of Agriculture, Hydrometeorology Division

(3) <u>Relative Humidity</u>

The monthly mean relative humidity in the morning hours varies from about 70% to 90%, the annual mean is about 78% in both Lhuntshi and Mongar areas.

			Re	lativ	ve Hu	midit	y (1	985-1	L987)	-		(Uni	t: %)
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug	Sep.	Oct.	Nov.	Dec.	Total
Lhuntshi Mongar											79.3 76.2		77.7 77.3

Source: Department of Agriculture, Hydrometeorology Division

3.4 Hydrology

3.4.1 Water Resources

The main river flowing southward through Lhuntshi and Mongar Districts is the Kuri chu which has a catchment area of about . 4,000 km² at the confluence with the Manas river at the southern boundary of Mongar District (See Fig. 3.4.1). The Kuri chu has its source in snow clad great Himalayan ranges. In its upper reaches, it is formed of two major rivers known as the Lhubrak chu and the Khoma chu. The Sheri chu, running southward in parallel with the Kuri chu in eastern side, is a tributary of the Damgme chu which joins the Manas river at the confluence with the Kuri chu. The Shongar chu is a tributary of the Kuri chu and originates from the mountainous boundary between Mongar and Bumthang Districts. It flows southeastward along the national road and joins the Kuri chu downstream of the suspension bridge (Kurizampa) in Mongar.

The main water resources of each project area are small and medium sized tributaries of the Kuri chu, the Khoma chu, the Sheri chu and the Shongar chu as shown below:

Project Area	Name of Tributary	Parent River
Lhuntshi Distric	t.	
1. Pang Khar 2. Gangzoor 3. Tangmachhu 4. Minji 5. Menjibi 6. Kupinesa 7. Wambur	Paka chu Lekpagang chu Begang Sher and Ngeh chu Narigang chu Begang chu Dungkhar chu Kheba chu	Yongla chu and Khoma chu Kuri chu Kuri chu Majebiri ch and Kuri chu Rogam chu and Kuri chu Kuri chu
Mongar District 1. Chali 2. Karbithang 3. Karibee 4. Masangdaza 5. Pangsibi 6. Gyelposhing 7. Kalapang 8. Yadi	Thruwan chu (Diwang chu) Shongjari chu (Shongjari chu) Shongjari chu (Shongjari chu) Drodi ri (Dagsamanang ri) (Kalapang and Dubrang ri) Seri chu	Kuri chu Shongar chu and Kuri chu (Shongar chu and Kuri chu) Shongar chu and Kuri chu (Shongar chu and Kuri chu) Kuri chu (Yunari chu and Kuri chu) Sheri chu
9. Chaskhar	Goda and Loda ri	Sheri chu

Note: Tributary in parentheses is a prospective main water resources.

The catchment area at the existing intake sites of respective water resources is very small, ranging from a few square kilometers to about 35 km². Altitudes vary between about 800 m and about 4,000 m. The lengths of tributaries from intake site to upstream ridge are also very short, ranging between a few kilometers to about 10 km and the tributary slopes are therefore very steep with a mean slope of about 1:3.

3.4.2 Assessment of Water Availability

In the absence of gauging stations and hydrological data on the project small and medium sized tributaries, the assessment of water availability of drought discharge was carried out on monthly basis applying monthly minimum specific discharge and annual rainfall ratio by use of discharge records of selected river around the project area which shows the similar characteristics of river basin and rainfall distribution pattern to those of the project tributaries.

As a result of the synthetic comparison with mean characteristics of all project river basins and rainfall distribution pattern, it is considered that Jiri chu, which is located nearest the project area, has the most similar basin characteristics and rainfall distribution pattern. Therefore, discharge and rainfall data of Jiri chu were applied to assess the available water of the project tributaries in this study.

		· · · · · · · · · · · · · · · · · · ·		1. A.
Month	Dis	tual charge ¹³ /s)	to be	Discharge Applied 's/km ²)
<u></u>	Mean	Minimum	Mean	Drought
Jan.	0.800	0.494	16.6	10.3
Feb.	0.628	0.456	13.0	9.5
Mar.	0.680	0.419	14.1	8.7
Apr.	1.027	0.510	21.3	10.6
May	1.192	0.755	24.7	15.7
Jun.	1.817	0.962	37.7	20.0
Jul.	3.197	1.477	66.3	30.7
Aug.	2.405	1.132	49,9	23.5
Sep.	2,639	0.864	54.8	17.9
Oct.	1.320	0.808	27.4	16.8
Nov.	1,078	0.771	22.4	16.0
Dec.	0.876	0.617	18.2	12.8
Average	1.472	0.772	30.5	16.0
	······································			

The specific discharge to be applied to the assessment of water availability on the project tributaries are as follows:

Note: - Catchment area of Jiri chu basin is 26.3 km².
- Annual rainfall ratio between Jiri chu area and project area is 0.55.

The drought discharge on the respective project tributaries are as shown in Table 3.4.1.

3.4.3 Water Quality

For the purpose of checking water qualities of the project tributaries for irrigation, the electric conductivity and pH tests were carried out. Water samples were collected at the each existing intake site on the project tributaries.

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The values of electric conductivity range from 25 μ mhos/cm to 120 μ mhos/cm and those of pH vary from 7.25 to 8.00. It can be said that the water qualities of the project tributaries are satisfactory for irrigation water.

3.5 Land Use and Soil

3.5.1 Land Use

Total area of the study area is about 5,600 km², consisting of 3,400 km² (61%) in Lhuntshi District and 2,200 km² (39%) in Mongar District.

To estimate the present land use in the study area, remote sensing was applied using the latest Landsat data. The results of the estimation may be summarized as follows:

	Lhun	tshi	a si	Mongar	Tol	al
Item	(ha)	(%)		(ha) (%)	(ha)	(名)
Paddy field	1,700	(1.5)		1,300 (0.7)	3,000	(1.0)
Upland and pasture	12,100	(11.0)		22,200 (11.5)	34,300	(11.3)
Bare land	1,300	(1.2)		3,500 (1.8)	4,800	(1.6)
Sparse forest	11,400	(10.3)		18,800 (9.7)	30,200	(9.9)
Dense forest	84,000	(76.0)		147,500 (76.5)	231,500	(76.2)
Total	110,500	(100.0)		193,300 (100.0)	303,800	(100.0)
Total study area	340,000			220,000	560,000	

Although these data are estimated on the basis of the gross area of each category of land use, the actual cultivated area of wet land and dry land is larger than the statistical data of the DOA and the District offices. 3.5,2 Soil

Soils in the study area are broadly classified into seven soil units according to the FAO/UNESCO soil classification system, namely Phaeozems, Cambisols, Acrisols, Gleysols, Arenosols, Regosols and Lithosols.

For land classification to evaluate the potential of the land, it is necessary to consider the following factors in addition to the criteria usually applied;

1) Present land use

Even in the narrow and low potential land such as stony and sloping land, farmers are presently cultivating by removing stones and terracing. Although much labour is required for removing stones and terracing to improve present farm land, these practices should be included in the classification.

2) Conversion of tsheri land

Tsheri land presently cultivated should be converted into permanent cultivated land for increasing agricultural production or into natural vegetation for fodder trees and land conservation.

Based on the above soil and land use surveys, potential for agricultural production of each soil unit is evaluated as follows:

a. Phaeozems

Because of steep slopes and high altitude, the potential is very low and it is best to keep natural vegetation or to be covered by vegetation to prevent soil erosion.

Lithosols, Regosols and Arenosols

Because of shallow surface soil and the high content of gravels and stones, the potential is low and it is best to retain natural vegetation or to cover by vegetation

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to prevent soil erosion. Tsheri land of these soil units should be converted into natural vegetation.

c. Cambisols, Acrisols and Gleysols

Present cultivated lands extend over these soil units, and the potential varies with topographic condition. Therefore, these soils can be cultivated by terracing and can increase production by irrigation water and proper farm management. However, some of these soil units should be converted into natural vegetation because of steep slopes.

3.6 Demography

The population of Lhuntshi and Mongar Districts is estimated at 42,100 and 77,200 respectively which accounts for 3% and 6% against the national population of 1,365,700 in 1988 according to the official population estimate.

Lhuntshi and Mongar Districts respectively have 53 and 119 villages covered under 8 and 11 blocks. An average village has 80 to 90 households and with population of 700. The average family size is 10 in Lhuntshi and 8 in Mongar.

The demographic conditions of the two districts may be summarized as follows:

Item	Lhuntshi	Mongar
1. No. of Blocks	8	11
2. No. of Villages	53	119
3. Population	42,100 (100%)	77,200 (100%)
- Per Block (3/1)	5,260	7,020
- Per Village (3/2)	790	650
4. No.of Households	4,200	10,160
- Per Block (4/1)	530	920
- Per Village (4/2)	80	90
5. Family Size (3/4)	10	8
6. Student Population	8,640 (21%)	19,650 (25%)
(5-14 age group)		
7. Labour Force	25,780 (61%)	39,220 (51%)
(15-54 age group)		

DEMOGRAPHIC INFORMATION OF STUDY AREA

Note : The age distribution data are based on the results of demographic surveys in the 16 project areas.

3.7 Agriculture

3.7.1 General

The study area is characterized by steep and rugged topography, and most of agricultural lands are located on small plateaux dotted with villages at various elevations.

At present, less than 15% of the cultivated land has been assured of irrigation water, and agricultural production largely depends on the monsoon.

3.7.2 Crop Production

Crop production in the study area is estimated on the basis of the present land use survey. The result of the estimation is shown in Table 3.7.1 and is summarized as follows:

Crop	Cropped	l Area (h	a)	Production (t)				
	Lhuntshi	Mongar	Total	Lhuntshi	Mongar	Total		
Paddy	1,190	830	2,020	1,430	1,000	2,430		
Maize	1,350	4,800	6,150	2,300	8,160	10,460		
Wheat	70	280	350	70	280	350		
Barley	.70	250	320	60	200	260		
Buckwheat	90	170	260	60	120	180		
Millet	200	20	220	140	10	150		
Soyabean	360	220	580	220	130	350		
Mustard	40	230	270	30	160	190		
Potato	50	260	310	420	2,180	2600		
Chilli	320	90	410	320	90	410		

The main cereal crops in the study area are paddy, maize, wheat, millet and barley. The main limiting factors to cultivating these crops is the altitude, availabity of irrigation water and topographic conditions. Paddy is cropped on the terraced land under irrigation at altitudes lower than 2,000 m. Maize is the dominant crop on dry and tsheri lands at middle hill (800 - 1,600 m) and foot hill (lower than 800 m). Wheat, barley and buckwheat are the main crops on dry land at upper hill (higher than 1,600 m). On both dry and wet land wheat, barley and buckwheat are often cropped as the second crop after paddy or maize. Generally, unit yields of the main crops are low. Unit yields of main crops were estimated based on the interview surveys at 1.2 t/ha for paddy, 1.7 t/ha for maize and 1.0 t/ha for wheat as shown in Table 3.7.1.

The low yields of the main crops in the area are caused by various factors, such as shortage of irrigation water, inadequate application of fertilizers or inadequacies in the cultivation practices such as weeding and harvesting. Out of these constraints, shortage of water is the most serious reason.

3.7.3 Cropping Pattern and Cropping Intensity

(1) Cropping Pattern

The dominant cropping pattern in the study area are shown in Fig. 3.7.1. The cropping pattern on wet land is based on paddy, normally planted in June and July and harvested in October and November. These wet lands are normally left fallow after harvesting. In upland areas (dry land), maize and pulses are generally planted in March and April and harvested in August, and wheat is planted as the second crop of these crops in September and is harvested in February. However, about two-thirds of the dry land is also left fallow in winter season.

(2) Cropping Intensity

The cropping intensity in the study area is estimated on the basis of the data collected from the project areas. The result may be summarized as follows:

	Lhuntshi	Mongar	Total
Wet Land	101	107	103
Dry Land	101	145	127
Tsheri Land	20	24	22
Total	84	110	97
			····

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The average cropping intensity in the study area is 97% and is low compared with the national average of 123%. It is believed that these low cropping intensities on wet and dry lands are derived from the following:

- Tradition,

- Labour shortages for farming,

- Shortage of reliable and stable irrigation water supply,

- Lack of incentives for the farmers,

- Grazing on fallow land during the winter season.

3.7.4 Farming Practices

Farming practices have changed very little, retaining labourintensive practices and using only limited modern technologies. Farming practices are usually carried out by family labour, but most of the farm households provide and exchange labour, as well as draught power.

Labour shortage at the peak of labour requirements influences farming practices, and limits cropping intensities and yields. In the off-season for cultivation, farmers have compulsory and voluntary labour obligations to the government on communal projects such as construction and maintenance of irrigation facilities and roads as well as individual sharing for house construction in the villages.

Land preparation usually commences 4 to 5 weeks before planting. Paddy fields are ploughed twice and puddled thereafter. Before ploughing, organic manure is often applied. Ploughing is normally carried out by bullock power operated by two farmers using a locally made wooden plough. Ploughing for upland crops is done only once, but for mustard and potatoes fields are ploughed twice.

· 是你们的人们的人们,我们就是你们的事实,我们都是这些人们事实,我们的人们都能能不能。"

Generally farmers prefer to grow local varieties and to select seeds from the previous harvest. Main varieties of paddy and maize in the study area are shown below:

Paddy	Maize
Wangdikarma	Asum Marpoo
Bumdalingpa	Samtshelingpa
Kaliphupa	Bodhona
Awsting Bara	Bepa Asum

Usually, nurseries for paddy are prepared on the dry land, one to two months before transplanting at a seed rate of 40 kg to 50 kg/ha and in size 1/15 to 1/20 of the paddy field. Sowing of upland crops is usually made by broadcasting.

Just after the monsoon starts, wet land is prepared for transplanting. Farmers randomly transplant paddy by helping each other on a rotational basis.

Farm yard manure (compose) is applied to both wet and dry land together with natural manure (cattle tied in fields). Application of chemical fertilizer is limited to the demonstration plots only.

Weeding is carried out manually, and no herbicides are applied. Weeding requires much labour and is generally carried out insufficiently owing to shortage of labour force. Pest control by agro-chemicals is uncommon in the study area.

Other cultural practices such as harvesting, threshing and milling are all done by manual labour. Paddy panicles are cut by sickle and bound for drying in the field. The remaining straw is used for feeding cattle during the dry season. Threshing or milling is done by hand on nets in the farm field or in the farm yard.

3.7.5 Livestock Production

The number of livestock and poultry in the study area is 46,800 head of cattle, 2,700 head of horses, 9,700 head of pigs and 23,600 head of poultry.

Livestock raising plays a very important role in agricultural production and the farmers' livelihood. The farming system, including

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seasonal land use rotation comprises crops, forage and livestock production which are interdependent with each other.

The main breed of cattle is the local Siri breed (black and white, pure black and some red in color). The Siri cattle together with the local varieties of chicken and pig are adapted to the local conditions, but very poor producers. To increase the productivity of local livestock, the Department of Animal Husbandry (DAH) under MOA is introducing more productive varieties into the study area such as Jersey and Mithun (Assam) bulls.

The experiment and extension center for livestock development in the study area is the animal husbandry farm at Lingmethang, Mongar. Trials on cross breeding and fodder production and distribution of improved livestocks are made on this farm. On the other hand, there are two veterinary hospitals, one in each district, and seven veterinary centers, three in Mongar and four in Lhuntshi as shown in Fig. 3.7.2.

The main constraints on livestock development are the lack of feed production and pasture management technology in addition to the lack of vaccination and other preventing practices. The shortage of winter feed will continue to limit the livestock population.

3.7.6 Processing and Storage of Agricultural Product

After harvesting basic grains such as paddy, maize and wheat, the majority of farmers are processing and storing them in conventional ways using manual tools and equipment.

Rice mills and oil mills with diesel engines have been introduced in the study area under Agricultural Mechanization Program since the Fourth Plan. Existing rice mills in Lhuntshi and Mongar Districts are 27 and 23 respectively. Only two oil mills are in Mongar Districts.

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The milling rate of paddy is estimated at 65%. Mustard oil mills have a milling rate of 30% after 3-4 times extraction. Most of

the mills belong to rich farmers or shopkeepers and operate for the neighboring farmers with a milling charge of Nu 2-4 to mill 10kg of paddy.

Another major agro-processing facility is a lemon grass oil factory in Mongar owned by Tashi Corporation. Wild lemon grass is growing in the two districts, and the harvest season is from June to November.

3.7.7 Land Holding and Farmers' Economy

(1) Land Holding

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Statistical data on land holding and tenure in Lhuntshi and Mongar Districts are not available. Field surveys in the 16 project areas have shown that most of the farmers are owner operators. The average farm size of owner operators is 1.7 ha in Lhuntshi and 1.1 ha in Mongar according to the field survey.

(2) Farmers' Economy and Intention

Present farm economy in the project areas was analyzed on the basis of average holding size, average yield and production, farm and non-farm income, and living expenses derived from the field survey. District by district features of farm economy are shown in Table 3.7.2.

The average farm size, especially the holding size of wet land, reflects farm economy together with land productivity. Cash crops such as soyabean, potato, chilli, orange and some vegetables have been introduced in the study area, though at present their production and share of farm income are limited. Limited farm and non-farm cash incomes are mostly spent on the living expenses and the net reserves are negligibly small.

Farmers' intentions on development with priority collected by the farm economic surveys are summarized as follows:

- 1st) Improvement and rehabilitation of existing irrigation facilities due to shortage of water.
- 2nd) Construction of motorable feeder road for accessibility improvement.
- 3rd) Strengthening of agricultural extension services including promotion of agricultural mechanization.
- 4th) Rural electrification.

3.7.8 Agricultural Support System

Agricultural support services are supervised by each district agricultural officer (DAO) under the Dzongkhag administration. Extension works in the field are carried out by agricultural extension workers (AEW) appointed at each block of the district. There are no any agricultural research and experiment stations except the animal husbandry farm at Lingmethang, Mongar. Agricultural support activities implemented in the study area are limited to extension matters.

Extension subjects mostly cover the Central Programs carried by Department of Agriculture, Thimphu. Seed, fertilizer and farm equipment are delivered at subsidized prices throughout the country, on the basis of the farmers' requests. Agro-chemicals are provided free to the farmers with lendable sprayers. Farmers can ask the credit services for the purchase of fertilizer, farm machinery and implements, and the recommended land development.

The major constraints on the agricultural support services at present are (i) difficulty of regular and close contacts with farmers by one AEW due to the hardness of access in the mountainous terrain, (ii) limitation of diffusion of improved technology due to the lack of satisfactory experimental data and informations, and (iii) the difficulty of second cropping due to cattle grazing during the winter season.

3.7.9 Marketing and Prices

The surplus of basic grains, mainly paddy and maize, is traded within villages and/or with neighboring villages and sometimes bartered for other agro-products with other farmers and for the daily necessities with shopkeepers.

Cash crops other than basic grains in the study area are potato, soyabean, dry chilli, orange, apple and vegetables. They are traded in the Sunday market which is held in the district capital. The main market for cash crops from the study area is Samdrup Jongkhar which is a border town in the eastern part of Bhutan and the sole export destination from the study area.

Some of the local shop keepers are buying products from the farmers and transporting them to Samdrup Jongkhar. The food Corporation of Bhutan (FCB), a government marketing agency for food grains and cash crops has its centers in both the district capitals, and has an auction yard in Samdrup Jongkhar. FCB's procurement of cash crops from the study area is very limited at present.

Wholesale and retail prices of domestic basic grains are not clearly distinguished due to the limited marketing quantities. Retail price of local rice is usually higher than imported Indian rice. Prices of basic grains and cash crops are summarized as follows:

			(Nu/kg)
	Reťail Price	Wholesale Price	Farm Gate Price
Rice			
- Local	6.0.	6.0	5.3
- Imported	5.0	4.1*2	-
Maize	2.7	2.7	2.4
Wheat (local)	2.9	2.9	2.6
Buckwheat	· · · -	_	1.5
Soyabean	-	3.5*2	2.7
Potato(local)	2.5	1.9*2	1.8
Chilli		13.0*2	10.0
Apple	4.0*1	5.0	2.0
Orange (Nu/10.No.)	1 7*1	2.3*2	1.0

Note: *1; Retail prices in the study area. *2; Wholesale prices in Samdrup Jongkhar.

3.8 Irrigation and Drainage

3.8.1 General

The irrigation facilities in Bhutan in general have been developed as small scale projects for limited ares, but in the southern foot hills near the border with India, comparatively large scale irrigation projects have been developed recently with the new technology.

Many new irrigation schemes are planned by the Government in the 6th Plan since 1987/88, the Government of Bhutan, however, wishes to emphasize the renovation of existing schemes, because this is needed urgently and benefits of project implementation can be yielded instantly.

The progress of development in the study area is much behind in comparison with that of other districts due to the inferior physical and topographical conditions. The existing irrigation schemes in Lhuntshi and Mongar Districts have been developed since 1970. The number of schemes is 43 with 2,298 ha of the command area at present as shown in Table 3.8.1. Most of the schemes were completed in the last 10 years.

The irrigation blocks in the study area are scattered on the hillside, as small as about 50 ha on average, and blocks existing irrigation schemes were consisted very small scale facilities, and established based on traditional technologies and construction methods.

In general, these irrigation schemes were designed according to the design manual issued by the DOA. The implementation of irrigation projects is carried out according to the following procedures and manner:

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 The project formulation is made by DOA upon the request of the beneficiaries headed by the Gup. 2) The survey, planning and preliminary design are made by District Irrigation Engineers under the control of the District Administrator. The detailed design, cost estimation and implementation schedule are made by the Irrigation Division in Thimphu.

The construction works are relatively small scale, so that the works are carried out by force account and the beneficiaries are engaged in the construction works as common labour in most cases.

Renovation of the facilities is needed shortly after completion of an irrigation system, because these construction works are executed with very low investment and because of unfavourable site conditions.

3.8.2 Present Condition of Irrigation Facilities

The irrigation water is taken from the small tributaries of the Kuri chu, and conveyed to the paddy field by open canal system in all schemes. The runoff water of the Kuri chu itself is not available for gravity-irrigation, because the irrigation water is required some hundreds of meters higher than the river water. There is no water impounding reservoirs to regulate the intake discharge.

The existing canals are approximately 3 to 10 km long, but for the most part unlined. Water distribution structures are poorly provided, and secondary and tertiary irrigation systems are also very poor or absent.

Most of the irrigation schemes in the study area have no permanent intake structure and no canal protection facilities such as cross-drainage structures, spillways and waste ways. Furthermore, most of these irrigation systems are not fully functioning and not secured with adequate water supply.

As there are no on-farm irrigation facilities, actual water supply to the field is carried out by a plot to plot irrigation system, because many steps of small terraces are extend over a wide area with some hundred of meters of altitude difference. Under these circumstances, it is very difficult to introduce modernized irrigation systems from the physical and economical viewpoints.

The present conditions of sixteen (16) irrigation systems which were investigated by the study team are abstracted in Table 3.8.2.

3.8.3 Present Water Management

The water management and the operation and maintenance of each scheme are executed by the Gup with the support of the District Administration Office staff. The Government has a plan to establish Water User Associations in order to carry out these works throughout the country, but these have not yet been organized. However, organization of a sort have been established on some schemes and are functioning efficiently already. In practice, the operation staff consists of the Gup, his assistants and water distributors who are selected among the beneficiaries democratically.

During land preparation for transplanting, the available water is insufficient in many cases and rotational irrigation is applied in such cases as the water distribution practice.

3.9 OTHER RURAL FACILITIES

3.9.1 Roads

The east-west national road linking Thimphu and Tashigang goes through Mongar District. Lhuntshi District is solely connected to the district capital with 67 km of road from Mongar along the Kuri chu.

Both the districts have one motorable feeder road each, to Tangmachhu with 7 km in Lhuntshi, and to Demchi with 18 km in Mongar. Other feeder roads are steep and narrow foot paths. Foot paths are often destroyed during the rainy season and accessibility becomes worse. Social solidarity, agricultural extension activities, marketing of local products and the other rural development efforts suffer from such access constraints.

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3.9.2 Electrification

Of hydro power stations there is one with an installed capacity of 20kw in Lhuntshi and two with 420 kw in Mongar.

These stations supply only one out of 53 villages in Lhuntshi and 4 out of 115 villages in Mongar. The number of households supplied is only one and three percents of the total households respectively.

3.9.3 Rural Water Supply

Rural water supply beneficiaries in Lhuntshi and Mongar Districts are still less than 20% of the total population. If the present population growth of 2% per annum continues and the programs under the Sixth Plan are completed, beneficiaries in the study area will increase to over 20%

3.9.4 Communications

The civil wireless network covers the whole country with 34 stations. The study area has 3 stations, Lhuntshi has one station at the district capital and Mongar has two stations at the district capital and Kurizampa. This wireless network is the sole nationwide communication means at present. A nationwide telephone system by microwave linkage is still under planning and will be constructed in the near future.

Both districts have one post office at each district capital. Of branch post offices these are two in Lhuntshi and three in Mongar as shown in Fig. 3.9.1.

3.9.5 Education Facilities

Lhuntshi and Mongar Districts have four and six primary schools respectively which are managed under the district office. Junior high schools which are under the Ministry of Social Services exist at each district capital, while there are no other schools in the study area. Primary schools in the study area are not established at each block as shown in Fig. 3.9.1. Enrollment of primary education in the study area is at the low level of 27% as compared with the national average of 54% in 1986.

3.9.6 Medical Facilities

The medical facilities and their staffs in the study area have been improved the the assistance of UNICEF, a mission body and others. However, the medical care is not sufficient due to shortage of beds, drugs, equipment and instruments in addition to the shortage of trained medical personnel. The location of medical facilities in the study area is shown in Fig. 3.9.1.

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4. BASIC INTEGRATED AGRICULTURAL DEVELOPMENT PLAN

4.1 Necessity of Integrated Agricultural Development Plan

The study area which is relatively less developed than average for Bhutan is a virtually independent economic-social zone having little relation to the central and western regions in Bhutan due to the inferior conditions of location, underdeveloped transportation system including national roads and subsistence oriented economy. Since the Fifth 5 year Development Plan, the government of Bhutan has given development priority to the eastern region for equitable development of the nation and has promoted the integrated area development projects on the basis of the water-shed linked area

The physical and economic environment in the study area, however, is in no sense favourable for industrial development. It would be quite difficult to find, any industry with a higher dévelopment potential than agriculture. On the other hand, the large majority of the rural inhabitants is engaged in agriculture and has acquired a certain level of techniques to increase production and to exploit their farm lands. Therefore, the prospects for development of the study area will heavily rely on agricultural development which will encompass crop and livestock production, irrigation, and agrobased industries as integrated components.

The Lhuntshi and Mongar Integrated Agricultural Development Plan has been required from the above political point of view together with the natural and socio-economic conditions of the area. This development plan has been selected as for one of the national priority projects in the 6th Five Year Development Plan.

4.2 Current Situation and Constraints

Agriculture in the study area is of an extensive nature in the subsistence oriented communities. Villages lie scattered on the mountain slopes. The social and economic connections between villages are very weak due to the topography and poorly developed

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transportation and communication facilities. Farming practices are traditional without improved seed, fertilizers, agro-chemicals, improved farm equipment and machinery. The main crops grown in the area are paddy, maize and other cereals, and cash crops such as soyabean, mustard, chilli, potatoes, etc. are as yet uncommon. Crops other than paddy are mainly planted under rainfed conditions. In general irrigation during the wet season is limited. Farmers rely heavily on these cereals for home consumption. However, unit yield of these crops are generally low; 1.2 t/ha of paddy and 1.6 t/ha of maize, and yields fluctuate from year to year. This makes the farm economy unstable and keeps it low and at a subsistence level.

The reasons for unstable and low productivity are manifold; however major constraints are considered to be as follows:

- The arable lands for crop production are limited due to the steep and rugged topography. Most of the farm lands are on slopes and at various elevations.
- 2) Rainfall is distributed seasonally and is concentrated in the period of June to September. Agricultural production relies heavily on rainfall, while irrigation and land developments such as contour bunding and terracing are limited to specific areas. Cropping intensity is at the low level of 97% on average, comprising wet land at 103%, dry land at 127% and tsheri land at 22%.
- 3) Tributaries of the Kuri chu are used for irrigation of the steep terraced land, while the Kuri chu itself has never been used for any irrigation purposes because of the heavy cost of high head pumping.
 - 4) Most of the irrigation facilities are poorly constructed and dilapidated due to insufficient O/M practices and lack of organizations; water losses in the canals and water shortage at the farm level are common, and heavy maintenance works are required.

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5) The extension services of one extension officer appointed for each block of the district are not sufficient, and concentrate on input supply rather than on the diffusion of improved farming technologies; there are no experimental data on appropriate farming practices in the study area.

6) Cattle grazing during the winter (dry) season interferes with the second cropping of wet and dry land; the shortage of feed in winter necessitates cattle grazing on the farm land, and most of the rural communities are insufficiently organized for solution of the grazing problem.

7) The sole marketing channel from the study area through Tashigang to Samdrup Jongkhar requires heavy transportation costs and this obstructs the expansion of cash crop production.

4.3 Basic Concept for Integrated Agricultural Development Plan

Social and economic development efforts in the study area have only just begun. Development constraints of the study area are manifold and interrelated. Mitigation of the development constraints is naturally required in order to accelerate the regional development to:

 expand the regional economy through increasing agricultural production, and

 improve the farmers' present subsistence situation, together with adaptation or smooth transfer to a monetary economy.

The basic principles of the development outlined above correspond exactly to the agricultural development policy given in the Sixth plan. In order to attain these objectives, agricultural development should play a pivotal role. While considering the absolute limitation of the physical resources, the possibilities for intensification of agricultural production basically lie in better utilization of existing land and water. The following basic and

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priority developments have been conceived for the achievement of these objectives:

- a) increasing agricultural productivity, e.g. by improving yields on existing crops,
- b) increasing intensity of resource use, e.g. expansion of double cropping,
- c) encouragement of farmers to move into higher value crops,
- d) improving irrigation efficiency through rehabilitation and/or improvement of the existing irrigation facilities, and
- e) converting upland into wet land as well as tsheri land into upland where it is feasible.

4.4 Basic Integrated Agricultural Development Plan

4.4.1 Land Use

Suitable land for agricultural production is situated sporadically on flat to gently sloping areas in the mountains, and some tsheri land and dry land is cultivated even on steep slopes. Therefore, almost all land available for cultivation of crops is already under utilization or over-utilization for agriculture, and it is impossible to expand agricultural land significantly by converting steep and gravely forest land, bare land, pasture and other land with shallow soils of low fertility.

Owing to the limited land suitable for agriculture in the study area, land use for the agricultural development should be planned taking following matters into consideration:

- Expansion of wet land (irrigated land)
- Maintenance or improvement of soil fertility
- Conversion of tsheri land (shifting culture) into dry land (annual cropped upland)

4.4.2 Agricultural Development

The objective of the basic agricultural development plan is to increase agricultural production in the study area. Increasing production will stimulate and expand the regional economy, and will improve the living standards of the farmers. Increasing agricultural production will be attained by the following approaches in combination:

- increase of unit yield
- increase of cropping intensity
- promotion of cash crops
- improvement and construction of irrigation facilities
- promotion of agricultural mechanization

(1) Increase of Unit Yield

Because of land and water resources limitations, agricultural production must be increased primarily by increasing the unit yield of the main crops through (i) introduction of improved varieties suited to the natural conditions of the area and (ii) improvement of the present traditional cropping systems and farming practices.

(i) Introduction of suitable varieties

The main varieties of paddy in the study area are local varieties such as Wangdikarma and Bumdalingpa, and are grown by the traditional farming methods. Therefore, for short term development, high yielding varieties such as IR-36, IR-64 and No.11, which were selected by CARD, should be introduced. These varieties should be extended to farmers through demonstration and field trials in the study area.

The main varieties of other cereal crops such as maize are also local, and seeds are multiplied by farmers themselves. It would be difficult and not practical to introduce HYVs in the study area immediately because of the low commercial value of these crops. Therefore, for short term

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development, the unit yields of local varieties have to be increased through improvement of farming methods.

Improvement of cropping systems and farming practices Cropping systems and farming practices for paddy cultivation should be improved to obtain maximum yield. In addition to improvement and construction of irrigation facilities, HYV seeds, chemical fertilizers and agro-chemicals such as pesticide should be introduced.

Although it is necessary to improve the cropping systems and farming practices of other cereals, introduction of modern and costly input materials such as chemical fertilizers and agro-chemicals should be postponed for future development because such drastic changes will not be acceptable. Increases in unit yield by agronomic improvement of farming practice have already been achieved in other countries as shown Table 4.3.1 and the same approach to improvement of farming practices should be applied in the study area for short term development.

(2) Increase of Cropping Intensity

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The increase of cropping intensity on wet land is essential for increasing agricultural production. Double cropping in particular can be introduced where sufficient irrigation water can be supplied through the year coupled with establishment of proper cropping systems. For short term development, mustard and wheat will be selected as the second crops to paddy.

It is also necessary to increase the cropping intensity on dry land. For short term development, crops to be cultivated extensively are chilli, maize as the second crop, wheat and barley, because of the local demand.

(3) Promotion of Cash Crops

Promotion of cash crops cultivation to increase farm income is required since the monetary economy is rapidly developing in the study, area, and the expenditure of the farm households is increasing. The following crops have been identified as important cash crops for the study area : mustard as the second crop after paddy on wet land, soyabeans intercropped with maize on dry land, chilli at low to middle altitude on dry land, and potatoes at middle to high altitude on dry and wet land.

(4) Strengthening of Agricultural Support Services

For implementation of the basic agricultural development plan through increase of unit yield, increase of cropping intensity and promotion of cash crops as mentioned above, it will be essential to strengthen the agricultural support services such as research, extension as follows:

a) Research

Although it would be desirable to establish a new regional research station for applied research in the study area to accelerate agricultural development, this should be left to the long term because establishment of research stations needs to be planned according to national priorities and a long term development plan for research. Accordingly, it is recommended that the existing research stations should be strengthened as far as possible, and that research should be directed to the transfer of satisfactory results of research to farmers through extension workers.

b) Extension

In order to develop farmers' confidence in the introduction of new cultivation systems, pilot farms should be established for demonstration and trials on:

- new farming practices for rice using HYVs and modern agricultural inputs,

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improved farming practices for mustard using local or improved varieties,

improved farming practices for maize more suitable for local varieties.

4.4.3 Irrigation and Drainage Development

Constraints for development of irrigation facilities in the area are the topographical conditions of steep slopes and the technical limitations of existing water resources, and the requirement for comparatively large budgets financially. Renovation works for small scale existing irrigation facilities will have first priority in the development of irrigation facilities in the 6th Five Year Development Plan. This is logical and practical.

Accordingly, the following general priorities should apply to the development of irrigation and drainage projects in the area:

- In order to obtain the maximum benefits from project implementation and to secure the irrigation water supply instantly and constantly, existing facilities should be renovated first.
- Operation and maintenance must be organized on a sound basis to maintain the facilities satisfactorily and for smooth operation.
- Any new irrigation and drainage development projects which have technical and economical advantages should be implemented.

4.4.4 Other Rural Facilities' Development

The basic development plan for other rural facilities was formulated as follows:

(1) Agricultural Mechanization

Shortage of agricultural labour in the area, especially during land preparation, planting and harvesting, is a obvious fact to be

considered due to the small population and minimal farm mechanization. Agricultural mechanization including diffusion of improved farm tools and implements, therefore, should be promoted to increase labour productivity in the area.

(2) Small Scale Agro-industry

The following small scale agro-processing facilities will be given priority on the basis of the promising cash crops of the area:

a) Oil extraction facilities for mustard and soyabean

b) Milling facilities for chilli

(3) Establishment of Workshop

The study area has no workshop for diffusion and repair of agricultural machines and tools at present.

For promotion of agricultural mechanization and small scale agro-industry mentioned above, establishment of a workshop will be indispensable.

(4) Improvement of Agricultural Extension Center

The existing agricultural extension centers in the study area are inadequate in all respects. Improvement of these centers is * essential for improvement of the agricultural extension services.

(5) <u>Others</u>

The study area is characterized by its underdevelopment not only in agricultural infrastructures but also in such social infrastructures as roads, power and water supply. The improvement of social infrastructures will have an important impact in improving the living conditions of rural inhabitants as well as in increasing agricultural productivity. Thus it may be argued that improvement of the social infrastructures is urgently required. However, the unfavorable state of social infrastructure is a common problem

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throughout the country and one that should be solved nationwide and on a long term basis taking requirements and priorities into consideration.

In this study, the basic development plan for social infrastructures will not be considered independently. Rather, when specific social infrastructures are required in the context of facilities' planning for the improvement of agricultural productivity of the area, the improvement and/or the construction of social facilities should be integrated with the project.

4.5 Approach to the Development

The villages and farm lands are scattered throughout the study area. In view of the shortage of development funds and of trained personnel, full-scale implementation of the basic plans mentioned above throughout the study area in the short-term is considered to be an impractical development approach. Hence the approach should be directed to the long-term and step by step.

The following strategies for integrated agricultural development of the area are therefore recommended on the basis of the development constraints:

- Selection and development of priority project areas which have relatively large development potentials and which will spread effects to the other areas.
- Expansion of these project areas according to the availability of funds and personnel taking development experiences in the priority projects into consideration.

According to the above development approach, selection of one model project area in each of Lhuntshi and Mongar Districts out of 16 project areas is considered as a realistic approach. Feasibility plans for two model project areas should conform to the basic concept and plans for integrated agricultural development of the area.

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5. DEVELOPMENT PLAN OF MODEL PROJECT AREA

5.1 Selection of Model Project Area

5.1.1 Criteria for Selection

For the selection of one model project area from each of Lhuntshi and Mongar Districts, the following criteria have been applied:

(1) Development Requisites

For successful and efficient implementation of the possible projects, the model project areas should have the following development characteristics:

economically advanced with a relatively wide-spread monetary
 economy to facilitate the introduction of cash crop
 production,

- sufficient populations and labour force,

 relatively well equipped with infrastructures, especially transportation not only for construction but also for spreading effects to other area.

(2) <u>Typical Conditions of the Area</u>

Development of the model project areas should play the role of a pioneer project for later development of other areas. The area too should be representative from the physical, economic and social points of view.

(3) <u>Development Potential</u>

Considering the importance of the successful development of the study area, the model project areas should be selected out of those having highest physical potential, particularly in terms of water and land resources.

(4) Non-existence of the Same Sort of Projects

In order to avoid a duplication of projects, areas will be excluded from selection as model project area if there are similar agricultural projects elsewhere.

5.1.2 Selection of Model Project Areas

16 project areas have been evaluated as shown in Table 5.1.1 according to the criteria for selection of model project areas.

In Lhuntshi District, Tangmachhu project area is the most suitable site for the model area in accordance with all selection criteria. Tangmachhu area has a leading economic position in Lhuntshi, hence spreading effects can be expected through the development.

Each of the areas in Mongar District has some faults in relation to the criteria as follows:

1)	Chali, Chaskhar ;	On-going project site under IFAD
2)	Yadi, Gyelposhing ;	Deficiency of water resources
3)	Pangsibi ;	Lack of water resources
4)	Karibee, Karbithang ; Masangdaza	Limited land resources and population
	and the second second second second	and the second

Yadi is located next to Chaskhar under IFAD, hence development effects from Chaskhar will be expected.

Karibee, Karbithang and Masangdaza including Bongdima adjoin one another and their water resources will be the same river of Shongjari chu. Hence the development of these three areas can be made one project and will best meet the criteria. The area comprising of Karibee, Karbithang and Masangdaza, which is called Masangdaza integrated project area, is the preferred site for the model area in Mongar District.

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5.2 Present Condition of the Model Project Areas

5.2.1 Location

The Tangmachu model project area is located about 8 km south of from the capital of Lhuntshi District. The distance by road along the national road from the capital to the entrance of the feeder road to the Tangmachu area is about 15 km and it takes almost 30 minutes driving. The area is situated along the Kuri chu in the shape of a fan on the mountain slope.

The Masangdaza model project area is located about 8 km west of the capital of Mongar District. The distance by road along the national road from the capital to the entrance of the Masangdaza area, Lingmethang GREF camp, is about 30 km and takes 50 minutes by car. There is no motorable road from the GREF camp, and it is necessary to walk 20 minutes beyond the bridge crossing over the Shongar chu.

5.2.2 Land Resources

The soils in the Tangmachu area are Cambisols, Acrisols and Gleysols. Gleysols are situated on the almost flat land and are utilized as paddy fields. Acrisols are mainly found in the upper part of the area and are mainly utilized as dry land. Cambisols extend over the middle to lower part of the area, and are utilized as paddy fields and dry land depending upon the steepness of slopes. Gleysols have good potential for paddy cultivation. The potential of Acrisols and Cambisols is not so high, but there is no serious limitation for cultivation. Most of tsheri lands are found on Acrisols in the higher part, and these lands are rather steep. These soils have low potential for cultivation and high erodibility when the vegetation cover has been removed.

In the Masangdaza area, the predominant soils are Cambisols and Regosols. Cambisols extend over the villages of Masangdaza, Karbithang, Karibee and part of Bongdima. These soils, when the slope is not steep, are utilized as permanent cultivated land. The potential for cultivation of these soils is moderate, but in some

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areas the contents of stones is high. Cambisols situated on steep slopes are utilized as tsheri land or grazing forest. Regosols are found in part of Bongdima village, and have a coarse texture and shallow top soil. These soils have no potential for cultivation.

5.2.3 Climate

The climate of the model project areas is classified as that of the lower zone of the microthermal Himalayan climate. In general, it is humid and warm in the wet season or summer and it is the dry and cold in dry season or winter.

The model project areas are located in the monsoon region. The monsoon divides the climate into two pronounced seasons. The wet season generally lasts from June to September, while the dry season occurs from November to March. April, May and October are transition periods of these seasons. The annual mean rainfall is about 830 mm and 985 mm respectively in Tangmachhu and Masangdaza project areas. More than 60% of the annual rainfall is concentrated in the wet season.

The mean air temperature in Tangmachhu area is about 16° C over the year with the highest mean monthly maximum of 24° C in June and the lowest mean monthly minimum of 5° C in January. In Masangdaza area, the mean temperature is about 23° C throughout the year, having the highest maximum of 32° C in June and the lowest minimum of 9° C in January.

An annual mean relative humidity is about 78% in both model project areas and varies from about 70% in the dry season to 90% in the wet season. The lowest relative humidity occurs in January and April respectively in Tangmachhu and Masangdaza area and the highest appears in July and September in each area.

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5.2.4 Hydrology

(1) River System and River Basin

The main water resources of Tangmachhu project area are the Begang Sher chu and the Begang Ngeh chu which is a tributary of the Begang Sher chu. These rivers rise in the mountain to the west, about 10 km from the project area, and flow southeastwards. The Begang Sher chu joins the Begang chu which is the main water resource for Menjibi project area, and flows westward to the Kuri chu as the Majebiri chu in southern part of the project area.

The catchment area at Gorgan intake is 15.1 km² and the altitude varies between about 2,000 m and 4,000 m. The length of the main river from the intake site to the upstream ridge is 6.7 km with an average slope of 27%. Most of catchment area is covered with dense mixed tropical forest.

The Shongjari chu is a major an important resource for Masangdaza integrated project area and rises in the mountain ranges in the southern part of the project area. It flows northeastwards between Manangdaza and Karbithang project areas where it joins the Shongar chu. The Shongar chu runs from east to west on the northern side of the project area and flows into the Kuri chu.

The catchment area at Bongdima intake is 22.0 km² and its altitude ranges from 800 m to 2,800 m. The length of the river from intake site to upstream ridge is 7.3 km with an average slope of 27%. The catchment area is covered with fairly dense mixed forest.

(2) Assessment of Water Availability

The water availabilities of the project tributaries were estimated on a monthly basis, by applying the monthly specific discharge and annual rainfall ratio by use of discharge records of the selected river, the Jiri chu, which shows the most similar river basin characteristics and rainfall distribution pattern to those of the project tributaries as mentioned in the previous chapter.

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The assessment of water availabilities in the model project areas, i.e., Tangmachhu and Masangdaza areas, was made on a 10-day basis in conformity to the above procedure.

The specific discharges to be applied for the assessment are given below:

n an Aritana an Aritana. An taonachta	Speci	fic Discl	harge to	be applie	ed (1/s	/km ²)
Month		Mean	<u> </u>	D	rought	
n est stilles	. E	м. М . н. н.	$\mathbb{P}^{1} = \{\mathbf{L}_{i,j}\}_{i \in \mathbb{N}}$	E	M	$\mathbf{L}_{1,2,2}$
Jan,	16.4	16.8	16.5	10.5	10.7	9.5
Feb.	14.1	12.3	12.6	9.9	9.7	8.7
Mar.	14.8	14.2	13.4	8.8	8.9	8.3
Apr.	18.1	20.8	21.6	10.4	8.8	12.6
Mav	25.7	24.3	24.1	12.4	16.8	17.6
Jun.	33.3	34.6	45.4	18.9	19.0	21.6
Jul.	60.5	65.8	71.4	29.4	31.0	31.2
Aug.	56.1	45.8	47.9	29.6	21.4	19.3
Sep.	56.4	63.8	38.8	17.5	19.2	17.1
Oct.	29.9	26.9	25.5	16.2	15.6	18.4
Nov.	23.2	21.3	20.5	16.1	15.9	16.0
Dec.	19.1	18.7	16.9	14.2	13.0	11.3

Note: E; Early 10-day, M; Middle 10-day, L; Last 10-day

From the above specific discharges, the available discharges, that is, mean and drought discharges at the prospective intake sites for both model project areas were computed as shown in Table 5.2.1.

(3) Flood Discharge

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In this study, the peak flood discharge on the project tributaries were estimated by the Rational Formula as recommended in the Hydrology Manual published by the Department of Agriculture as this is applicable and suitable for the catchments with areas of less than 25 km²

The estimated peak flood discharges at the proposed intake sites are as follows:

Project Area	Name of Intake	······································	Catchment Area (km ²)	Flood Discharge (m ³ /s) <u>Return Period in Years</u> 2 5 10 25 50
	Tangmachhu I Tangmachhu I Gorgan Masangdaza Bongdima		5.4 4.5 15.1 15.2 22.0	$\begin{array}{cccccccccccccccccccccccccccccccccccc$

5.2.5 Demographic Condition

Tangmachhu model project area extends over 20 local villages having 253 resident households with a total population of 2,427. The average family size in Tangmachhu is 9.6. Masangdaza model project area comprises 4 local villages, namely Karibee, Karbithang, Masangdaza and Bongdima. However, some farmers of Masangdaza model project area are living outside the project area. The total population and households related to Masangdaza model project area are 498 and 87 respectively. The average family size in Masangdaza is 5.7.

Farmers in the project areas are categorized as (i) wet land owner, (ii) dry land owner, or (iii) landless farmer. A wet land owner is a holder of wet land together with or without dry land, tsheri or other land. A dry land owner is a holder of dry land, tsheri or other land without wet land. About 84% - 85% of total resident households in both project areas are wet land holders. Tangmachhu and Masangdaza project areas have 23 and 3 landless farmers respectively. Demographic condition of both project areas may be summarized as follows:

Item	Tangmachhu	Masangdaza
1. District	Lhuntshi	Mongar
(Block)	(Tangmachhu)	(Salling)
2. No. of Local Villages	20	5/1
3. Population	2,427(100%)	498 (100%)
- Per Local Village (3/	· · · · · · · · · · · · · · · · · · ·	100
- Share of Population i		11%
4. Family Size	9.6	5.7
5. Student Population	582 (24%)	133 (27%)
(5-14 age group)		
6. Labour Force	1,464 (60%)	272 (55%)
(15-54 age group)		. · ·

/1: Included Pangsibi out of the project area.

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5.2.6 Agriculture

(1) Land Use

On the basis of the field survey, present land use is estimated as follows:

	in a start way	
	` Tangmachhu	Masangdaza
Description	Area	Area
	(ha)	(ha)
Irrigated land	220	30
Rainfed land	114	81
Tsheri land	95	3
Others/1	49	9
Total	478	123
	and the second	

/1 : Others includes fallow land, kitchen garden, glassland, etc.

Out of 220 ha of irrigated land in the Tangmachhu area, about 170 ha is cultivated with rice in an average year owing to the shortage of irrigation water. An other 50 ha of irrigated land is not cultivated. In the Masangdaza area, about 40% of rainfed land is cultivated in average year.

(2) Land Holding and Tenure System

Land holding and tenure system surveys were carried out on the basis of the registered land records in both project areas. The average holding size is 1.84 ha in Tangmachhu and 1.20 ha in Masangdaza. Wet land owners in Tangmachhu and Masangdaza project areas hold 1.99 ha and 1.22 ha of farm land on average respectively. On the other hand, the average holding size of dry land owners in Tangmachhu is only 0.49 ha compared with 1.00 ha in Masangdaza.

Farm lands of absent land owners are mainly cultivated by landless farmers or small scale land owners with the tenants receiving about 40% of the total harvest.

Classification of land owners is done by wet and dry land holding size based on the registered land records of the land owners as a whole. The first quartile, median and third quartile farmers in ascending wet and dry land holding size are identified. Their holding sizes may be summarized as follows:

Farmers Classified	Wet/Dry Land Holding			
by	Tang	machhu	Masangdaza	
Wet/Dry Land Size	No.	Area (ha)	No. Area (ha)	
First Quartile Farmer Median Farmer Third Quartile Farmer	65th 130th 195th	0.59 1.08 1.74	26th 0.80 51st & 52nd 1.20 77th 1.20	
Total No. of Farmers	259		102	

(3) Cropping Pattern

The cropping patterns of both model project areas are basically the same as those in Lhuntshi and Mongar Districts.

The cropping patterns in both areas are estimated and shown in Fig. 5.2.1. The cropping intensity in Tangmachhu area is estimated at 79% on wet land, 108% on dry land, 40% on tsheri land and 78% on average, and in Masangdaza area, 100%, 62%, 20% and 70% respectively.

(4) Farming Practices

Farming practices for all crops are carried out labour intensively. Although all the active family members participate in farming, there is a labour force shortage.

The main varieties of paddy are local ones. Paddy seeds are sown in the dry nursery beds which are prepared in the ratio of about 1/15 to 1/20 of the paddy field size to be transplanted. Field preparation is made before transplanting by bullock power. Transplanting is carried out by hand. Random transplanting is popular and one (1) plant per seedling is applied. Weeding is also done by hand. Harvesting is generally carried out by using sickle and harvested paddy is dried on the bunds of the paddy fields. After

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drying, threshing is carried out by hitting on a stone on a local bamboo mat and threshed grains are stored in bamboo pots.

The main varieties of maize are Ashum Karupa, Bepa Ashum, Ashum Marupo and Hybrid 410 in the Tangmachu model project area, and Bepa (the first crop), Teksumpa (the second crop) and X440 in the Masangdaza model project area. Random sowing is usually employed. Seeds of soybean and mango bean are usually sown at the same time or at the first weeding after about 30 days. The second weeding is carried out at a plant height of 120 cm. Harvesting is carried out by cutting maize stems and removing the corn. Drying and threshing of the corn is done in the farm yard.

For other minor crops like millet, second crops such as the second maize, wheat and buckwheat, ploughing by bullocks is carried out only once just after harvesting the first crop. While only wheat is irrigated before sowing in the Tangmachu area, other crops are cultivated under rainfed condition.

(5) Crop Yields and Production

The average unit yields and production of the model project areas may be summarized as shown below:

	Unit Yield	Harvested Area	
a da serie de la composición de la comp	(t/ha)	(ha)	(t)
Tangmachu area			
paddy	2.2	170	374
wheat	1.0	2	2
potato	2.1	2	.4
maize	1.2	152	183
(1st maize)	(1.4)	(112)	(157)
(2nd maize)	(1.4)	(2)	(3)
(tsheri land)	(0.6)	(38)	(23)
soybean	0.3	58	17
chilli	0.9	2	2
mustard	0.2	7	1
Masangdaza area			
paddy	1.5	30	45
buckwheat	0.4	8	3
maize	1.1	40	44
(1st maize)	(1.1)	(32)	(35)
(2nd maize)	(1.1)	(8)	(9)
mustard	0.3	2	1

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(6) Livestock Production

The number of livestock and poultry in the model project areas were estimated as follows:

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Item	Cattle Horses	Pigs Poultry
1. Tangmachhu - Total Number - No. per Household	1,541 161 6.1 0.6	
2. Masangdaza - Total Number - No. per Household	647 59 7.4 0.7	92 353 1.1 4.1

(7) Processing and Marketing

Eight (8) rice mills equipped with diesel engines of 7 H.P were introduced in the Tangmachhu project area. These mills are mainly located at such villages as Rakidung, Tangmachhu, Dangsha and Takila along the Tangmachhu feeder road. Farmers who live in villages far from the feeder road still depend on manual milling due to difficulty of access to a mill site. The Masangdaza project area has no rice mills.

No oil mills have been introduced in both project areas. Mustard oil is manually extracted. The Manual extraction is a time and labour consuming work and results in a large processing loss.

Most of the farm products in the project areas are locally consumed at present. In Tangmachhu about 20 t of soyabean and 3 t of potato are annually transported to Samdrup Jhongkhar by some of local shop keepers. There are not any prevailing sales of cash crops in Masangdaza.

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(8) Farmers' Economy and Intention

(a) Farmers' Classification

The sampled farmers in the farm economic survey in Tangmachhu and Masangdaza project areas comprised 16% and 33% of the total resident household respectively. They were classified into four groups according to the wet and dry land sizes on first quartile, median and third quartile farmers mentioned before.

(b) Disposal of Farm Products

Farm products are mainly for home consumption. The proportion of sold paddy to total production is estimated at 12% in Tangmachhu and 4% in Masangdaza on average. About 6% of the maize in Masangdaza is sold. Per capita food consumption of cereals is 260 kg in Tangmachhu and 307 kg in Masangdaza on average of which paddy accounts for about 81% in Tangmachhu and 23% in Masangdaza.

(c) Living Expenses

One family member spends on average around Nu 382 in Tangmachhu and Nu 151 in Masangdaza on living expenses. The main items of farmers' living expenses are clothes and foods such as rice, salt and edible oil.

(d) Farm Economy

Cash income of the farmers is divided from farm income and nonfarm income. Farm income mainly accrues from paddy in Tangmachhu and maize in Masangdaza. Dairy products provide secondary farm income, mainly for farmers with more than the median scale of land holding which is 1.08 ha in Tangmachhu and 1.20 ha in Masangdaza. Farmers below the median scale rely heavily on non-farm incomes for their living expenses.

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(e) Farmers' Concerns

The farmers' priority development requirements in the project areas are the same as in the study area as a whole. Development of irrigation facilities is commonly needed. Desires for agricultural support services include timely distribution of fertilizer and agrochemicals, extension of cash crops, diffusion of agricultural machines and tools, and marketing services. Rural electrification is also required mainly for lighting and as a power source for rice mills instead of diesel engines.

(9) Labour Balance

The peak labour requirement is estimated at 2.44 persons/day/ household during the last ten days of May in Tangmachhu and 1.76 persons/day/household during the last ten days of July in Masangdaza as detailed in Annex IV. The available form labour force per day per household in Tangmachhu and Masangdaza were estimated at 2.58 and 1.87 respectively.

The peak labour requirement in the project area is 94% - 95% of the available labour force. It is considered that demand and supply for farming labour is barely balanced at present. The low intensity of land use and low productivity of crops are derived from the shortage of labour.

(10) Agricultural Support System

An extension center together with a veterinary center, a basic health unit and a primary school covering the Tangmachhu Block is located at Takila in the Tangmachhu project area. Takila is a rural center of the Tangmachhu Block. An extension center covering the Masangdaza project area in Salling Block is located at Lingmethang which is on the far side of the project area after crossing the Shongar chu. An animal husbandry farm, a dispensary and a primary school are also located at Lingmethang. Facilities at each extension center comprise one building with one office room and one store. The buildings were poorly constructed and parts of the walls and roofs have deteriorated and storage conditions for fertilizers and agro-chemicals are unsatisfactory. The Tangmachhu extension center together with other public service facilities will be newly constructed by 1990 under the nationwide project for "Rural Development Service Centers." On the other hand, renovation of the Lingmethang extension center is not planned at present.

Agricultural support services in each project area are carried out by one agricultural extension worker (AEW). As each AEW has to supervise a whole block, sufficient contacts with local farmers are often not possible due to difficulties of access in some areas.

5.2.7 Irrigation and Drainage

(1) Tangmachhu Area

(a) Condition of Paddy Fields

This area is a largest paddy farming area in East Bhutan. About 220ha of wet land has been developed, extending approximately 3 km from south to north and 2.5 km from east to west. The difference of altitude is estimated to be about 800 m from the lowest place to the highest.

The paddy fields have been developed on a comparatively gentle slope with many small terraces. Most of the paddy fields are 2 m to 3 m wide and extend along the contour line of the original ground. The height of terraces is 0.3 m to 0.6 m usually, but 1 m or more sometimes. There is no protection of these terraces such as masonry walls.

(b) Condition of Irrigation Facilities

There are two irrigation systems, Tangmachhu and Gorgan canal systems. The Tangmachhu and Gorgan canals command the upper and lower

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part of the area respectively. These two canals are located at about 200 m difference in altitude, and run in the same direction parallel to the same hillside.

The water resources of these canals are the Begang Sher and the Ngeh chus respectively. The altitude of their intakes is 2,240 m and 1,960 m, and the canal tails 1,960 m and 1,840 m respectively. The canal lengths are about 8.6 km and 4.0 km respectively.

The intake weirs are made of random filled stones and boulders. Neither regulating facility for discharge control nor releasing facility for sedimented materials are provided. These temporary facilities have to be repaired every after flood and have a high seepage losses.

The canal gradients are about 1 to 100 in most of cases. The canals were constructed on a 30 to 40 degree cross-slope along the contour line. Most of canals are earth canals without lining. At gullies and land collapses, wooden flumes have been made from large logs.

There are no adequate spillways, waste ways or retaining walls as canal protective structures. Cross drainage facilities to cut the inflow of surface water into the canal in the rainy season are not provided adequately. As a result, canal collapses occur at many places due to overtopping of the canal. These cause shortage for water supply and high O&M and repairing costs.

The water distribution system of the secondary and tertiary canal networks have not been developed enough and farm ditches have not been provided in most parts of the paddy fields. They have no regulating facility for discharge control and most of them are excavated earth trenches only. This is one for the reasons for low irrigation efficiency.

It will very difficult to rearrange the secondary and tertiary irrigation network on this very steep ground. However, this is not a

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substantial problem because these distribution canals are mostly of short length.

(c) Operation and Maintenance

At present there is no organization of water management and operation and maintenance in the area. However, these are the responsibility of the Chimi, the elected member of the national assembly in a block; the Gup, head of block; and the Mangup or assistant Gup. No Chusumpa or gate ditch tender, is nominated for the water management at the field, and this has to be carried out by beneficiaries themselves without regulation.

Annual maintenance works comprise mainly the repair of intake weirs and collapsed canals, and the removal of sediment. These minor works are executed by beneficiaries. Major renovation works are undertaken by the government with beneficiaries contributing the labour force.

(2) Masangdaza Area

(a) Condition of Paddy Fields

This area has small blocks of paddy scattered on both banks of the Songjari chu. They belong to existing irrigation schemes of Masangdaza, Karbithang, Bongdima and three (3) other old schemes which cover 13 ha of command area. Karibee area is a proposed new development area. Irrigation schemes of Masangdaza and Bongdima have been constructed since 1976 under new land reclamation and settlement programs of the government.

The paddy fields in the area are of two kinds. There are the many small terraced paddy fields which have been developed on very steep hillsides, and the comparatively flat paddy fields developed on a river terrace along the Shongar chu. Masangdaza and the upper part of Bongdima areas belong to the former category and Karbithang and lower part of Bongdima areas belong to the later. These irrigation schemes could expand the command area up to 80 ha in total when these irrigation facilities are completely renovated and strengthened. Existing maize fields may be changed into irrigated paddy fields at Masangdaza, Bongdima and Karibee areas in the future.

(b) Condition of Irrigation Facilities

The existing irrigation systems consist of six (6) small scale canals. Masangdaza, Karbithang and Bongdima canals have been renovated with the government assistance. The other three (3) canals have very poor facilities which have been constructed and repaired privately. There are no distribution canals except in the Karbithang system which has some very short and poor secondary canals. The Masangdaza canal's length is 3.3 km, the Karbithang's 1.6 km, and the Bongdima's 4.5 km at altitudes of 906 m, 741 m, 640 m at their tails respectively. The other three (3) canals are each only a few hundred meters long. The gradients of these canals are mostly 1 in 100, 1 in 1,000 in paddy fields and steep chute at rock area.

All water resources are taken from the Songjari chu. The Masangdaza, Karbithang and Bongdima areas each have separate intakes. The altitudes of these intakes are 919 m, 819 m, and 804 m respectively. The other three (3) intakes are located about 50 m to 100 m below Bongdima intake.

All intake weirs, except Masangdaza intake are made of random arrangements of stone and boulders combined with log frames. These temporary facilities have to be repaired after every flood. Masangdaza intake is a wet masonry weir. None of these intakes have regulating facilities for discharge control or flushing facilities for sediment.

Masangdaza and Bongdima canals have already been renovated. They have extensive masonry lined sections, but Karbithang canal has an earth canal in most sections except for a short rocky section. Even where some sand traps and spillways have been provided in renovated canals, they are not functioning properly. (c) Operation and Maintenance

The water management of Masangdaza and Bongdima canals has been undertaken by Chusumpas, but no other canals have Chusumpas. The former Gup is carrying out the water distribution practice for Karbithang Canal.

Operation and maintenance and water management for the all irrigation facilities in Masangdaza area are in practice carried out by the Chimi, Gup and Mangups.

Repair and renovation works for the facilities are carried out by the beneficiaries themselves for minor works and by the government with farmers' labour for major renovation works.

5.2.8 Other Rural Facilities

(1) Feeder Road

The existing feeder road passes through the Tahgmachhu area from the lowest place to the heli-port at an altitude of approximately 1,850 m. The average gradient of the feeder road is 1 in 15. The slope is even steeper in some places. Minimum curvatures are about 10 m to 15 m radius.

The feeder road ends near the tail of the Gorgan Canal. There is no other road in the construction area except for narrow foot paths for pedestrians and horses.

Masangdaza area is to be accessed from the national highway between Bumthang and Mongar. At present there is no bridge over the Shongar chu, a tributary of the Kuri chu. There is a traditional cantilever type wooden bridge at Duptho, but this cannot be used for the transportation of heavy materials and equipment.

Even the foot path network is inadequate in Masangdaza area. There are O&M roads about 50 cm wide along the canal in most parts of Masangdaza and the upper part of Bongdima. There is no passable O&M road along any other canals.

(2) Others

(a) Electrification

Tangmachhu and Masangdaza project areas have no electric power supply at present.

(b) Rural Water Supply

Beneficiaries of rural water supply are estimated at 900 in Tangmachhu and 400 in Masangdaza which are about 37% and 80% of the total population respectively.

Masangdaza project area has ample water resources, therefore rural water supply is easy to provide. On the other hand, Tangmachhu has no tributaries to provide a year-round rural water resource. Rural water supply in Tangmachhu is limited to a few springs.

(c) Other Facilities

In Tangmachhu area there is a primary school, a basic health unit, an agricultural extension center and a veterinary center.

The nearest no primary school or other public facilities in Masangdaza area are at Lingmethang just next to the Masangdaza area.

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5.3 Development Plan for the Model Projects

5.3.1 Project Formulation

The Tangmachhu and Masangdaza model projects have been formulated in line with the strategy of providing basic integrated agricultural development in Lhuntshi and Mongar Districts, the present conditions of the areas and local requirements. The following components were selected for priority development:

(a) Tangmachhu Model Project Area

(i) Irrigation and drainage development

(ii) Other rural facilities development

- Feeder road construction

Agro-processing facility (Mustard oil mill, chilli

powder mill and multi-purpose dryer)

- Strengthening agricultural support services through supply of agricultural machines and tools

(b) Masangdaza Model Project Area

(i) Irrigation and drainage development

(ii) Other rural facilities development

- Feeder road construction

- Construction of an agricultural extension center

- Strengthening agricultural support services through

supply of agricultural machines and tools

(c) Lhuntshi and Mongar Districts

(i) Construction of a workshop with a mobile workshop

(ii) Strengthening O&M activities for feeder road and irrigation facilities through supply of O&M equipment

5.3.2 Agricultural Development Plan

(1) Land Use Plan

Based on the basic integrated agricultural development plan, the present land use will be changed with the project as follows;

Description	Without project Condition (ha)	With project Condition (ha)
Tangmachu area		
irrigated land	170	220
(non-irrigated) 1	50	
rainfed land	11 4	114
tsheri land	95	0
others (rainfed) 12	49	144
total	478	478
Masangdaza area		
irrigated land	30	80
rainfed land	81 <u>/3</u>	31
tsheri land (rainfed)	3	
others (rainfed)/2	9_	12
total	123	123
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/1: About 50 ha of irrigated land would not be cultivated in an average year because of the unreliability of irrigation water supply.

12 : Others include fallow land, kitchen garden, glassland, etc.

13 : About 32 ha of rainfed land would not be cultivated.

(2) Proposed Cropping Patterns

Based on the basic integrated agricultural development plan, the following crops have been selected for the model projects;

- (a) Paddy will be the main crop on wet land, and maize will be the main crops on dry land to achieve self-sufficiency in foodstuffs for the farm households. Other crops presently grown in the area such as wheat and other cereals will also be planted.
- (b) The main cash crops to increase income of the farmers will be soyabeans, chilli and mustard.

Based on available research data obtained from the IFAD project, the following varieties of crops were selected:

	Paddy :	No.11 for higher altitudes IR 64 for middle and low altitudes
	Wheat :	Sonalica de la contra de la con
. *	Mustard :	M 27 or local variety (Yungkere)
		Local varieties (Ashum Karpa, Bepa Ashum, Ahum Marupo, Maringmo Ashum, etc.)
	Soyabean :	Local varieties (Sawling Kurupa, Sawling Nagpo, etc.)
,	Chilli :	Local varieties (Kurtetpa Bengala, Ngalung Bengala, Sha local, etc.)

Based on the above mentioned conditions together with irrigation water supply, climatic conditions and overlapping of farming operations, rotational cropping is proposed as follows:

Crop	Summer Crop	Winter Crop	'Total
angmachhu Area:			
Irrigated crops on the wet]	land		
paddy	220		220
wheat	-	55	-55
mustard	-	55	55
total	220	110	330
Rainfed crops on the dry lar	nd		an an ag
maize/soyabean	57	-	57
chilli	57	-	57
wheat		29	29
mustard	<u> </u>	29	29
total	114	58	. ∾ 172 ₃₄
asangdaza Area:	ta a tu		
Irrigated crops on the wet 1	Land		
paddy	80		80
wheat		20	20
mustard	· · ·	20	20
total	80	40	120
Rainfed crops on the dry lar	nd	•	
maize/soyabean	31	· · · · · · · · · · · · · · · · · · ·	31
wheat	· · · ·	8	. 8
mustard	. •	8	8
total	31	16	47

Model Project Area

On wet land, paddy for the summer crop will be planted throughout the area. After paddy, wheat and mustard for winter crops will each be grown on 25% of the area. The sequence of the crops on one plot will be on a 4 years rotation of paddy-wheat in the first year, paddy-fallow in the second year, paddy-mustard in the third year and paddy-fallow in the last (fourth) year.

On dry land of the Tangmachu area, chilli and maize intercropped with soyabean for the summer crop will each be planted on 50% of the area. In the Masangdaza area, maize intercropped with soyabean for the summer crop will be planted throughout the area. After summer crops, wheat and mustard for winter crops will each be grown 25% each of the area on a rotational base. The proposed cropping pattern is illustrated in Fig. 5.3.1.

(3) Proposed Farming Practices

To increase agricultural production based on the proposed cropping patterns, proper farming practices will have to carried out. The proposed farming practices are shown in Annex IV. The recommended main items of farming practice for paddy may be outlined as follows:

The paddy seed should be selected by using clean water. Pregermination is recommended to increase the germination ratio. The wet nursery of the semi-dry method has to be prepared as flat as possible. A basal application of fertilizer is essential. The recommended dosage is 5 kg/ha of urea. Careful water management is very important for healthy growth of seedlings. The nursery period is 40 days from seeding. Transplanting is made by manual labour in line using a planting rope, and planting 3 seedlings per one hill is recommended.

The basal application of fertilizers is 80 kg/ha of urea, 70 kg/ha of T.S.P. and 4 t of farm yard manure. A top dressing of 70 kg of urea is made at panicle initiation stage.

After transplanting, weeding is carried out at least twice by rotary weeder. As regards the plant protection, fungicide and pesticide will be applied based on a diagnosis of diseases and insects. Harvesting is carried out by manual labour. Use of a pedal thresher, instead of traditional hand threshing, is recommended.

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The labour balance was studied on the basis of the proposed cropping pattern and farming practices. The available labour force per farm household is 2.58 man-days in the Tangmachhu area and 1.87 man-days in the Masangdaza area. Estimated peak labour requirement per farm household is 2.55 man-days in the Tangmachu area and 1.84 man-days in the Masangdaza area. These peak labour requirements are less than the available labour force. This indicates the proposed farming practices can be made by the family labour and bullock power through labour exchange and a rotational base.

(4) Anticipated Yields and Production

After completion of the projects, the present yields of crops will be stabilized and increased. The following anticipated crop yields are estimated on the basis of the results of the research data:

	Without Project		With
Crop	Tangmachhu (t/ha)	Masangdaza (t/ha)	Project (t/ha)
irrigated crops			
paddy	2.2	1.5	5.0
wheat	· · · · -		1.8
mustard	, s s , −	· . – .	0.9
rainfed crops			•
maize	1.4	1.1	1.5
maize(tsheri)	0.6		
soyabean	0.3	en en en en en ser fil	0.5
wheat	1.0	7	1.2
mustard	0.2	0.3	0.6
chilli (dried)	0.9		2.0
potato	2.1	· · · · ·	
buckwheat	· · · ·	0.4	***

Based on the proposed cropping patterns, the cropped area and crop yields, future crop production is estimated as follows:

		(Unit: t)		
Crops	Tangmachhu	Masangdaza	Total	
irrigated land				
paddy	1,100	400	1,500	
wheat	99	36	135	
mustard	50	18	68	
rainfed land				
maize	86	47	133	
soyabean	29	16	45	
chilli	114	-	114	
wheat	35	10	45	
mustard	17	5	22	

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The annual paddy production at full development stage in the Tangmachhu area would amount to 1,100 t of dried paddy in total, and the expected annual increment of paddy production would be about 726 t. However, the maize production will decrease to 86 t at the full development stage from 160 t under without project condition respectively. The annual paddy production at full development stage in the Masangdaza area would amount to 400 t of dried paddy in total, and the expected annual increment of paddy production would be about 355 t.

(5) Price Forecast and Marketing

(a) Price Forecast

Financial prices of farm inputs and outputs were estimated on the basis of current market or farmgate prices prevailing in the project area as of 1988.

Economic prices for trade goods such as paddy, maize, wheat, soyabean, mustard and fertilizers were estimated on the basis of the projected world market prices of the World Bank in the long term range for the period of 1987 to 1995 as detailed in Annex IV. The other economic prices are converted from financial prices by SCF of 0.90. Financial and economic prices of all outputs and inputs may be summarized as follows:

	and the second		김 씨는 것 같아요. 그는
Item	Unit	Financial Price (1988)	Economic Price (1995)
<u>Outputs</u>			ta da greco.
1) Paddy	(Nu/t)	3,000	2,900
2) Maize	(Nu/t)	2,600	3,100
3) Wheat	(Nu/t)	2,400	3,900
4) Soyabean	(Nu/t)	2,700	5,300
5) Mustard	(Nu/t)	4,000	3,600
6) Chilli (dry)	(Nu/t)	10,000	9,000
7) Buckwheat	(Nu/t)	1,500	1,400
8) Potato	(Nu/t)	1,800	1,600
<u>Inputs</u>		and the second second	
1) Fertilizers		1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -	
- N	(Nu/kg)	2.3	10.7
- P ₂ O ₅	(Nu/kg)	12	9.2
- K ₂ O	(Nu/kg)	1.4	4.8
2) Agro-chemicals		an a	
- Liquid	(Nu/1)	72.2	100.1
- Granular	(Nu/kg)	11.8	16.4
3) Labour	(Nu/day)	15.0	13.5
4) Hired animal power	(Nu/day)	60.0	54.0

(b) Marketing of Agricultural Products

Demand and supply analysis on the future agricultural products in the project areas was carried out on the basis of (i) future crop production and (ii) local consumption on foods, seeds and others in 1995 based on the future population estimation. The result of the analysis may be summarized as follows:

			·			(Uni	t: t)
	Area/Item	Paddy (Rice)	Maize	Wheat	Soyabean	Mustard (0il)	Chilli
т.	Tanqmachhu		ta di se				
~ •	[1] The second state of	1,100	86	134	29	67	114
		765 -	86	88	5	8	6
	3. Marketable Quantity	335	· · · · 0	46	24	59	108
	a second seco	(217)				(20)	
II.	Masangdaza	Sec. 1		$(1, 2^{n-1})$	1. The second	1	
·	1. Production	400	47	46	16	23	 5
	2. Local Demand	173	35	9	3	3	
	3. Marketable Quantity	227	12	37	13	20	-
1	a de la companya de l	(147)	· · · · ·			(7)	

The marketable quantity of rice can make up around 93% of the present the deficit of both Districts with 390 t of rice. The surplus of soyabean and chilli can be exported to India through FCB and private channels. The marketable mustard oil after meeting the deficit of about 23 t is estimated at 4 t. This edible oil surplus can supplement the deficit of Bhutan.

5.3.3 Irrigation and Drainage Development Plan

(1) Irrigation Water Requirement

Rice will be the principal crop in the project area and upland crops such as wheat and mustard are also recommended as consumable and profitable crops for the Project. Therefore, a study of the irrigation water requirement was made for these crops.

The irrigation water requirements were calculated for the proposed cropping pattern on a 10-day basis. The crop water requirements for paddy and upland crops were calculated as follows:

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(a) Paddy

CWR =	NWR + P	WR + FWR
where,	CWR :	Crop water requirement (mm/day)
	NWR :	Nursery water requirement (mm/day)
	PWR :	Puddling water requirement (mm/day)
	FWR :	Field crop water requirement (mm/day

(b) Upland Crops

CWR = J	WR + F	$\mathbf{W}\mathbf{R}$
	omit i i	
where,	CWR :	Crop water requirement (mm/day)
	LWR :	Land preparation requirement (mm/day)
	FWR :	Field crop water requirement (mm/day)

In the above calculation, the potential evapotranspiration, which is used to assess the field crop water requirement, was calculated by Blaney-Criddle Method using the air temperature data obtained at Tangmachhu and Lingmethang Meteorological Stations. The crop coefficient at each growth stage is derived from the Irrigation Design Manual published by DOA and Irrigation and Drainage Paper, No.24 by FAO. The percolation rate was estimated at 1.0 mm/day in Tangmachhu area and 10.0 mm/day in Masangdaza integrated area, considering the actual field measurement results and the special feature of the terraced fields on steep hillsides.

The farm water requirement was assessed on a 10-day basis, deducting the effective rainfall from crop water requirement. The effective rainfall for paddy was estimated by the daily water depth balance method and that for upland crops by the daily moisture level balance method. The estimated 10-day effective rainfall for paddy and upland crops, and the 10-day farm water requirements are shown in Table 5.3.1.

The diversion water requirement is defined as the amount of farm water requirement plus allowances for farm waste, conveyance and operation losses. The overall irrigation efficiency for paddy was roughly estimated at 60% consisting of application efficiency of 85%, operation efficiency of 80% and conveyance efficiency of 90%, taking into account the special feature of the terraced paddy field on steep hillsides where the surplus irrigation water flows down to lower terraces and is not completely wasted. The overall irrigation efficiency for upland crops was roughly assumed to be 55%. The unit diversion requirement for each crop is presented in Table 5.3.2 and the peak unit diversion requirement for each crop is summarized below:

an againg	Tangmachhi	i Area	<u>Masangdaza</u> Inte	grated Are
Crop	Peak Unit Diversion Requirement (l/s/ha)	Period	Peak Unit Diversion Requirement (l/s/ha)	Period 10-day
Paddy	1.49	Jun. 3rd	2.85	Aug. 2nd
Wheat	1.32	Nov. 2nd	0.95	Nov. 3rd
Mustard	0.85	Dec. 2nd	0.76	Mar. 2nd

(2) <u>Irrigable Area</u>

The irrigable areas for paddy and upland crops were estimated by water balance calculation between the available river discharge at lower prospective intake site and the unit diversion requirement as shown in Table 5.3.2. In this calculation, it was assumed that the cropping intensity of both wheat and mustard would be 25% in each case and that the available discharge for Masangdaza integrated area was after deduction of 10 1/s required for the Animal Husbandry Area and Public Road Construction Camp (DANTAK) for their domestic water.

As a result of the above calculation, the irrigable areas for respective crops guaranteed by the drought discharge at the lower proposed intake site were estimated as follows:

		(Unit: ha)
Crop	Tangmachhu Area	Masangdaza Area
Paddy	221	148
Upland crops	334	473

(3) Proposed Irrigation Facilities

The irrigation facilities have been developed in both project areas, but these facilities have following problems:

At Tangmachhu area there is no room for increasing the extent of paddy fields beyond the existings level. Moreover, some parts of the existing paddies are not available for paddy farming every year due to the present ineffective water utilization practices.

At Masangdaza area there is a considerable acreage of dry land which would be convertible into wet paddy land if the irrigation water supply is adequate. These dry lands have to be used at present for dry farming because existing irrigation facilities are either inadequate in capacity or non-existent.

The irrigation plan being proposed aims to secure a water supply throughout a year to develop the paddy land as much as possible and to utilize the water resources as much as possible. For these purposes the existing irrigation facilities would be improved or new irrigation facilities constructed in order to increase the availability of intake water, and the efficient water conveyance and water distribution às much as possible.

Followings main irrigation facilities are proposed in this plan:

(a) Tangmachhu Area

i

New construction, intake	Tangmachhu 1st intake	11	No.
	Tangmachhu 2nd intake	11	No.
	Gorgan intake	1 1	No.
Renovation, main canal	Tangmachhu canal	8.6	km
${\cal L}_{\rm eff}$, where the state of the st	Gorgan canal	4.0	km
		0.4	km
· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·		km km
	Renovation, main canal New const'n secondary canal (2 secon Renovation, secondary canal	Tangmachhu 2nd intake Gorgan intake Renovation, main canal Tangmachhu canal Gorgan canal New const'n secondary canal (2 secondary canals to be combined) Renovation, secondary canal Ngunmaling secondary canal	Tangmachhu 2nd intake1Gorgan intake1Renovation, main canalTangmachhu canal8.6Gorgan canal4.0New const'n secondary canalTangmachhu secondary canal0.4(2 secondary canals to be combined)0.4

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(b) Masangdaza Area

	Masangdaza intake Bongdima, Karbithang intake ng 2 intakes to be combined)		No. No.
ii) Renovation, main canal	Masangdaza canal	3.3	km
	Bongdima canal	4.5	km
	Karbithang canal	0.7	km
iii) New const'n main canal	Karbithang canal	0.9	km
iv) New const'n, secondary canal			
	Tshanglungshing secondary canal	10.2	ĸm

After completion of the above new construction and renovation of existing irrigation facilities, the capacities and command areas for each irrigation canal can be increased to the following:

Area/ Canal System	Command Area (ha)	Discharge (m ³ /sec)
	and the second	and the second
Tangmachhu	85.9	0.13
Tangmachhu Gorgan	134.1	0.20
Total	220.0	0.33
	a sector a sector a sector a sector a	1 - Eliza
Masangdaza Masangdaza	37.4	0.11
Bongdima	26.5	0.086
Karbithang	16.0	0.046
(Including new Kari	bee area)	
Total	79.9	0.242

The irrigation system would follow the existing plot to plot system due to the particular topographical conditions described in 5.2.7.

(4) Irrigation System

At Tangmachhu area, two (2) existing irrigation systems are available without restructuring the canal networks. Due to the particular local topographical conditions there is no possibility of modifying the network.

At Masangdaza area, the irrigation system would be reorganized to use two (2) intake systems instead of the existing six (6) small

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