



Environmental Monitoring Report

Project Number: 37399
July 2008

BHU: Green Power Development Project

Prepared by:

Royal Government of Bhutan
Bhutan

For Asian Development Bank

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Asian Development Bank

Environmental Assessment Report

Summary Initial Environmental Examination
Project Number: 37399
July 2008

BHU: Green Power Development Project

Prepared by the Royal Government of Bhutan for the Asian Development Bank (ADB).

The summary initial environmental examination is a document of the borrower. The views expressed herein do not necessarily represent those of ADB's Board of Directors, Management, or staff, and may be preliminary in nature.

CURRENCY EQUIVALENTS

(as of 30 April 2008)

Currency Unit – Ngultrum (Nu)

Nu1.00 = \$0.025

\$1.00 = Nu40.50

ABBREVIATIONS

ADB	–	Asian Development Bank
ADF	–	Asian Development Fund
BPC	–	Bhutan Power Corporation
CDM	–	clean development mechanism
DGPC	–	Druk Green Power Corporation
DHPC	–	Dagachhu Hydro Power Corporation
DOE	–	Department of Energy
DOF	–	Department of Forests
EIA	–	environmental impact assessment
GDP	–	gross domestic product
EIA	–	environmental impact assessment
EMP	–	environmental management plan
IEE	–	initial environmental examination
NEC	–	National Environment Commission
RED	–	Renewable Energy Division
SIEE	–	summary initial environmental examination
TA	–	technical assistance
WLED	–	white light emitting diode

WEIGHTS AND MEASURES

km	–	kilometer
kV	–	kilovolt (1,000 volts)
kWh	–	kilowatt-hour
MW	–	megawatt

NOTES

- (i) The fiscal year of the Government ends on 30 June and the fiscal year of its companies ends on 31 December.
- (ii) In this report, "\$" refers to US dollars

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I. INTRODUCTION

1. With its mountainous terrain and abundant rivers, Bhutan has great potential for generating clean and renewable energy. The country has 27 hydropower stations with an installed capacity of around 1,500 megawatts (MW). It exports more than 80% of the power generated to India, providing over 60% of government revenue. However, most residents in Bhutan do not have access to electricity, mainly because of the difficult terrain and scattered low-density population. The Government's Vision 2020, *Electricity for All*, pledges 100% electrification by 2020; and the Rural Electrification Master Plan targets 85% under the 10th Five-Year Plan (FYP) 2008–2013.

2. Since 1995, the Asian Development Bank has been helping Bhutan expand rural electrification via three loans covering more than 19,250 households. Approximately 25,000 additional households are earmarked in the 10th FYP. The Government has requested additional ADB assistance in providing power to 9,284 rural households or 10,275 consumers, including facilities from the 10th FYP located in eight *dzongkhags*.¹ Rural electrification of the eight *dzongkhags*² forms part of the Green Power Development Project, which consists of three components: (i) a grant investment for clean rural electrification, (ii) a loan for the Dagachhu hydropower export development, and (iii) an capacity development technical assistance for Promotion of Clean Power Export Development. The Green Power Development Project will provide separate financing for each of the following two major physical investments: Dagachhu hydropower development, and (ii) clean rural electrification. The Department of Energy (DOE) is the Executing Agency for all components; the implementing agencies are Dagachhu Hydropower Corporation (DHPC) for the Dagachhu component and Bhutan Power Corporation (BPC) for the rural electrification component.

3. Bhutanese law and ADB policy require that the environmental impacts of development projects be identified and assessed as part of the planning and design process, and that action is taken to reduce impacts to acceptable levels. This is done through the environmental assessment process, which has become an integral part of lending operations and project development and implementation worldwide.

4. An environmental impact assessment (EIA) was completed for the Dagachhu hydropower component. The outcomes and content of the study were used to prepare an environmental assessment and application for the environmental clearance required by the Government under the Environmental Assessment Act (2000). For the rural electrification component, initial environmental examination (IEE) studies were conducted in each dzongkhag, and national environmental and forest clearances were granted.

5. For the rural electrification component, IEES were prepared for each of the eight dzongkhags as required by ADB procedure. Separate IEES were developed for the rural electrification component and the Dagachhu hydropower component. All documents comply with ADB's *Environment Policy* (2002) and *Environmental Assessment Guidelines* (2003), and the Government's Environmental Assessment Act.

6. This summary initial environmental examination (SIEE) discusses the environmental impacts and mitigation measures related to the location, design, construction, and operation of

¹ Dzongkhags are districts; the country has 20 dzongkhags, and several gewogs (the lowest administrative unit) in each dzongkhag.

² During the July 2008 appraisal mission, one of the subprojects located in Zhemang dzongkhag was deferred until the next rural electrification project planned for 2010.

all physical works proposed for the Dagachhu hydropower and rural electrification components. The SIEE consists of two distinct sections for each component.

II. BHUTAN'S ENVIRONMENTAL ASSESSMENT AND REVIEW PROCEDURES

A. Environmental Assessment

7. Sustainable development is enshrined in the Government policy via the “middle path” approach of the National Environment Strategy for Bhutan (1998), which aims to maintain a balance between environment and development. One of the key implementing mechanisms is the Environmental Assessment Act, which establishes procedures for assessing the potential impacts of plans, policies, programs, and projects. It requires that environmental clearance be obtained from the National Environment Commission (NEC) or other competent authorities (e.g., Department of Forests [DOF] of the Ministry of Agriculture) for any project or activity that may have adverse environmental impacts.

8. The environmental clearance procedure is described in the Regulation for the Environmental Clearance of Projects (2002), and specific guidance is given in a series of sectoral guidelines, prepared in 1999 and revised with ADB technical assistance (TA) in 2006. The current national procedures conform to the safeguard policy requirements of international financing institutions such as ADB and the World Bank to facilitate the preparation and processing of development projects. The proponent is required to submit an environmental clearance application, containing information on the applicant, the project, funding agency, affected environment, potential impacts, mitigation, monitoring, and public consultation. In the case of power transmission and distribution projects, information on impacts includes details of affected areas, types, uses, and tenure of land; houses and/or infrastructure; protected areas; wildlife; and cultural and heritage sites. The applicant must provide signed “no objection certificates” from specified stakeholders, including affected households, DOF, and other relevant government agencies (e.g., Department of Culture, Nature Conservation Division).

9. The competent authority (NEC in this case) considers the application and issues or denies environmental clearance, or decides that a full EIA is necessary. If an EIA is required, the proponent submits proposed terms of reference to NEC, and then conducts the study and prepares the report according to the approved terms of reference. NEC will review the completed report and decide whether environmental clearance is granted or denied. Environmental clearance may include certain conditions with which the proponent must comply, which would include some or all of the mitigation proposed in the EIA or environmental clearance application, plus other measures if necessary.

10. For rural electrification, NEC requires an EIA for projects that include work within national parks, buffer zones, or biological corridors; and an environmental clearance application without an EIA for projects outside protected areas. In discussions during preparation of the rural electrification component, NEC advised DOE they would expect one application per dzongkhag, comprising an EIA and/or environmental clearance application as relevant. DOE prepared the relevant EIAs required by NEC as part of the environmental clearance process with the assistance of the ADB project preparatory technical assistance consultants. In parallel, forest clearances and environmental clearance applications were completed and submitted to NEC. The nationally required EIA for rural electrification subprojects has the same content as IEEs required by the 2003 ADB *Environmental Assessment Guidelines*. The ADB project preparatory technical assistance consultant assisted in preparing the IEE reports.

B. Other Environmental Laws and Regulations

11. Several other laws and regulations include elements that may apply to rural electrification subprojects, depending upon their specific nature and location.

12. **Forest and Nature Conservation Act, 1995.** The Forest Act (1969) was the first environmental legislation in Bhutan and brought all forest resources under government custody to regulate utilization. This was repealed with the enactment of the Forest and Nature Conservation Act in 1995, which allows community stewardship of forests, and aims to provide protection and sustainable use of forests, wildlife, and related natural resources. Schedule 1 lists wild animals and plants that are given full protection under the act (Appendix 2). The act establishes that all forests in Bhutan are government reserved forests, and prohibits any development activity in these areas without a permit.

13. **Forest and Nature Conservation Rules, 2000.** The rules, promulgated by the Ministry of Agriculture in 2000, include the following:

- (i) allotment of land and land rights in government reserved forests;
- (ii) prohibitions, restrictions, and concessions in government reserved forests;
- (iii) transport and trade of forest produce;
- (iv) declaration and administration of protected areas;
- (v) protection of wildlife and use of certain wild species;
- (vi) prevention of forest fires, land clearance, and activities potentially impacting soil, water, and wildlife resources; and
- (vii) enforcement of penalties for offences related to these and other aspects of the Forest and Nature Conservation Rules.

14. As rural electrification subprojects are likely to involve some of these activities, DOF provided a formal no objection.

15. **Protected Areas.** The four national parks, four wildlife sanctuaries, and one strict nature reserve in Bhutan have conservation policies stating that all proposed development projects within the boundaries of the protected area will be subject to an EIA under the jurisdiction of NEC. This includes buffer zones outside the protected areas, and was extended to biological corridors in 2006 by an addendum to the Forest and Nature Conservation Rules.

16. Biological corridors are defined as “areas set aside to connect one or more protected areas, which shall be conserved and managed for the safe movement of wildlife.” Although biological corridors do not have the same status as protected areas, activities such as new settlements, quarrying and mining, and leasing of land for grazing are prohibited. All other development activities, including construction of roads, electricity transmission and distribution lines, or any other structures, require a permit from DOF and an environmental clearance application to NEC, supported by an EIA.

17. **Land Act, 1979 (amended 1998).** The Land Act provides the basis for land tenure in Bhutan, and allows the Government to requisition land required for the benefit of the country. If land is requisitioned, the Government is required to compensate the owner by providing substitute land from the same dzongkhag, or to provide cash compensation according to the land classification if substitute land is not available. If a house is acquired, compensation is paid on the basis of an evaluation carried out by a qualified engineer appointed by the competent authority. Amounts of compensation are set down by law in the 1998 Land Compensation Rate.

18. **Government Decentralization Policy, 2002.** The dzongkhag and geog yargay tshogchung acts were implemented in 2002 to support the Government's decentralization policy and empower locally elected community bodies (dzongkhag yargay tshogchhungs and gewog yargay tshogchhungs) with the authority and responsibility to plan and implement development programs and activities, including those related to environmental management. Through this legislation, the dzongkhag community groups can undertake such activities as

- (i) making recommendations on activities with major environmental impacts;
- (ii) designating and protecting sites and monuments of cultural or historical interest;
- (iii) designating and protecting areas of special scenic beauty or biodiversity, such as dzongkhag parks and sanctuaries;
- (iv) establishing and enforcing regulations to control noise pollution; and
- (v) prohibiting construction of structures within 15 meters of highways.

19. The gewog community groups can establish and enforce regulations that include

- (i) controlling and preventing pollution of air, soil, and water;
- (ii) ensuring safe disposal of waste and adequate standards of sanitation;
- (iii) conserving and protecting water resources, including rivers, streams, springs, and lakes; and
- (iv) retaining custody of communal lands and community forests, and preventing encroachment onto land and forests.

20. DOE therefore consulted the dzongkhag and gewog community groups in dzongkhags in which rural electrification subprojects are proposed, determined if any local legislation was in place with which the subprojects should comply, and secured no-objection issuance.

21. Of the total length of all feeders, 7.4% is inside the park, 10.6% inside the buffer zones, and 10.8% in the biological corridors. The remaining 71% is outside protected areas. Feeders that are planned inside the parks (mainly in Zhemgang³ and Trashigang) will be placed along the proposed national highway in Zhemgang and farm roads in Trashigang. The only other sensitive area is the feeder to be placed on the perspective borders of the Jigme Singye National Park in Wangdue Dzongkhag. The subject feeder is less than 9 km long. The assessed actual impact area is less than 2 km. Adequate mitigation measures are proposed in the corresponding environmental management plan, including the installation of covered conductors; manual execution of preparatory and civil construction works; implementation of soil replacement measures, and reduction of the right-of-way (ROW) width.

22. Zoning of protected areas including core zones in national parks, buffer zones, biological corridors, and multipurpose zones is not complete. DOF has issued draft guidelines for forestry officers to start zoning planning. The completion of zone demarcation is planned during the next 3 years. As of July 2008, national parks (including core zones), buffer zones, biological corridors, and multipurpose zones do not have set boundaries.⁴

³ As per outcomes of the July 2008 appraisal mission, the Zhemgang subproject is proposed to be postponed until the next loan due to substantial cost overrun.

⁴ As per results of an interview with the head of DOF held during the July 2008 appraisal mission. Additional e-mail communication was carried out with a nature conservation specialist, DOF, Ministry of Agriculture.

23. At present management of protected areas is governed by the Conservation Policy, which states that all development projects within the park boundaries, inclusive of all zoned areas, will be subject to an EIA as set forth by NEC. This policy has been extended to buffer zones.⁵

24. For practical reasons, national park management and territorial divisions do not follow designated boundaries as shown on maps presented in the IEEs, but are administratively responsible for entire gewogs. Therefore, depending on where the gewog is located, it may be administratively placed under the park protected area or park territorial management.

25. **National Park Conservation Management Plan, 2001.** The plan defines policies for each zone within the protected area, however, full-scale enforcement of the subject policies is suspended until the zoning of the parks is complete.

26. According to the Park Conservation Management Plan, different management zones within protected areas are to be defined to address various management objectives. These objectives range from protection of key biological sites, to developing ecologically and economically viable land uses in the park and adjoining areas. Wildlife and their habitats in the park are to be protected, the needs of resident communities are given due consideration, and development activities are not to adversely affect the ecosystems of the parks.

III. RURAL ELECTRIFICATION COMPONENT

A. Description of the Project

1. Type, Category, and Need

27. ADB classifies the rural electrification component as environment category B, as it is expected to have minimal and mitigatable environmental impacts.

28. Rural electrification-4 (Rural Electrification phase-4 program) will supply electricity to 9,284 households and 991 facilities (schools, monasteries, rice mills) in 624⁶ villages (Map 1, Table 1). The infrastructure will comprise 1,019 kilometers (km) of 11 and 33 kilovolt (kV) medium-voltage conductors (power lines), running through mainly forest and farmland, on approximately 45,000 cast iron poles. From the 754 transformers to be located at the edge of villages, 1,219 km of low-voltage lines (230 volts for single phase and 415 volts for the three phases) will run to individual consumers, terminating in service connections outside houses. Infrastructure will be designed during 6 months in 2008, and built over the following 4 years (2009–2012). Table 2 summarizes the likely approach to construction and operation.

29. This will assist the Government to attain the target of providing electricity to all citizens by 2020; and it should generate significant improvements in environmental and social conditions in the rural areas, including

- (i) improvements in the quality of life from the availability of electricity;

⁵ Nature Conservation Division. 1997. *Conservation Management Plan, Jigme Dorji National Park*. Forestry Services Division, Thimphu.

⁶ The number is counted by the number of village names surveyed and included into the target of the rural electrification component. The definition of village used may not be the same as that used for other statistics.

- (ii) reductions in production of greenhouse gases from burning of kerosene and wood;
- (iii) long-term reductions in environmental damage from the logging of trees for fuel;
- (iv) improvements in health from reduced exposure to smoke and other pollutants;
- (v) reduction in time spent collecting and transporting firewood; and
- (vi) opportunities for alternative livelihoods, generating socioeconomic benefits.

30. An estimated 67,362 people will benefit from the rural electrification which is estimated to cost \$31.9 million (Appendix 1).

2. Location, Size, and Implementation Schedule

31. The rural electrification component is located in eight dzongkhags⁷ namely Punakha, Lhuentse, Wangdue, Trashigang, Pema Gatshel, Zhemgang, Samdrup Jongkhar, and Sarpang.

B. Description of the Environment

1. Physical Resources

32. Bhutan is located in the eastern Himalayas, between the Tibetan plateau in the north and the Indian plains in the south, east, and west. It covers an area of 38,394 square kilometers (km²).⁸ The target dzongkhags Punakha and Wangdue lie in western part of the country, while Zhemgang is centrally located. Lhuentse, Trashigang, and Pema Gatshel are located in eastern Bhutan; and Sarpang and Samdrup Jongkhar are along the southern border of the country. The eight dzongkhags total approximately 17,500 km² (45.4% of the total land area of the country).⁹

33. The country is divided into 20 dzongkhags), which are divided into gewogs (administrative blocks), the number depending on the size and geophysical terrain of the dzongkhag. Large dzongkhags are also subdivided into *dungkhags*, administered by a *dungpa*.

a. Topography, Geology, and Soil

34. The dominant topographic features are the High Himalayas in the north with snow-capped peaks and alpine pastures, transmontane plateaus, north-south valleys and ranges forming watersheds, deep valleys created by fast-flowing rivers, rugged foothills, and alluvial plains with broad river valleys. Valleys in western and central Bhutan like Punakha and Wangdue are wider with straight or concave lower slopes and substantial alluvial deposits. The valleys in eastern Bhutan like Lhuentse, Trashigang, and Zhemgang cut deeper, and have steep convex side slopes, narrow V-shaped valley floors, and negligible alluvium. Sarpang and Samdrup Jongkhar are in the foothills of the Himalayas with dense deciduous forests and alluvial lowland river valleys. Within a span of 175 km, the altitude ranges from 200 meters (m) above sea level to 7,500 m⁶.

⁷ Pemagatshel Dzongkhag includes a small part of Mongar Dzongkhag where the distribution line is extended from Pemagatshel. Sarpang Dzongkhag includes three gewogs (blocks) of Dagana Dzongkhag, which belonged in Sarpang before the dzongkhag delimitation exercise conducted in 2007.

⁸ National Statistical Bureau. (2004). *Statistical yearbook of Bhutan, 2004*. Thimphu.

⁹ Ministry of Agriculture. 1997. Thimphu.

35. The geology and topography of Bhutan are shaped by intense tectonic activity that resulted from the collision of the Indian and Eurasian continental plates, the closure of the intervening Tethys Ocean, and the uplift of the Himalayas. Along the southern border and in the southeast is a wide range of sedimentary and low grade metamorphic rocks, including argillites and metargillites, sandstones and quartzites, limestone, dolomite, and gypsum. The main nongneissic rocks are three large outcrops of marine sediments, submarine basalts, and their metamorphic derivatives.¹⁰ The most widespread deposits at high altitudes are glacial and periglacial mixtures of stones and sand. At lower altitudes, many of the slopes are covered with colluvium. The topsoil in agricultural areas has a pH between 5 and 6, loamy clay between 10% and 30%, and silt between 20% and 50%.¹¹

¹⁰ Cencho et al. 2000.

¹¹ MPFD, 1991.

Map 1: Rural Electrification Infrastructure Improvements and Projects

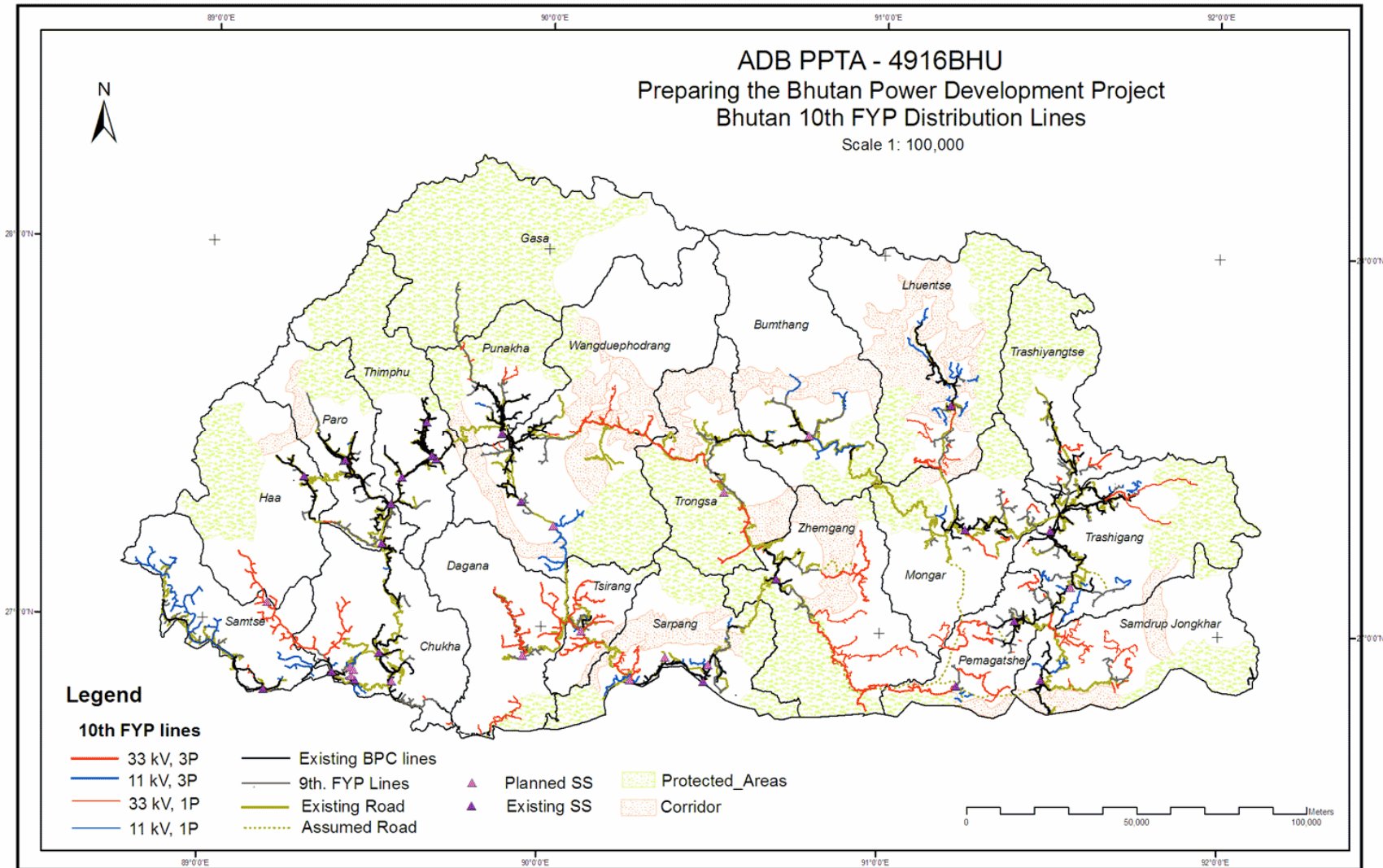


Table 1: Details of the Rural Electrification Infrastructure Proposed in Each Dzongkhag

Dzongkhag	Gewog	No. of Feeder	Length 11 kV m	Length 33 kV m	MV Total m	No. of Poles	Transformer	LV m	No. of Poles	No. of HH	No. of Facility	No. of Industry
Lhuentse	Gangzur		11,211	0	11,211	225	6	8,180	164	78	6	6
	Jarey		0	17,330	17,330	347	15	15,650	313	170	12	15
	Khoma		14,240	0	14,240	285	10	10,970	220	124	8	0
	Kurtoe		7,819	0	7,819	157	7	11,720	235	75	11	11
	Menbi		11,398	9,140	20,537	411	9	13,490	270	140	30	0
	Metsho		0	24,181	24,181	484	23	24,550	491	243	32	0
	Minjay		6,149	0	6,149	123	4	7,800	156	58	7	0
	Tsenkhar		0	5,163	5,163	104	12	12,890	258	145	10	11
	Tshenkhar		0	11,749	11,749	235	12	10,730	215	132	2	6
		Total	16	50,817	67,562	118,380	2,368	98	115,980	2,320	1,165	118
Pemagatshel	Borang (Chongshing)		0	1,669	1,669	34	2	1,755	36	18	0	0
	Chhimung		0	18,151	18,151	364	14	20,445	409	177	15	0
	Chhokholing		2,866	18,730	21,596	432	23	19,350	387	264	20	0
	Dechhenling		0	17,262	17,262	346	9	12,140	243	102	7	0
	Dungme		0	29,916	29,916	599	26	36,600	732	277	41	4
	Gongdue ^a		0	19,510	19,510	391	14	17,450	349	135	20	2
	Khar		0	2,427	2,427	49	2	3,100	62	10	3	0
	Nanong		0	14,135	14,135	283	14	16,500	330	191	14	11
	Norbugang		5,249	26,151	31,400	629	27	52,800	1,056	388	11	0
	Shume		0	947	947	19	3	2,950	59	40	2	1
	Yurung		0	0	0	0		1,100	22	2	0	0
	Total	16	8,115	148,899	157,014	3,141	134	183,740	3,675	1,604	133	18

Dzongkhag	Gewog	No. of Feeders	Length 11 kV m	Length 33 kV m	MV Total m	No. of Poles	Transformer	LV m	No. of Poles	No. of HH	No. of Facility	No. of Industry
Punakha	Chhubu		0	8,387	8,387	168	3	3,340	67	28	4	0
	Goenshari		0	7,730	7,730	155	6	17,225	345	90	3	0
	Guma		0	0	0	0		1,610	33	4	0	0
	Kabjisa		0	1,519	1,519	31	1	1,230	25	13	0	0
	Toewang		0	7,405	7,405	149	7	12,800	256	67	6	0
	Total	7		25,042	25,042	501	17	36,205	725	202	13	0
Samdrup	Deothang		0	3,043	3,043	61	6	10,070	202	63	5	0
Jongkhar	Gomdar		0	43,019	43,019	861	45	86,250	1,725	677	56	0
	Martshala		0	39,183	39,183	784	24	65,000	1,300	267	19	1
	Orong		14,675	384	15,059	302	11	17,640	353	145	14	0
	Pemathang		0	4,458	4,458	90	3	15,200	304	125	10	5
	Phuentshotang		0	7,173	7,173	144	5	20,400	408	155	4	3
	Wangphu		0	19,788	19,788	396	22	40,000	800	299	23	0
	Total	13	14,675	117,049	131,724	2,635	116	254,560	5,092	1,731	131	9
Sarpang	Bhur		6,076	0	6,076	122	4	6,770	136	81	10	0
	Deorali ^b		0	26,718	26,718	535	13	29,380	588	222	8	2
	Gelephu		3,933	0	3,933	79	3	7,060	142	56	0	0
	Hiley		9,721	34,208	43,928	879	28	37,570	752	279	5	0
	Jigmechhoring ^b		3,555	0	3,555	72	3	5,720	115	44	3	0
	Lhamoj Zinkha ^b		0	7,466	7,466	150	10	20,820	417	188	4	2
Sarpang	Nichula		0	3,566	3,566	72	5	13,650	273	77	2	5
	Sarpang		3,864	8,047	11,911	239	9	13,870	278	104	1	0
	Senge		7,884	0	7,884	158	8	15,970	320	205	5	1
	Total	11	35,032	80,004	115,037	2,301	83	150,810	3,017	1,256	38	10

Dzongkhag	Gewog	No. of Feeder	Length 11 kV m	Length 33 kV m	MV Total m	No. of Poles	Transformer	LV m	No. of Poles	No. of HH	No. of Facility	No. of Industry
Trashigang	Bidung		2,009	0	2,009	41	3	4,250	85	37	3	2
	Kangpara		9,327	0	9,327	187	10	10,850	217	113	8	4
	Khaling		3,945	0	3,945	79	3	5,910	119	89	1	3
	Lumang		11,045	0	11,045	221	13	10,300	206	131	10	3
	Merak		0	14,475	14,475	290	17	6,630	133	256	14	2
	Phongme		12,706	8,932	21,638	433	12	11,450	229	139	11	6
	Radhi		0	15,444	15,444	309	0	0	0	0	0	0
	Sakteng.		0	19,945	19,945	399	24	14,030	281	318	30	8
	Thrimshing		14,288	0	14,288	286	19	19,100	382	221	18	1
	Udзорong		0	3,410	3,410	69	3	4,770	96	76	3	4
	Total	14	53,321	62,205	115,526	2,311	104	87,290	1,746	1,380	98	33
Wangdue	Athang		18,734	0	18,734	375	8	7,115	143	68	11	8
Phodrang	Bjena		0	1,823	1,823	37	1	100	2	1	1	0
	Daga		27,927	0	27,927	559	8	9,634	193	88	16	4
	Dangchhu		0	33,856	33,856	678	19	30,670	614	159	54	0
	Nahi		0	2,380	2,380	48	2	565	12	22	4	0
	Nyisho		0	12,674	12,674	254	8	15,955	320	73	0	0
	Sephu		0	32,623	32,623	653	17	18,950	379	229	40	1
		Total	10	46,661	83,356	130,017	2,604	63	82,989	1,663	640	126
Zhemgang	Bardo		0	39,327	39,327	787	30	78350	1,567	277	23	1
	Bjoka		0	15,838	15,838	317	9	13,700	274	89	15	0
	Goshing.		0	33,099	33,099	662	29	58,360	1,168	241	25	1
	Nangkor		0	17,869	17,869	358	4	12,850	257	44	3	0
	Ngangla		0	36,880	36,880	738	25	53,900	1,078	248	82	0
	Norbugang ^c		0	8,916	8,916	179	0	0	0	0	0	0
	Phangkhar		0	31,739	31,739	635	15	17,000	340	113	25	0
	Shingkhar		0	33,280	33,280	666	22	59,850	1,197	244	27	0
	Trong		0	9,641	9,641	193	5	13,600	272	50	0	0

	Total	6	0	226,588	226,588	4,532	139	307,610	6,153	1,306	200	2
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^a Gongdue Gewog belongs to Mongar Dzongkhag. The source of the area is Pemagatshel.

^b Deorali, Jigmechhoeling, and Lhamoi Zningkha Gewogs were in Sarpang and shifted to Dagana in 2007.

^c Norbugang is administratively in Pemagatshel. The line is for interconnection to Pemagatshel sourced from Zhemgang. There is no end-use consumer.

Source: Asian Development Bank project preparatory technical assistance study.

Table 2: Infrastructure Operation and Construction Approach

Element	Construction Method
General	All components manually carried to site from nearest metaled road (usually several kilometers) MV line routes located along farm roads and footpaths to reduce tree felling Conductor fully insulated with full coverage of cable carrying two distribution lines The Department of Forests has selected and marked trees for cutting during field surveys
MV Lines	Three strands of aluminum conductors strung on iron poles every 30–70 m (depending on terrain) Section poles (2 legs) every 200–250 m, with interval poles (1 leg) located in between In forest, 10 m right-of-way manually cleared of trees (4 m for covered conductors) Pits 600 x 700 millimeters dug to 1,900 millimeters manually and concrete poured in to form a floor Pole inserted, soil and stone are packed around, and layer of concrete added at surface Conductors are attached by hand to insulators at top of each pole
Transformers	Prepared units attached to section pole by hand; poles erected as described above
LV Lines	Poles located alongside roads and footpaths, erected as above. No need to clear right-of-way in village Covered (insulated) conductors and service connections and meters attached manually
	Operation and Maintenance
General	BPC is responsible for service provision, via ESD in dzongkhags
MV Lines	Right-of-way kept clear by teams of laborers removing overhanging branches and replanting trees Outage detected at substation; line removed and repaired manually (tree cutting, replace pole and line)
Transformers	Specialized teams check all facilities annually; parts removed, repaired in Thimphu; replaced
LV Lines	Faults reported to ESD by villagers; poles and conductors, for example, replaced by hand as noted above.

BPC = Bhutan Power Corporation, ESD = electricity service division, LV = low voltage, m = meter, MV = medium voltage.

Source: Asian Development Bank project preparatory technical assistance study.

b. Climate

36. The climate is wet and hot in the southern plains and foothills, dry and warm in the inner valleys, moist and cool on the north-south ranges, and dry and cold in the northern regions. Summer and winter are distinct, and spring and autumn are very short. Temperatures vary with altitude, with summer temperatures reaching as high as 35° Celsius and winter temperatures falling as low as -4° Celsius. Rain falls mainly during the summer monsoon. Precipitation is generally higher than in the Central and Western Himalayas, due to proximity to the head of the Bay of Bengal.

c. Air Quality

37. No information is available on ambient air quality of the various dzongkhags as currently ambient air quality (PM, NO₂, and SO₂) monitoring is limited to Thimphu and Phuentsholing. The average respirable particulate matter (PM₁₀) concentration of 24.5 micrograms/cubic meter (m³) in Thimphu¹² is lower than the internationally set PM₁₀ concentration of 40 micrograms/m³.¹³ Since all other dzongkhags have a much lower population, construction and industrial activity, and vehicles, the air quality is expected to be much better than that of Thimphu. Vehicle and industrial emissions and domestic activities are the main sources of air pollution. While cleaner sources of energy such as electricity, liquefied petroleum gas, and solar power is used in urban areas, the rural population still uses traditional wood stoves and kerosene lamps.

d. Surface Water

38. The four major river systems are the Drangme Chhu, PunaTsang Chhu, Wang Chhu, and Amo Chhu (Torsa Chhu). The Drangme Chhu has three major tributaries: the Drangme Chhu, Mangde Chhu, and Chamkhar Chhu, which form the Drangme Chhu basin. The Drangme Chhu is called the Manas Chhu at lower altitudes where eight tributaries join. The Puna Tshang Chhu is formed by the Mo Chhu and Pho Chhu in Punakha, which are fed by glaciers in the north. The Wang Chhu flows southeasterly through west-central Bhutan before draining into West Bengal. The Amo Chhu in the west is the smallest river system.

39. Bhutan has 2,674 glacial lakes; the majority are small and located above an altitude of 2,200 m. Of these, 24 are identified as “potentially dangerous lakes” that could pose a glacial lake outburst flood threat. Three of these floods have occurred in Bhutan since 1957, mostly in the Po Chhu subbasin.¹⁴

e. Groundwater

40. No data are available on groundwater. Groundwater resources are abundant with springs emerging from basement rocks, old landslides, and fluvial deposits. Groundwater in landslide and alluvial deposits is estimated at an exploitable rate of 3 liters/second/km².¹⁵ Generally the state of Bhutan’s water resources is good but with expanding settlement along

¹² National Environment Commission, personal communication.

¹³ World Health Organization. 2000. *Air Quality Guidelines for Europe*. World Health Organization Regional Publications, European Series, No. 91

¹⁴ Ministry of Home and Cultural Affairs. 2006. *National Disaster Risk Management Framework. Reducing Disaster Risks for a Safe and Happy Bhutan*. Disaster Management Division. Department of Local Governance. Thimphu.

¹⁵ ADB. 2004. *Bhutan, Country Environmental Analysis*. Draft. Manilla.

rivers, localized pollution problems are due to unsanitary conditions and waste along the banks of streams and rivers in urban areas and in rural locations.

f. Aquatics

41. A total of 41 indigenous fish species have been identified in the rivers and one lake of Bhutan. The brown trout (*Salmo trutta*) was introduced in cold waters, and seven exotic species are now used in warmwater aquaculture in southern lowlands, which have more than 175 ponds. The most common fish in all the rivers are the indigenous asla (*Schizothorax progastus*) and Himalayan trout (*Barilius* spp). Other indigenous species of economic interest are katle (*Acrossocheilus hexagonolepis*) and the mahseers *Tor tor* and *T. putitora*.¹⁶ Very little baseline information is available on the distribution, abundance, and migratory patterns of individual fish species in streams, rivers, and lakes.

(i) 2. Ecological Resources

a. Protected Areas

42. The protected area network (26.32%) and biological corridors (9%) constitute 35.32% of the country, and include four national parks, four wildlife sanctuaries, and one strict nature reserve. All are surrounded by buffer zones and joined by biological corridors. DOF defines biological corridors as areas set aside to be managed for the safe movement of wildlife between two or several protected areas.¹⁷

43. Some of the project villages, namely Punakha, Lhuentse, Wangdue, Trashigang, and Zhemgang are located on the edges of protected areas and in biological corridors, while parts of Samdrup Jongkhar, Sarpang, and Pema Gatsel fall within buffer areas or biological corridors.

Table 3. Target Dzongkhags and Gewogs Located in Protected Areas

Protected Area	Dzongkhag	Gewog
Jigme Dorji National Park	Punakha	Toewang, Kabji, Goenshari, Chhubu
Jigme Singye Wangchuck National Park	Zhemgang Sarpang Wangdue	Trong Patale, Doban, Surey Athang, Phobji
Thrumshingla National Park	Lhuentse Zhemgang	Jaray, Metsho Kheng, Shinkhar,
Bumdeling Wildlife Sanctuary	Lhuentse	Khoma
Royal Manas National Park	Zhemgang	Phangkhar, Ngangla
Sakteng Wildlife Sanctuary	Trashigang	Sakteng, Merak
Khaling Wildlife Sanctuary	Samdrup Jongkhar	Not operationalized
Phibsoo Wildlife Sanctuary	Sarpang	Not operationalized

Source: Asian Development Bank project preparatory technical assistance study.

¹⁷ Ministry of Agriculture, Department of Forest. 2007. *Rules on Biological Corridors*. Thimphu.

b. Biodiversity

44. Bhutan has the highest percentage of land under protected areas and the greatest proportion of forest cover compared to any Asian country. It has more than 5,446 species of vascular plants and 178 species of mammals.¹⁸ Species found in protected areas, buffer areas, and biological corridors include the One-Horned Rhinoceros, Elephant, Gaur, Pygmy hog, Spotted deer, and Golden langurs in the warmer subtropical regions; Common leopard, Sloth bear, Himalayan Black bear and Tiger across various altitudes; and Takin, Musk deer, and Red panda at higher altitudes.

45. Species commonly found across most ecosystems include the Grey langur, Assamese macaque, Goral, Serow and squirrels, Sambar, Wild pig, Macaques, Barking deer, and porcupines, which cause immense damage to crops; while leopards, bears, and wild dogs depredate livestock causing socioeconomic losses to livestock owners.

46. Although Bhutan's avifauna is still not well known, around 770 species have been recorded.¹⁹ Due to their diverse habitats each dzongkhag has many species of birds, including significant number of Hornbills, Black-necked cranes, White-bellied herons, among others. The Herpetofauna of Bhutan is poorly documented but a list of 15 reptiles and three amphibians have been recorded in Manas National Park.

c. Forest

47. While 72.5% of the land area (29,045 km²) is under forest cover, this includes conifer forests (26.55%), conifer and broadleaf forest (3.4%), Broadleaf forest (34.3%), scrub forest (8.1%), and plantations (0.2%). The forests can be divided into three ecofloristic zones based on altitude. The alpine (above 4,000 m) and subalpine (between 2,000 m and 2,700 m) zone comprises mixed conifer forest of altitude. The temperate zone (between 2,000 m and 4,000 m) contains temperate conifer, cool broadleaf forest, and Blue Pine forest. The subtropical zone (between 150 m and 2,000 m) contains tropical and subtropical vegetation.

48. The total firewood demand of Bhutan's population is estimated at 505,000 m³ (4.68 m³ per household).²⁰ The demand for firewood is met from commercially managed forests for urban areas and from forests within 1.5 km of villages for rural residents. However in highly populated dzongkhags such as Thimpu, Paro, Trashigang, Sarpang, and Samdrup Jongkar this is becoming increasingly more difficult.

(ii) 3. Economic Development

a. Land Use and Agriculture

49. While the major part of the country is covered by forest, 7.8% is utilized for agriculture. The dominating land uses are dryland (kamzhing), wetland (chuzhing), shifting cultivation (tseri), and horticulture. The major crops grown are rice, maize, wheat, barley, millet, potatoes, mustard, beans, ginger, chilli, and green vegetables. Cash crops include oranges and cardamom. Livestock rearing is an important source of livelihood with 3.9% of the land under pasture. Settlements occupy about 0.1% of the total land area. The majority of rural households own

¹⁸ Department of Forest. 2002. *Forestry in Bhutan, Facts and Figures 2002*. Ministry of Agriculture. Thimphu.

¹⁹ MacKinnon 1991, RGOB, 1996

²⁰ Department of Forest. 2007. *Rules on Biological Corridors*, an addendum to the *Forest and Nature Conservation Rules 2006*. Ministry of Agriculture. Thimphu.

some livestock mostly to meet their needs for dairy products such as milk, butter, cheese, meat, and manure. Livestock play a very important role in rural areas by providing draught power in the absence of mechanized farming.

50. The Department of Industries has issued 14,730 industrial licenses, of which 8,038 are in the eight dzongkhags (59% in Samdrup Jongkhar). These include 477 small (Nu1 million–Nu10 million), 27 medium (Nu10 million–Nu100 million), 24 large (>Nu100 million), and 7,510 cottage (<Nu1 million) industries. The country has 299 manufacturing establishments; 53 are in the target districts. These are based on agriculture, forestry, minerals, services, or contracts.

51. Of the 9,775 contract firms, 2,947 are located in the eight districts, and include 67 grade A and B contractors, 282 grade C contractors, and 2,598 petty contractors.²¹

b. Infrastructure

52. The dzong is the center of administration and all other sector' offices are located within its premises, including the district court and its offices. Most of the towns are small except for the border towns of Samdrup Jongkhar and Gelephu in Sarpang, which are commercial centers for the other dzongkhags. Most of the offices such as the district forest office, renewable natural resource office, BPC, banks, post office, finance corporations, police station, high and middle secondary schools, and hospitals are located within the main town. Now almost all gewogs have administration officers, as well as agriculture and livestock extension officers.

53. Infrastructure is better developed in the towns than in rural areas, because of the technical difficulties presented by the mountainous terrain, and the proportionally high cost of providing services to scattered communities.

54. Much progress has been made in terms of improving access to safe drinking water and improved sanitation. On average, 81.4% of households in the country now have access to piped drinking water, via household systems in the towns and some of the larger villages, and community standpipes in smaller villages. This coverage is higher than 86% in all target dzongkhags, except Zhemgang (67.7%).

55. Apart from Thimphu and Phuntsholing, most dzongkhags do not have a centralized sewerage system; in towns, individual houses have septic tanks; and in villages, residents use mainly self-built pit latrines normally located in a brick or wooden enclosure away from the house. Within the target dzongkhags, the percentage of sanitary facilities varies from 75% for Zhemgang to 96.5% for Wangdue.

56. The towns have some drainage and footpath infrastructure, consisting mainly of open concrete drains alongside roads and shops. In some villages, earth drains fulfil the same function. This is better developed in Lhuentse (71%) and Wangdue (63%) compared to other target dzongkhags where it is less than 50%. Waste disposal is an emerging problem in almost all urban towns; currently only Thimphu and Phuntsoling have solid waste collection systems and people generally burn their waste or deposit it on open ground.

²¹ National Statistical Bureau. 2007. *Statistical Yearbook of Bhutan, 2007*. Thimphu.

c. Transportation

57. At present, the country has 4,544.73 km of motor roads (including 574.80 km of forest roads). Pema Gatshel with 98.2 km (2.2%) has the second lowest percent of the road network in the country after Gasa. In total 52% of the road network is in the target dzongkhags.²² These roads are tarred, and mainly two lanes, often with a concrete drain running alongside.

58. The number of farm roads being constructed in each dzongkhag is increasing. Farm roads are mud tracks, wide enough for one vehicle, with no hard covering or drainage, and therefore may become impassable during rain. However many of the targeted villages can be reached via footpaths often requiring a walk of 2 or more hours from the nearest motor road.

59. As of 2005, 40 mass passenger transport service operators had a total fleet of 139 passenger buses. Thimphu is the only urban center with a city bus service. In the villages, entrepreneurs and civil servants mostly own the few vehicles. In most target areas transportation modes are mainly by foot or on horseback.

60. No air travel is available within Bhutan; the only airport is at Paro, 30 km west of Thimphu.

d. Tourism

61. Since the 1970s, tourism has grown gradually. In 1991 the industry was privatized and numerous tourist agencies were established. Visitor numbers have continued to rise, particularly over the past few years, despite the requirement for all tourists to pay a nonrefundable daily tariff of \$200 to the tour operator for the cost of accommodation, food, and internal travel. Tourism is now the third largest provider of foreign exchange, earning \$18.5 million in 2005 when 13,600 people visited.

62. Punakha, Wangdue, Trashigang, Zhemgang, and Lhuentse have tourists but the southern dzongkhags like Sarpang and Samdrup Jongkhar, and remote dzongkhags like Pema Gatshel do not have many visitors. The small number of hotels, guesthouses, and restaurants that cater for tourists are rudimentary in most target dzongkhags except Punakha and Wangdue. Because of the difficulty of reaching most locations, tourism has little impact on the villages, most remain much as they have for the past few centuries.

4. Social and Cultural Resources

a. Demography

63. Bhutan has a low and relatively dispersed population, with the 2005 census²³ reporting a total of 634,982 people living at an average density of 16 per km². People are moving from the countryside into towns to seek better economic rewards; by 2005 almost a third of the population was living in urban areas. Literacy is reasonably good at almost 70% for males and 50% for females, although this will be lower in rural areas. The growing population is reflected in 2004 statistics of 12,538 births compared with 4,498 deaths.

²² Ministry of Works and Human Settlement. 2006. *Annual Information Bulletin*. Thimphu.

²³ National Statistics Bureau. 2005. *Population and Housing Census of Bhutan 2005*, Thimphu.

64. The population includes many ethnic groups such as the Sharchops from the east, Ngalongs from the west, Khengpas from the central region, nomads from the north, and Lhotshampas from the south. Because of the mix of ethnicities a wide variety of dialects is spoken, of which Dzongkha, Khengkha, Sharchop, and various dialects of Nepali are the most common. The majority are Buddhist (around 70%); the remainder are mainly Hindu.

b. Health, Education, and other Facilities

65. The Ministry of Health now has a wide network of health facilities across the country, covering around 90% of the population. Institutional health facilities were earlier concentrated in urban centers, but today the emphasis has shifted to rural areas where the majority of the population live. As of 2005, the country had 29 hospitals, 176 BHUs, and 514 outreach clinics staffed by more than 1,087 health personnel of different categories. Twelve hospitals, 86 BHUs, and 235 ORCs are located in the eight dzongkhags.²⁴

66. The Government is making concerted efforts to develop a comprehensive education system. Of the 494 educational facilities in the country, 224 are in the eight target dzongkhags with a total of 57,676 students and 1,985 teachers. This includes 9 high schools, 13 middle secondary schools, 37 lower secondary schools, 49 primary schools, and 116 community schools. Besides the modern education system, traditional institutions continue, but data has not been maintained. The non-formal education program providing basic literacy courses in reading and writing for those unable to attend school such as housewives has expanded rapidly with a total of 646 centers spread throughout the country.²⁵

67. Each dzongkhag has a network of renewable natural resources facilities which include renewable natural resources extension centers, agriculture extension centers, seed production farms, agriculture machinery centers, livestock extension centers, veterinary hospitals, and forestry and park ranger and beat offices.

c. History and Culture

68. The Special Commission lists 1,619 religious structures (*ihakhangs, goenpas, gomdeys*), which are state, public, or privately owned; 61% are located in the eight target dzongkhags. Wangdue, Punakha, and Lhuentse dzongkhags have a few culturally significant sites.

69. Most of the larger villages have a temple, smaller Buddhist shrines are located inside and outside inhabited areas, and various other places or objects that are of significance to the community, including particular trees, rivers, and other locations.

²⁴ National Statistical Bureau. 2007. *Statistical Yearbook of Bhutan, 2007*. Thimphu.

²⁵ Ministry of Education. 2007. *General Statistics*. Policy and Planning Division. Thimphu.

Table 4: Environmental Features of the Study Area

Aspects	Main Features
Topography soil, geology	Bhutan is at the eastern end of the Himalayas, between India, People's Republic of China, and Tibet. Altitude ranges from 100 to 7,541 meters (m). The terrain is mainly steep-sided, forested mountains cut by fast-flowing rivers and streams, running down to wider floodplains. Most areas have a gneiss and/or limestone bedrock with alluvial surface layers.
Climate	Climate is tropical below 1,000 m in the south, alpine above 5,000 m in the northwest, and temperate in most of the study area. Highest temperatures occur in June–August (average 25–30° Celsius) and lowest in December–February (5–20° Celsius). Rainfall is very low in winter and 100–300 millimeters per month during the monsoon, which peaks in June–August.
Air quality	Little data is available on air quality, but the low population and lack of industry in most areas mean that air quality is generally good. People are however exposed to smoke and other pollutants from burning wood and kerosene.
Surface water	Most dzongkhags have large rivers (<i>chhu</i>) flowing broadly north–south and some cross the southern border into India and Bangladesh. Flow is low in winter, increases with the spring snow melt, and is high during the summer monsoon, when rivers carry high volumes of sediment washed off hillsides. Most large tributaries are perennial.
Groundwater	Little is known of the groundwater. Some of the many springs in the mountainous areas are used for domestic purposes. Few data are available on water quality, although arsenic is known to be low.
Protected areas	Bhutan has the highest proportion of forest cover and protected areas in Asia. The four national parks, four wildlife sanctuaries, and one strict nature reserve are surrounded by buffer zones and joined by biological corridors. Protected areas cover 26% of the land surface and biological corridors cover a further 9%.
Rare and endangered species	Bhutan is in the top 10% of countries with the highest species density in the world, because of its remote nature and variable geography and climate. Most of the species are protected under the government's forest and nature conservation act (1995).
Forest	Forest covers 72% of Bhutan's land area, and the government's policy is to maintain at least 60%. Forests extend up to 4,500 m and include conifer at higher and lower altitudes and temperate broadleaf forest at 2,000–3,000 m.
Wildlife	Most of the target villages are surrounded by forest that supports a wide range of plant species and a variety of wildlife. Common and rare species include tiger, leopard, Himalayan black bear, white-bellied heron, black-necked crane, various primates, small mammals, birds, reptiles, and amphibians.

Aspects	Main Features
Land use, industry and agriculture	Forest dominates land cover, and areas have been cleared for residential use in villages and agriculture beyond. Most farmers grow rice in terraced paddy fields fed by rain and irrigation from rivers. There is some dry production of wheat, maize, potatoes, vegetables, and fruit in gardens. Industries include rice mills, weaving, car repair.
Infrastructure	Rural villages have little infrastructure because of the difficult terrain and high cost of reaching them. Some have piped drinking water supplied to houses or standpipes. No sewerage is available; residents use septic tanks or self-dug pit latrines. Wood or kerosene is used for cooking and heating; some households use solar panels for lighting.
Transportation	Main roads are metaled, mostly two lanes, and run along river valleys or take a circuitous route over hillsides. They have drains and crash barriers in places, but these are not universal. Most villages are several km from main roads and are reached via farm roads or forest footpaths.
Tourism	Tourism in bhutan has grown in the past 20 years. Visitors are limited by a requirement to pay a nonrefundable daily tariff of \$200, but tourism now provides one third of foreign revenue. Trekking is the main activity and pursuits are planned to limit their environmental impact. Few tourists visit the target villages because of their remoteness.
Demography	Bhutan has a low and dispersed population of 634,982 in 2005, at a density of 16/km ² . One third live in towns, to which many have migrated in recent years. The target villages are mainly small, with populations of <500, and some are groups of 1–3 houses. The country has a variety of ethnic groups; most people are buddhist or hindu.
Health and education	Public facilities are very limited in most target villages. Most have no health care and people have to travel large distances to urban centers for treatment. Many villages have small primary schools, but children have to travel sometimes large distances for secondary education, for which the cost and difficulty may be prohibitive.
History and culture	Most of the historical and cultural centers and festivals are in the main towns. However most villages have a buddhist temple, plus smaller shrines and areas or objects that are important to the community.

Source: Asian Development Bank project preparatory technical assistance study.

Table 5: Length of Feeders in Protected Areas, Multipurpose Buffer Areas and Biological Corridors

No.	Target Dzongkhag	Inside Park	Multipurpose Buffer Area	Biological Corridor	Total Length
1	Punakha	7.698 ^a	17.311	0.000	25.000
2	Zhemgang (not relevant for the current loan program ^b)	30.327 ^c	16.000 ^f	12.802	226.600
3	Wangdue	9.700 ^d	0.000	42.230	130.00
4	Lhuentse	0.000	17.000 ^g	55.000	118.400
5	Trashigang	27.423 ^e	30.023	0.000	115.500
6	Samdrup Jongkhar	0.000	0.000	0.000	131.700
7	Sarpang	0.000	0.000	0.000	115.000
8	Pema Gatshel	0.000	27.500 ^h	0.000	157.000
	Total Length	75.10	107.800	110.000	1019.200
	Percentage of Total Length	7.4%	10.6%	10.8%	100%

^a Jigme Dorji National Park (Goenshari gewog: along farm road and access trails)

^b As per results of the appraisal mission (July 2008), the Zemgang subproject is proposed to be postponed until the next rural electrification project loan due to substantial cost overrun.

^c Royal Manas National Park (Pangkhar and Ngangla gewog: along proposed national highway and 132 KV transmission line)

^d Thrumshingla National Park (Shingkhar gewog)

^e Jigme Singye Wangchuk National Park (Athang gewog-covered conductor recommended for sensitive habitat)

^f Thrumshingla National Park (Jarrey gewog: buffer area)

^g Sakteng Wildlife Sanctuary (Merak and Sakteng gewogs: along access route)

^h Royal Manas National Park (Norbugang gewog: buffer area)

Source: Asian Development Bank project preparatory technical assistance study.

D. Forecasting Environmental Impacts and Mitigation Measures

70. The provision of electricity to 9,284 households and 991 facilities in eight dzongkhags will involve construction of

- (i) 106 11/33 kV low- and medium-voltage lines, 1,019 km in total length, of mainly 3-strand bare conductors, located on approximately 20,400 poles, to convey electricity from existing distribution lines;
- (ii) 754 transformers, in or outside villages, to reduce voltage from 33 kV to 230 or 415 volts; and
- (iii) 1,219 km of low-voltage lines, of mainly single-strand covered conductors located on about 24,400 poles in the villages, to carry electricity to meters outside individual households.

71. In general the activities that have the greatest potential for environmental and social impacts during construction are

- (i) clearance of the ROW where low- and medium-voltage lines pass through forested areas including protected areas; and
- (ii) migration of foreign workers and housing them in villages or nearby settlements.

72. Construction of distribution infrastructure is not expected to have major adverse impacts because

- (i) low- and medium-voltage line routes were chosen under the supervision of the DOF representatives to minimize the need for forest clearance and acquisition of private land;
- (ii) the existing lack of access roads to the sites means that all construction components will be carried out manually to and at the site from the nearest motor road;
- (iii) all construction work is small in scale and will be conducted by small teams without the use of vehicles and machinery (in areas located away from motor roads);
- (iv) excavation will be carried out using simple equipment (such as picks and construction shovels) and only a very small quantity of material will be excavated, comprising 0.7–0.8 m³ per pole, and 33,588 m³ in total; poles are located 50–70 m apart (depending on the terrain), so no large concentration of excavated or stockpiled material will be in any single location;
- (v) around 53% of low- and medium-voltage lines will be in unforested areas where the ROW will not be cleared;
- (vi) along the 1,019 km route of the medium-voltage line, 482 km runs through forested land (Appendix 2), in which a total of 5.6 km² of forest will be cleared (as the ROW is 10–12 m wide); this is not a major loss in the context of the total of 30,000 km² of forest in Bhutan, also 70% of this is in the multiple-use buffer zones, where activities such as farming are permitted and rare animal species are less likely to be passing, given their reclusive nature; in protected areas such as parks, covered conductors will be used to limit the ROW (to about 10 m);
- (vii) almost all of the excavated material will be replaced and compacted around the pole foundations, so material will only be stockpiled for a few hours;
- (viii) most affected areas outside the villages are uninhabited, and in villages work can be conducted without causing major disruption to residents; the forest itself will provide a good natural screen as the trees outside the ROW are taller than the electricity poles;
- (ix) construction work is relatively straightforward and can be completed in a fairly short time (an average of approximately 1 year for each location);
- (x) contractors will conduct excavation in the drier months to avoid the difficult and often dangerous working conditions of the monsoon;
- (xi) visual impacts are generally considered significant when they affect large numbers of people, and that will not be the case here because of the remote nature of these areas;
- (xii) around 39% (400 km) of the medium-voltage lines pass through privately owned land (Appendix 3); the area required for poles however is so small and dispersed (approximately every 50 m) that the need to acquire a significant proportion²⁶ of the land of any one owner or tenant is unlikely; also route surveyors were instructed to apply specific criteria for site selection to ensure that poles are located on field boundaries as far as possible, to reduce the loss of productive land;
- (xiii) only 28.8% of the feeders will be located in or near protected areas; 7.4% (75 km) of the distribution lines pass through protected areas, 10.6% (108 km) traverse multipurpose buffer areas, and 10.8% (110 km) are in biological corridors; insulated covered conductors are recommended specifically for

²⁶ ADB's *Involuntary Resettlement Policy* (1995) considers loss of land to be significant if it amounts to 10% or more of the total landholding of any one owner.

- feeders in protected areas to (a) reduce the width of ROWs and reduce tree felling, and (b) mitigate ecological impacts on the wildlife habitat in national parks; and
- (xiv) insulated covered conductors are not needed where feeders are aligned along proposed farm roads and highways outside national parks (Pema Gatshel, Zhemgang, Punakha) or along access routes (Trashigang and Lhuentse).

73. Several environmental subsectors should not be affected by construction (Table 6). However, because most target villages are located in forested areas, construction will cause some moderate negative impacts (Table 7).

Table 6: Fields in which Construction is not Expected to Have Significant Impacts

Field	Rationale
Climate	Short-term production of dust is the only effect on atmosphere
Geology and seismology	Excavation will not be large enough to affect these features
Coastal resources	Bhutan is a landlocked country, approximately 350 km from the sea
Industries	No major industries are in any areas to be affected
Tourism	Few tourists visit these villages because of their remote location
Population and communities	Construction will not affect population number, location, or composition

km = kilometer.

Source: Asian Development Bank project preparatory technical assistance study.

74. The schemes should operate without major negative impacts because
- (i) rural electrification schemes normally operate with routine maintenance and only occasional repair; and
 - (ii) DOE and BPC ensure that the infrastructure will be inspected and maintained regularly, so that repairs should be small in scale and infrequent.

Table 7: The Field with Its Impacts

Field	Rationale
Climate	Operation of electricity supply infrastructure should not affect climate
Geology and seismology	Any excavation to replace poles will not affect these features
Coastal resources	Bhutan is a landlocked country, approximately 350 km from the sea
Industries	No major industries are located in the rural areas
Tourism	Few tourists visit these villages because of their remote location

km= kilometer.

Source: Asian Development Bank project preparatory technical assistance study.

75. Once the system is operating the main risks come from (i) accidents harming workers during maintenance or repairs to the system, and (ii) accidents harming end-users who may not be aware of the safety aspects of using electricity. Mitigation measures to reduce physical, ecological, economic, and social and cultural impacts are included in Table 8.

Table 8: Environmental Impacts and Mitigation for Rural Electrification Infrastructure Construction and Operation

Potential Negative Impacts	SI	DI	Mitigation Activities and Method	R	L	DD	Construction				Op	H			
Design (preconstruction)															
Encroachment upon environmentally protected areas in national parks, disturbance of protected or endangered species habitat, and contamination of water bodies	M	P	Design of feeder ROW and alignment routes outside national parks or protected areas; in cases where the encroachment upon environmentally protected areas cannot be avoided (human settlements are located inside the parks) use alignment along the existing or planned highways or farm roads; avoid crossing any major rivers or water systems	BPC	All sites								0		
Construction															
Air emissions from vehicular movement during drop off of materials at project sites and increased air pollution due to construction traffic on main roads	M	T	Schedule one-time drop off for all construction materials at each specific site	C	All sites		1	2	3	4					
Dust may blow from areas cleared of vegetation in ROW	M	T	Leave a covering of grass and other low vegetation in ROW	C	MV route								0		
Risk of forest fires if cut vegetation is burned	S	T	Leave cut material to rot in situ and do not burn	C	MV route								0		
			Dispose of trees as required by Forest Development Corp										+		
Felling of trees will destroy forest habitat	S	P	Reduce ROW where this would not increase shorting risk	DOE	MV route								0		
			Use covered conductors in protected areas to limit ROW										0		
Workers could damage species and habitats outside the ROW	M	P	Mark ROW boundary with tape and prohibit trespass outside	C	MV route								0		
			Only fell trees marked by Department of Forests										0		
			Prohibit hunting or fishing by workers and enforce strictly										0		
			Train workers in importance of wildlife and habitats										0		
			Locate temporary labor camps in villages or where no forest clearance is needed	C	Temp-orary labor camps in villages										0
			Provide adequate catering and heating in temporary camps so that workers do not need to hunt or collect firewood												0

Potential Negative Impacts	S	D	Mitigation Activities and Method	R	L	DD	Construction	Op	H
Excavation for poles could damage water pipes in villages	M	P	Consult community to identify and avoid infrastructure	C	LV lines				0
Carriage of materials to site could block farm roads	M	T	Consult farmers: transport material when roads are free	C	MV & LV				0
Work in villages may create noise and dust, and impede access	N S	T	Inform communities of work in advance	C	LV lines				0
			Identify sites of local significance; locate no poles nearby						0
			Consult custodians of facilities (e.g., monasteries, nunneries, schools, clinics) and avoid working at sensitive times						0
Economic benefits if local people are employed in contractor's workforce	M	T	Employ as many local residents as possible in workforce	C	All sites				+
Water pollution and waste generation from construction camps	M	T	Provide sewerage collection and disposal						
Waste generation from construction camps	M	T	Provide solid waste management system						
Migrant workers can cause environmental and social problems at labor camps and in host community	S	T	Situate sanitation facilities (pit latrines) away from water sources	C	Temporary Labor Camps				0
			Provide access to safe drinking water						0
			Train workers in required behavior with host community						0
			Prohibit hunting and fishing by camp occupants						0
			Clean up sites of labor camps after work has finished						0
			Provide initial screening of workers for HIV/AIDS, TB, malaria, etc.						0
Diseases can be introduced into host communities from social and sexual contact with migrant workers	S	T / P	Provide workers with health services including regular screening for infection	C	Temporary Labor Camps				0
			Provide free medical treatment at clinic and dzongkhag hospital						0
			Raise worker and community awareness of risks of socially and sexually transmitted disease via posters and pamphlets						+
			Implement prevention measures						+

Potential Negative Impacts	S	D	Mitigation Activities and Method	R	L	D	Construction				Op	H	
							1	2	3	4			
Workers and villagers are at risk from accidents on site	M	T	Prepare and implement a site health and safety plan that includes measures to - prevent public access to construction sites - ensure that workers use personal protective equipment - provide health and safety training for all personnel - follow documented procedures for all site activities - keep accident reports and records - inform local communities about the work and dangers Ensure BPC staff follow procedures to avoid spills Remove any contaminated soil in sealed containers	C	All sites							0	
Operation													
Spills of transformer oil can pollute land and water	M	P	BPC should repair faults quickly and effectively Do not procure transformers containing PCBs Train and supervise BPC field operatives to ensure that they check house wiring carefully and reject if deficient	BPC	Transformer Sites							0	
												0	
Spills of PCB insulating fluid cause permanent pollution	M	P	Provide public education to raise villagers' awareness of dangers of electricity and how to utilize the system safely	DOE								0	
People cannot use new electrical machines during power cuts so income may suffer	M	T	Check BPC operation and maintenance and health and safety manuals and revise if necessary to increase safety of workers	ESD	All sites							0	
Consumers are at risk of electrocution if they do not understand the dangers of electricity	S	P	Provide regular training of BPC workers to raise awareness of dangers and working procedures to be followed Improve supervision of field workers	BPC	Electrified Houses							0	
												0	
BPC workers are at risk if they do not follow BPC procedures when clearing ROW or repairing faults	S	P	Conduct regular management reviews of safety record, with remedial action where necessary	BPC	All ESDs Head Office							0	
												0	
												0	
												0	

SI = significance of impact: NS = not significant, M = moderately significant, S = significant.

DI = duration of impact: T = temporary, P = permanent.

DD = detailed design; Op = period when infrastructure is operating; 1, 2, 3, 4 = quarters of the 1-year pre- or construction period;

ESD = dzongkhag electricity service division, BPC = Bhutan Power Corporation, L = location, R = responsibility, MV = medium voltage, C = contractor;

H = shows impacts remaining after mitigation: 0 = zero impact (impact successfully mitigated), + = positive impact (mitigation provides a benefit)
Note: Shaded columns: Black shade = continuous activity; grey shade = intermittent
Source: Asian Development Bank project preparatory technical assistance study.

E. Institutional Requirements and Environmental Monitoring Plan

76. Environmental and forest clearances were submitted to NEC. All EIAs (national requirements, and as required for an ADB IEE) were completed and approved by NEC. At the end of July 2008, NEC had cleared all the subprojects.

77. The subprojects will be managed and implemented within the institutional framework that already exists in Bhutan for the provision of rural electrification services. The main agencies are as follows:

- (i) DOE is the Executing Agency responsible for management, coordination, and execution of all activities funded under the loan.
- (ii) BPC is the Implementing Agency, responsible for construction and operation of all rural electrification subprojects. Implementation will be managed centrally by the Rural Electrification Department (RED) in Thimphu; it will appoint a project manager and staff from existing personnel.
- (iii) RED (through its rural electricity divisions) will coordinate construction of subprojects across all dzongkhags, and ensure consistency of approach and performance. They will appoint construction contractors to build elements of the infrastructure in a particular dzongkhag. Local implementation will be managed by the RED field unit in each dzongkhag; it will supervise the construction contractor and be responsible for quality control, contract supervision, monitoring, and reporting.
- (iv) DOE will be assisted by a steering committee to provide policy guidance and coordination across all subprojects. The committee will be chaired by DOE's director general, and members will include senior representatives of other relevant ministries and government agencies, including BPC, Planning Commission Secretariat, and NEC.

78. The BPC Environmental Unit will coordinate environmental issues; the unit has been managing environmental compliance for three rural electrification projects. It will ensure that all subprojects comply with ADB and national environmental safeguards. The IEEs, EIAs, and other documents were developed for all subprojects during project preparation to comply with ADB and Government requirements; BPC will liaise with both agencies to obtain the two remaining approvals. In the unlikely event that further study is required, this will be conducted by the BPC Environmental Unit and/or domestic environment consultants.

79. Each IEE includes an environmental monitoring plan (EMP), involving observations and surveys to be conducted during construction and operation to ensure that mitigation measures are provided and that they protect the environment as intended. Table 9 summarizes an EMP for the rural electrification component. RED field officers will conduct monitoring during construction, and the BPC Environmental Unit will provide monitoring during operation.

80. Once commissioning tests are completed, operation and maintenance of each scheme will be the responsibility of the BPC electricity service division in each dzongkhag.

F. Public Consultation and Disclosure

81. Primary stakeholders include residents of target households, and owners and users of facilities to be electrified; people who work on farmland crossed by medium--voltage lines; and owners and users of land acquired for the erection of poles. Secondary stakeholders are DOE, BPC, DOF as the custodian of protected areas and other forested land through which medium-voltage lines will pass, NEC as the authority granting environmental clearance, other Government institutions, and ADB.

Table 9: Environmental Monitoring Plan

Mitigation Activities and Method	Location	Responsible for Mitigation	Monitoring Method	Monitoring Frequency	Responsible for Monitoring
Construction					
Leave a covering of grass and other low vegetation in the ROW	MV route	Contractor	Site observations	2 weeks	REDFO
Leave cut material to rot in situ and do not burn	MV route	Contractor	Site observations	2 weeks	REDFO
Dispose of trees as required by Forestry Development Corporation	MV route	Contractor	Site observation; villager survey	Monthly	REDFO
Reduce width of ROW where it would not increase risk of shorting	MV route	DOE	Design reports; site observations	2 weeks	REDFO
Use covered conductors in protected areas to reduce ROW to 4 m	MV route	DOE	Design reports; site observations	Monthly	REDFO
Mark ROW boundary with tape and prohibit trespass outside	MV route	Contractor	Site observations	Weekly	REDFO
Only fell trees marked by Department of Forests	MV route	Contractor	Site observations	Weekly	REDFO
Prohibit hunting or fishing by workers and enforce strictly	MV route	Contractor	Site observations; worker survey	2 weeks	REDFO
Train all workers on importance of wildlife and habitats	MV route	Contractor	CC records; worker survey	Monthly	REDFO
Locate labor camps in villages and where no forest clearance is needed	Temporary Labor camps	Contractor	CC records; site observation	Monthly	REDFO
Provide adequate catering and heating in accommodation facilities	Temporary Labor camps	Contractor	Site observation; worker survey	2 weeks	REDFO
Consult with community to identify and avoid infrastructure	LV lines	Contractor	CC records; villager survey	Monthly	REDFO
Consult with farmers; transport material when roads are free	MV & LV lines	Contractor	Site observation; farmer survey	2 weeks	REDFO
Inform communities of work in advance	LV lines	Contractor	CC records; villager survey	Monthly	REDFO
Identify sites of local significance; do not locate poles nearby	LV lines	Contractor	Site observation; villager survey	2 weeks	REDFO
Consult with custodians of facilities: avoid working at sensitive times	LV lines	Contractor	Site observation; custodian survey	2 weeks	REDFO
Employ as many local residents as possible in workforce	All sites	Contractor	CC records; worker survey	Monthly	REDFO
House imported workers in adequate accommodation, including	Temporary Labor camps	Contractor	Site observation; worker survey	2 weeks	REDFO
- safe drinking water	Labor camps	Contractor	Site observation; worker survey	2 weeks	REDFO
- temporary sanitation facilities situated away from water sources	Labor camps	Contractor	Site observation; worker survey	2 weeks	REDFO
- solid waste collected daily and buried offsite	Labor camps	Contractor	Site observation; worker survey	2 weeks	REDFO
- sewage collection and disposal	Labor camps	Contractor	Site observation; worker survey	2 weeks	REDFO
- workers trained in required behavior in host community	Labor camps	Contractor	Site observation; worker survey	2 weeks	REDFO
- prohibition of hunting and fishing by camp occupants	Labor camps	Contractor	Site observation; worker survey	2 weeks	REDFO

Mitigation Activities and Method	Location	Responsible for Mitigation	Monitoring Method	Monitoring Frequency	Responsible for Monitoring
Clean up campsites after work is finished	Labor camps	Contractor	Site observation	As needed	REDFO
Provide initial screening of workers for HIV/AIDS, TB, malaria, etc.	Labor camps	Contractor	Contractor record; worker survey	As needed	REDFO
Provide camp clinics, and regular screening for infection	Labor camps	Contractor	Site observation; clinic records	Monthly	REDFO
Provide free medical treatment for workers at clinic or dzongkhag hospital	Labor camps	Contractor	Site observation; worker survey	Monthly	REDFO
Institute practical measures to avoid infection, e.g., free condoms for workers	Labor camps	Contractor	Site observation; worker survey	Monthly	REDFO
Prepare and implement site health and safety plan that includes	All sites	Contractor	Site observation; CC records	Monthly	REDFO
- exclude the public from all construction sites	All sites	Contractor	Site observation; CC records	Monthly	REDFO
- ensure workers use personal protective equipment	All sites	Contractor	Site observation; CC records	Monthly	REDFO
- provide health and safety training for all personnel	All sites	Contractor	CC records; worker survey	Monthly	REDFO
- follow documented procedures for all site activities	All sites	Contractor	Site observation; CC records	Monthly	REDFO
- keep accident reports and records	All sites	Contractor	CC records	Monthly	REDFO
- inform local communities about the work and dangers	All sites	Contractor	CC records; villager survey	Monthly	REDFO
Operation					
Ensure BPC staff follow procedure to avoid spilling transformer oil	Transformers	BPC	Site observation; worker survey	Monthly	BPC
Remove any contaminated soil in sealed containers	Transformers	BPC	Site observation	Monthly	BPC
Do not procure transformers containing PCBs	Transformers	DOE	DOE records; site observation	As needed	BPC
Maintain system regularly; repair faults quickly and effectively	All sites	SJESD	SJESD records; villager survey	Annual, 3 y	BPC
Train and supervise BPC field operatives to ensure they check house wiring carefully and reject if deficient	New customers	BPC	BPC records; villager survey	Annual, 3 y	BPC
Public education: raise villager awareness of dangers of electricity	New customers	BPC	BPC records; villager survey	Annual, 3 y	BPC
Check BPC operation and maintenance, and health and safety manuals and revise if necessary	All ESDs	BPC	BPC records	As needed	BPC
Regularly train BPC workers on dangers and working procedures	All ESDs	BPC	BPC records; worker survey	6 months	BPC
Improve supervision of field workers	All ESDs	BPC	BPC records; site observations	3 months	BPC
Conduct regular management reviews of safety, with remedial action	All ESDs	BPC	BPC records	3 months	BPC
Long-Term Surveys					
Monitor scheme benefits, adequacy of service, identify deficiencies	All sites	BPC	Customer satisfaction survey	Annual, 3 y	BPC

BPC = Bhutan Power Corporation, ESD = dzongkhag electricity service division
Source: Asian Development Bank project preparatory technical assistance study

82. Primary stakeholders were involved in developing the IEEs through face-to-face consultations during site surveys and public meetings in affected villages. Public consultation was conducted in each dzongkhag. More than 2,000 residents attended 26 public consultation meetings in the eight dzongkhags organized by the local environment consultant. These meetings were chaired by the village headman (gup) and attended by dzongkhag or gewog staff such as BPC staff; park, forestry, livestock, and agriculture staff; local school teachers, and shop owners. The details of public consultations are presented in Table 10.

Table 10. Date and Location of Public Consultation Meetings

No.	Dzongkhag	Date	Gewogs/villages	No. of participants
1	Punakha	30 Jul 2007	Kabjisa gewog	25
		31 Jul 2007	Toewang and Chubu Gewog	85
		1 Aug 2007	Goenshari gewog	40
2	Lhuentse	30 Jun 2007	Minjay gewog	40
		1 Jul 2007	Menbi gewog	25
		2 Jul 2007	Khoma gewog	35
		3 Jul 2007	Metsho gewog	23
		5 Jul 2007	Jarrey gewog	46
		23 Jul 2007	Gangzur gewog	66
3	Pema Gatshel	12 Aug 2007	Ningshiborang Norbugang	58
		14 Aug 2007	Nganglam	163
4	Wangdue	9 Oct 2007	Athang gewog	25
		6 Nov 2007	Nyisho and Dangchu gewogs	174
		6 Nov 2007	Sephu gewogs	106
5	Zhemgang	26 Nov 2007	Pantang and surrounding villages	42
		27 Nov 2007	Shilingtoe, Chengarzam	51
		28 Nov 2007	Panbang	32
		29 Dec 2007	Shingkhar	65
6	Trashigang	18 Nov 2007	Merak and Gengo villages	117
		20 Nov 2007	Sakteng, Pusa, Borangmang, Borangtse	112
		21 Nov 2007	Thakthri and Thrakalum	15
		22 Nov 2007	Joenkhar, Tholong, Murphi, Bumlog, Yongbazor	20
7	Sarpang	1 Dec 2007	Taklai gewog	26
		3 Dec 2007	Senge gewog	29
		3 Dec 2007	Hilley gewog	56
8	Samdrup Jongkhar	7 Apr 2008	Gomdar gewog (20 villages)	550
				Total

Source: Asian Development Bank project preparatory technical assistance study.

83. Public meetings were organized with the objectives of disseminating information to local government officials and community about the proposed rural electrification to explain potential impacts anticipated and mitigation measures, and to solicit the views of the community and clarify any issues or doubts regarding the work. Prior to each meeting the village headmen were contacted to set the date, time, and venue for the meeting.

84. The topics covered include introduction to the rural electrification component and its objectives; DOE's Master Plan²⁷ to provide electricity in rural villages during the 10th FYP; introduction of NEC's Environmental Assessment Act; the Forest Conservation Policy and the Conservation Policy of protected areas; social, religious, cultural, and environmental aspects of the component and types of wildlife found in the adjacent forests. Discussions were held on the positive and negative impacts of rural electrification, and participants were asked their views on the rural electrification.

85. To seek the full consensus of individual households to align the feeders through their private property, public consensus forms, prepared by DOE, were given to each village headman. The village headmen then organized gewog meetings to apprise the communities of the purpose of the forms, following which each household gave signed consent for the rural electrification work. From the village headmen, these were endorsed by the district committee and forwarded by the dzongkhag to BPC.

86. Secondary stakeholders participated in three workshops in May and September 2007 and January 2008. Views expressed were incorporated into the IEEs and the planning and development of the component. IEEs and other relevant documents will be made available at the BPC website.

G. Findings and Recommendations

87. Environmental issues were considered throughout development of the rural electrification component and changes were made to outline designs to avoid or reduce impacts. Actions include the following:

- (i) Ensure all construction work is small in scale and conducted with manual labor by small teams without the use of heavy vehicles and machinery.
- (ii) Excavate using simple equipment and excavate only a very small quantity of material so no large concentration of excavated or stockpiled material will accumulate at any one location.
- (iii) Carry all construction components manually to the site from the nearest metaled road.
- (iv) Route medium-voltage lines along existing farm roads and footpaths where possible, where the forest has already been partially cleared, thus reducing the felling of new trees and acquisition of private land.
- (v) Reduce ROW (about 10 m) to minimize impacts in protected areas;
- (vi) Use insulated conductors in protected areas to allow for reduced ROW and wildlife protection.
- (vii) Locate poles on field boundaries where medium-voltage lines cross agricultural areas, to reduce the loss of productive land.

²⁷ The 2005 Japan International Cooperation Agency-funded Integrated Master Plan Study for dzongkhag electrification prepared on-grid and off-grid, 10th FYP and 11th FYP electrification action plans based on economic evaluation and government priority.

- (viii) Locate poles for low-voltage lines in villages on public land alongside roads and tracks to reduce the acquisition of private land.

88. Most target villages are located in forested areas. Accordingly avoiding all negative impacts is impossible. Table 7 shows that the main impacts occur during construction and are related to the cutting of the ROW (to prevent tree branches touching conductors), and the need to import foreign workers (which could cause social and environmental problems in accommodation camps and neighbouring communities). These and other impacts are common where electricity is provided to remote areas, and methods for their mitigation are well-developed. These include the following:

- (i) Reduce the width of the ROW where there is no risk of branches touching the line.
- (ii) Mark the ROW boundary and prohibit workers from trespassing outside.
- (iii) Limit the felling of trees to those marked as approved for cutting by DOF.
- (iv) Provide migrant workers with adequate accommodation, safe drinking water, and temporary sanitation facilities; and clean up camps on completion of work.
- (v) Screen workers for infectious diseases and provide free treatment if necessary.

89. Small parcels of land will be required for pole foundations where medium-voltage lines cross agricultural areas. These may be acquired through the Land Act (2007), although in practice owners are eager to obtain access to electricity and allow BPC to erect poles on their land without the need for purchase or acquisition. The *ADB Involuntary Resettlement Policy* (1995) requires the provision of compensation to owners and users of acquired land for any related loss of income or assets. However that should not be necessary in this case because

- (i) areas are small (0.5 m²) and dispersed, so it is unlikely that a significant proportion of the land of any one owner will be acquired; and
- (ii) poles will be located on field boundaries to reduce the loss of productive land.

90. Measures to guard wildlife species in protected areas include

- (i) use covered conductors along environmentally sensitive habitats and reflectors to enable birds to avoid distribution lines;
- (ii) only fell trees marked by DOF;
- (iii) prohibit worker's from fishing, hunting, and trespassing outside the ROW; and
- (iv) train workers on the importance of wildlife and habitats.

91. Once the system is operating it should function with routine maintenance and occasional repair, neither of which should have significant impacts. The relevant electricity service division will remove overhanging branches and high-growing vegetation to maintain the ROW; lines damaged by fallen trees or landslides will be repaired by relocating poles and restringing conductors.

92. Consumers are at risk if they are not fully aware of the dangers of electrical shocks. A small number of recent fatalities suggest that BPC safety procedures may need to be strengthened. Recommended measures include

- (i) review and amend BPC operation and maintenance and health and safety procedures if necessary;
- (ii) enhance training and supervision of BPC staff operatives;

- (iii) implement measures to ensure that field officers check house wiring thoroughly before providing a connection and reject any that are deficient; and
- (iv) educate the community on the dangers and correct usage of the new rural electrification system.

93. If these measures are implemented thoroughly then the new infrastructure should provide major benefits for the recipient households and communities. These include

- (i) greatly improved living conditions from the availability of electrical power;
- (ii) improved health from reduced exposure to wood smoke and kerosene products;
- (iii) increased incomes from the use of electrical machinery to increase efficiency and provide alternative livelihoods; and
- (iv) improved communication and access to information from the use of television, radio, mobile telephones, and the Internet.

94. The reduced felling of trees will have ecological benefits, and the use of clean energy (hydropower) instead of fuel burning will significantly reduce greenhouse gas emissions.

95. Mitigation will be assured by a program of environmental monitoring summarized in Table 9. This will ensure that all measures are provided as intended and will determine whether the environment is protected as envisaged, enabling remedial action if necessary. The final column of Table 8 shows that mitigation measures should reduce all impacts to minimal or no significance, and some may provide small additional benefits.

96. The SIEE has two recommendations: DOE should ensure that

- (i) all mitigation, compensation, and enhancement measures proposed in each IEE and summarized in Table 8 are implemented in full; and
- (ii) the EMP described in each IEE and summarized in Table 8 is implemented in full.

H. Conclusions

97. The environmental impacts of the rural electrification component proposed by the Green Power Development Project were assessed by the IEE, conducted according to the ADB environmental safeguards policy and procedures. The overall conclusion is that providing the mitigation measures are implemented in full, no significant negative impacts should result from the location, design, construction, or operation of this component. Because the analysis has no uncertainties, no additional studies are required to address further concerns or to comply with ADB procedure or national law. Thus, no further study or EIA is needed.

IV. DAGACHHU HYDROPOWER PROJECT COMPONENT

A. Description of the Component

98. The Dagachhu hydropower development is located in the center of Dagana dzongkhag on the Dagachhu (river), approximately 10 km upstream of Dagachhu bridge in Trashiding gewog. A new access road is already under construction on the hillside between the highway and the powerhouse site; and the hydropower development will include a 19 km transmission line from Dagana to Dhajay in Tsirang gewog. The location map and its outline is in Appendix 5.

99. On completion of the Dagachhu development, power will be conveyed through a transmission line to a longer transmission line (45 km) between Dhajay and Gelephu, to be provided by the second part of this development). This will connect the western and eastern parts of the national grid, enabling power from the Dagachhu station (and other hydropower plants in the west) to be supplied to the central and eastern regions of Bhutan. Excess power will be exported to India, supplementing existing power export arrangements. The present investment package does not include the construction of transmission lines.

100. The Dagachhu development has applied for and been approved for implementation under the Clean Development Mechanism (CDM) as defined in the Kyoto Protocol. Energy sold to India will replace electricity that would otherwise have been generated from fossil fuels, and will thus contribute to a reduction of carbon emissions to the atmosphere. This will be verified by certified emission reductions (CERs) issued by the CDM Executive Board. The certified emission reductions will be sold to interested carbon funds in industrialized nations to offset their own carbon emissions, providing additional revenue that the Bhutan Government can use in developing this and other projects to generate energy from renewable sources.

101. The Dagachhu development is a run-of-river hydropower facility with the net head of 294.5 meters (m), which will be sufficient to provide an installed capacity of 114 MW with approximate annual energy production of 500 gigawatt-hours. A concrete gravity diversion dam 15 m above the riverbed (20.5 m from the river bottom) with a crest length of 21.7 m will be built on the Dagachhu. This will create a diversion reservoir of 0.07 million m³ at full supply level. An 8.0 km tunnel will carry water from the reservoir to the powerhouse located underground near Babithang village in Khebisu gewog. The powerhouse will be equipped with two turbines with installed capacity of 57 MW each. A total of 0.48 million m³ of spoils will be generated. The catchment area at the dam is 676 km². The Dagachhu is fed by snow as well as seasonal monsoons, thus providing a comparatively consistent supply of water for a run-of-river facility.

102. The power produced will be transmitted by a 19 km transmission line from Dagona to Tsirang Dhajay, where it will be exported to India. Total construction time is estimated at 4 years and mechanized construction methods are to be used. During peak construction, the facility will employ about 1,500 workers and the operating staff is estimated at 200.

B. Description of the Environment

1. Physical Environment

103. The facility is located in a remote area in the south-west of Bhutan, where the environment is not especially sensitive. The site lies mainly in a narrow, steep gorge, with wooded slopes leading down to the riverbed; there is little flat land. The altitude is 825 m on the riverbed at the dam site, making it one of the lowest regions of Bhutan. The mean annual flow of Dagachhu at Dagona, some 6 km from the dam, is estimated to be 25.42 m³/s. The Dagachhu has soft water quality with slightly acidic reaction. Pollution due to human activities is not significant. The climate is subtropical, with a hot and humid summer, cooler winter, and heavy monsoon rains between June and September.

104. Most of the cultivated land with milder terrain is located far from the riverbed. No irrigation scheme is found along the Dagachhu banks owing to its location in a deep gorge.

105. Geological conditions are generally consistent over the facility area, comprising mainly metamorphic rocks of crystalline nature of the High Himalayas. High precipitation causes

substantial chemical weathering of rocks and the mineral deposits in the area, mainly colluviums. Soils range in particle size from sandy clay to loamy sand.

106. No protected areas are in the vicinity of the site; the nearest is the Phibsoo Wildlife Sanctuary 30 km away. The broadleaf and chirpine forest on the hillsides is disturbed to an extent by human activity, and is said to support two protected mammals (the leopard and leopard cat) and one globally threatened bird (the Rufous-necked Hornbill). Surveys revealed only five fish species in the river, none of which are rare or endangered, and only one of which migrates upstream to spawn in the summer.

2. Social Environment

107. A few small communities are in the vicinity of the facility site, but none in any of the locations in which elements of the development will be built or created, including the small impounded area. Most people are engaged in mixed subsistence agriculture, mainly on farmer-owned. Predominant farming methods are kamzhing (dryland) or chuzhing (in natural wetlands); and the main crops are paddy rice, maize, millet, potatoes, buckwheat, oranges, and cardamom. Incomes are generally somewhat higher than the national average of Nu1,200 per month.

108. Schools, health facilities, and sites of religious or cultural importance are located in the dzongkhag, but not in the facility area. Around 40% of households have piped water through rural water supply schemes; the remainder collect water from rivers. No sewerage is available; almost all households use pit latrines. Waterborne diseases are common. Gender discrimination is rare in Bhutanese society and inheritance rules favor females. About 40% of households in the development area are headed by women, and women play an integral role in urban and rural society.

C. Forecasting Environmental Impacts and Mitigation Measures

109. Because the development is not located in or near protected areas, it will not encroach upon any declared protected areas of Bhutan, nor will it undermine the rich cultural heritage sites. Some localized impacts will result from construction and operation. These can be mitigated or minimized if suggested mitigation measures are applied.

110. On the basis of physical, biological, and social impacts identified in the Dagachhu EIA and the proposed scope for mitigation and enhancement measures, no obvious reason can be identified from an environment perspective to not advance the development to implementation.

111. The EIA proposes measures to mitigate adverse impacts and measures to enhance positive impacts of the construction and DHPC operation. The enhancement measures should receive equal attention as the mitigation measures. A total of 12.8 hectares (31.7 acres) of cultivated land will be lost due to the development activities. Agriculture land ownership lies with the communities. The Land Act 1979 (revised in 1998) requires that all affected households be compensated as per the revised Land Compensation of Rates, 1996.

112. All packages of civil contracts for the Dagachhu hydropower development will incorporate all required measures for slope stabilization and restoration of construction areas, camps, and other disturbed areas. The standard mitigation measures for adverse effects due to construction of roads, associated transmission lines in the next phase, powerhouse, tunnel, diversion dam, and reservoir are not to be taken separately and be part of the respective tender documents and implemented along with the component.

113. Air, water, and noise pollution from construction will remain within the national standards and can be minimized by taking proper measures. The air, water, and noise compliance standards provided in environmental standards for Bhutan will be observed during construction when major impacts occur.²⁸ Water quality of the reservoir will not deteriorate because water circulates relatively quickly.

114. The area is known to be visited by some bird and animal species: the Rufous-necked Hornbill (avifauna) and mammals include Golden Langur, Leopard, and Leopard Cat, which are protected by the Forest and Nature Conservation Act of Bhutan, 1995. Monitoring of these important species is elaborated in the main EIA report, but no significant impacts were identified.

115. In addition to the common species, the area is visited by other species protected under the International Union for Conservation of Nature. They are Great Hornbill (avifauna), Serow, Asiatic Wild Dog, and Assamese Macaque. The impact of the facility activities on the living environment of these species is expected to be temporary and minimal since facility implementation will not change the habitat environmental conditions.

116. The EIA recommends a minimum flow (ecological flow) release from the diversion dam of 1.4 m³/s (about 5%–10% of the mean annual natural flow) to support animal life, in particular fish migration from March to April (to a spawning site) and from September to October (return to lower altitude for warm water). The basis for determining minimum flow was drawn from the experiences of alpine areas such as Switzerland, France, and Austria applied for similar projects and environment. The calculation details are provided in the main EIA report. The provision of the minimum ecological flow is a requirement for the Implementing Agency, DHPC.

117. Following discussions during the loan appraisal mission in July 2008, ADB, DOE, and DHPC agreed that further studies to determine the minimal ecological flow will be carried out to cover at least 2 consecutive calendar years. NEC does not have data on hydrological fluctuations in the Dagana River; such studies were never conducted. In addition, NEC does not have specific guidelines on minimal ecological flow requirements or a calculation methodology. ADB has included a TA program to strengthen institutional capacity at NEC (including a subtask on developing a methodology for minimum ecological flow requirements in hydropower projects) in the 2009 TA pipeline with total funding of \$350,000.

118. Monitoring of the aquatic ecosystem and fish population will be needed during facility operation to confirm the minimum acceptable release and make necessary adjustments if the flow is observed to be insufficient.

119. Having a smooth increase and decrease in the stream flow (and hence in the water level when changing the load) downstream of the outlet from the power station is important. This can be done by implementing fixed start and stop procedures.

120. Monitoring of the fish population should be implemented during the preconstruction and construction phases to determine the need for building a fish ladder. Based on the analysis of the presently available data on fish migration, construction of a fish ladder is not recommended as only one migratory fish species inhabits the site. The fish migration route is estimated within 3 km and seems not to overpass the prospective dam site. However, to ensure that fish migration concerns are not overlooked in the EMP, during the July 2008 appraisal mission ADB,

²⁸ National Environmental Committee Report, Royal Government of Bhutan, 2003

DOE, and DHPC agreed that DHPC will conduct a 1-year fish migration monitoring study starting January 2009. The study recommendations will elaborate on the necessity of installing a fish ladder and assess design options (e.g., a fish ladder versus a fish lift). The requirement to complete the study is included in the project assurances.

121. ADB, DOE, and DHPC agreed that DHPC will carry out a separate study on water quality monitoring and seasonal water quantity variation to collect seasonal data to (i) determine the water quality baseline at the site (to monitor baseline deviations during implementation); and (ii) confirm (or recalculate) the minimum ecological flow requirement provided in the EMP. The EMP requirement is based on similar hydrological conditions in selected river systems in the Austrian and Swiss Alps, but does not consider specific conditions in Bhutan in general and at the Dagachhu site in particular. The requirement for the implementation of water quality and minimum ecological flow studies is incorporated into the project assurances. In addition, such studies will provide valuable baseline information for development of national guidelines for determining minimum ecological flow requirements for hydropower projects in Bhutan. The development of national guidelines is planned as part of 2009 ADB TA to NEC.

122. The hydropower development will greatly benefit the country's economy through the sale of hydropower energy. Even for communities surrounding project areas, the field investigations and analysis reveal that positive impacts outweigh potential negative impacts (loss of cultivated land, although there is no resettlement is envisioned). The following positive social impacts are anticipated to result for the people settling around the hydropower development areas:

123. All households will receive electricity that will drastically improve living conditions. Currently, 91% of households use kerosene for lighting and 98% use firewood for cooking. The 2001 study, National Strategy for Stoves and Other Alternative Energies, found the per capita consumption of firewood by people living between altitudes of 1,200 m and 2,800 m was about 3.4 kilograms/person/day. With a population of about 4,446 within the project influence area who are currently dependent upon firewood as their main energy source, the hydropower development will save cutting down about 15,000 kilograms of trees per day by replacing firewood with hydroelectric energy.

124. The development will also improve sanitary conditions of households through the income generated from the sale of farm products thus improving living conditions. Currently, 99% of the households use pit toilets.

125. The development will have minimal negative social impacts. It will impact the landholdings of 41 households. On average, the land losses per household account for about 16.2% of their overall landholdings, which the development will compensate as per the Land Act of Bhutan, 1979, and Land Compensation of Rates, 1996. The procedure and timeline of compensation will be provided in the resettlement action plan prepared as part of the project preparatory technical assistance. The plan addresses the amount of compensation, time schedule, responsibilities, and monitoring mechanism.

126. Another social impact is expected from the influx of about 1,500 construction workers into the area, where subsistence agriculture has been the norm for centuries and where long-established social and cultural institutions shape people's understanding. Thus special attention should be given to programs to mitigate adverse impacts of the interaction between existing communities and the construction work force.

127. Examples of specific measures proposed in the environmental management and monitoring plan for the Dagachhu development include the following: locate the contractor's camp as close as possible to various project sites to reduce the need of transport and unwanted interaction with the local community; provide cooking gas or kerosene stoves or any other alternative fuel to the camps by the respective contractor to avoid damage to neighboring forest and to thwart any outbreak of fire by using firewood for cooking; encourage laborers to make meals jointly or use mess facility so that meals can be prepared on cooking gas or kerosene stoves, since providing every labor group with cooking gas facilities is not realistic; and set up basic sanitation facilities in temporary labor camps to avoid contamination of drinking water sources.

128. The Environment Community Unit of DHPC was established to provide coordination among the project management personnel, government agencies, and other organizations involved in implementation of environmental and social mitigation, and the enhancement program. Two members of the unit attended the EMP implementation workshop organized and conducted by ADB in July 2008. NEC is responsible for oversight of EMP implementation activities and Environment Community Unit performance. The unit is to be fully funded by DHPC and continue to function as a permanent establishment with reduced staff during operation of the hydropower facility.

D. Institutional Requirements and Environmental Monitoring Plan

1. Institutional Requirements

129. DOE, the Executing Agency, will be responsible for overall implementation of the EMP. Specifically, DOE, will be responsible for management, coordination, and execution of all activities funded under the ADB loan. DOE will bear the overall responsibility for providing regular monitoring reports to ADB as specified in the EMP. DHPC, as the Implementing Agency, will be responsible for construction and operation of the Dagachhu hydropower development, and implementation of the EMP.

130. DHPC has already set up an environmental unit headed by an environmental manager and support staff. The unit will be responsible for day-to-day monitoring of EMP implementation and preparation of environmental monitoring reports as specified in the EMP. DHPC will assure the overall environmental compliance and adherence to the required mitigation measures as specified in the EMP. It will be responsible for reporting any changes in the project scope (e.g. addition of new civil works or changes of access roads alignments and the tunnel layout) to DOE. DOE will, in turn, inform ADB about any changes proposed to the agreed scope of works. If ADB finds that the changes will have impacts on environmental safeguard compliance, DOE will be required to complete either an IEE (for category B projects) or a full EIA if the changed scope is categorized as environment category A.

2. Environmental Monitoring Plan

131. The EMP for the Dagachhu hydropower component is summarized in Table 11. It comprises actions recommended in the EIA to mitigate negative environmental impacts; and monitoring of the effects of each mitigation measure, in terms of indicators, frequency, and responsibility for implementing the monitoring.

132. The EIA identifies impacts that are a result of the location, design, construction, and operation of the facility; and the EMP specifies actions to mitigate the negative impacts, which need to be taken during the preconstruction, construction, and operation phases.

133. **Preconstruction.** Obtain environmental clearance from NEC as required under the Environmental Assessment Act, 2000 (obtained in September 2007); prepare a resettlement plan to identify and compensate, where appropriate, losses of income and income-generating assets caused by the facility (completed); incorporate environmental requirements in facility design, particularly as clauses in construction contract documents (ongoing); and monitor implementation of the resettlement plan.

134. **Construction.** Establish an environment and community unit to be a focal point between the development and the community and oversee environmental and social enhancement measures; coordinate with the engineering unit to incorporate environmental concerns into operations contracts, guidance documents, and operation and maintenance manuals; provide environmental capacity building including for the contractor's engineer; monitor the execution of civil works; monitor wildlife, environmental quality, and social indicators; and report and mediate where necessary.

135. **Operation.** Monitor downstream flow variations, reservoir management, downstream water quality, and management of insect disease vectors; and mitigate any further impacts revealed by the monitoring if necessary.

Table 11: Summary of Environmental Impacts and Proposed Mitigation and Monitoring Plan

Environmental Management Plan		Monitoring Plan		
Impact	Proposed Mitigation	Indicator	Responsibility	Frequency
Location				
Watershed Erosion: Dam and reservoir site may be subject to increased erosion and landslides because of construction of access roads and fluctuation in reservoir levels	Biological: plant shrubs and trees Engineering: build check dams, gabion walls, stone masonry Monitor areas requiring slope stabilization Catchment: designate as watershed reserve forest; prohibit mining, grazing, forestry; raise awareness	Exposed cut slopes; landslide; rate of soil erosion; sedimentation to water course	Contractor, ECU	Monthly during construction and operation
Fish Migration: The dam will prevent migration of fish upstream to spawn. Changes in flow regime and sediment deposition would affect fish mobility and spawning conditions	Monitor fish populations, distribution of species, migration and spawning; measure water temperature, provide a fish farm to sustain the species if breeding migrations are affected	Loss of fish species and problem in fish mobility	ECU	Weekly Monthly
Agriculture: The facility will occupy 12.7 hectares of farmland and the remainder of the site will be broadleaf and conifer forest and scrub. The agricultural land is owned by 41 households, who are losing an average of 16% of their holding, from which they obtain most of their income	Survey agricultural production; recommend how to improve water utilization, increase availability of seeds and fertilizers, provide information about scientific farming Purchase land through Land Act 1998 (at rates updated in 2008) or provide replacement land if possible, give additional compensation for loss of crops and trees via resettlement plan Provide jobs during plant operations—1 person per affected family	Agricultural production	DHPPC, ECU	Quarterly
Wildlife: Leopard and Leopard Cat inhabit the project area. The Rufous-necked Hornbill inhabits tall trees in the area and feeds on fruit bearing trees	Prohibit encroachment into the prime habitat of the two mammals, which are thickly forested areas upstream of the reservoir and near the addit; do not locate labor camps in these areas; prohibit cutting of tall or fruit-bearing trees	Decreased number as per surveys before and during construction	ECU	Monthly

Environmental Management Plan	Monitoring Plan			
Impact	Proposed Mitigation	Indicator	Responsibility	Frequency
Design				
Road: The proposed 19.3 km of access roads will remove 12.3 hectares of agricultural land and 24 hectares of forest, which could cause physical impacts (landslides, erosion, runoff) and loss of income	Plant trees, shrubs, bushes in unstable areas; build retaining walls and use other slope stabilization methods; provide culverts and other drainage for storm runoff; use salvage soil in reclaimed land; schedule construction with farming cycle so that local people can take up employment; compensate losses in income via the resettlement plan	Number of dead trees and clearing of bushes and shrubs; incidence of erosion and landslides	Contractor, ECU	Monthly, half-yearly, yearly during construction and operation
Fish Screens: Screens to prevent fish entering powerhouse and ladders to enable fish to migrate upstream of the dam may be necessary if monitoring shows significant number of migratory fish	Monitor species and number of long distance migrators, and amend design to include fish lift and/or ladder and intake screens if necessary	Loss of migratory species and observed mobility problems	ECU	Further investigations
Associated Transmission Line (not part of the current facility): 19 km transmission line is 220 kV so will have a ROW of 40–50 m, and 3–4 towers per kilometer; no need to clear the ROW, but obstructing vegetation will be selectively cut back to 3 m height	Limit cutting to vegetation higher than 3 m and limit construction of access pathways; revegetate areas with steep topography to stabilize slopes; and provide measures to control drainage; provide involvement and awareness program for local residents	Cutting of trees and clearing of shrubs and bushes; land slides soil erosion	Contractor, ECU	Monthly, half-yearly, yearly during construction and operation
Construction				
Soil Excavation: Over 400,000 m ³ of waste spoil will be excavated to create the tunnel, powerhouse, desilting chamber; this needs to be safely disposed of so that it does not adversely affect drainage, water quality	Transport spoil to designated dumpsite, level after deposition, provide storm drainage and runoff control, and afforest the disposal site; minimize the release of sediment to rivers to protect water quality	Appearance, topography, dust	Contractor, ECU	Weekly, monthly
Worker Safety: The health and safety of workers and the public must be protected during construction	Provide first-aid kits, safety equipment (e.g., hard hats, gloves, boots), safe drinking water, toilets, safety barriers, mosquito control; produce and implement an occupational health and safety plan	Incidence of accident, injury, waterborne disease, malaria fever	Contractor, ECU	Daily, weekly, monthly

Environmental Management Plan	Monitoring Plan			
Impact	Proposed Mitigation	Indicator	Responsibility	Frequency
Air Quality and Noise: Air and noise pollution may be produced by blasting, excavation, drilling, crushing, and other construction activities	Sprinkle water on exposed dry soil; maintain all construction vehicles and equipment; fit crushers with cyclone filters; prohibit blasting at night; provide local communities with advanced notice of blasting operations	Levels of noise and dust, blasting operations	Contractor, ECU	Weekly, monthly
Water Quality: Construction will increase erosion and sediment loads in rivers; spills of oil, fuel, and other chemicals are possible; the increase in workers and people supplying services could cause water pollution from discharge of untreated sanitary effluent	Provide adequate pit latrines at labor camp and prohibit disposal of sewage to river Use settling tanks and prevent silt laden water from tunneling and other activities from entering river; prevent chemical spills Conduct sampling and analysis of water quality in the river, plus temperature measurements	pH, turbidity, dissolved oxygen, biological oxygen demand, phosphate, nitrate, temperature	ECU	Monthly
Solid and Liquid Waste: Various types of solid and liquid waste produced during construction will need to be disposed of responsibly	Design and provide a landfill away from human settlements, water bodies, and critical habitats; deposit solid waste to landfill; export metal, rubber, plastic, and batteries for recycling; use wood for fencing and fuel; use sawdust for soaking up spilled oil; store waste liquids in drums and export to India for reprocessing	Land and water pollution. Engine oil collected and exported for reprocessing	ECU	Weekly, monthly
Waterborne Diseases: Water in the river may be polluted resulting in a risk of workers contracting disease if water is consumed without treatment	Periodically sample water sources for fecal coliforms and other parameters; abstract water upstream of labor camp and treat with chlorine and slow sand filtration; raise awareness of need to boil water before drinking; include measures in the occupational health and safety plan	Coliform bacteria in water and increase in incidence of waterborne disease	ECU	Weekly, monthly
Fire Outbreaks: The site is forested so fire could be caused by use of explosives, or wood and kerosene for cooking	Store and use all explosives according to Ministry of Home and Cultural Affairs' rules; ensure proper fire-fighting equipment and trained personnel are present at all sites; labor camps must have common mess facility using gas for cooking and use of wood should be prohibited	Smoke in air	Contractor, ECU	As and when required

Environmental Management Plan	Monitoring Plan			
Impact	Proposed Mitigation	Indicator	Responsibility	Frequency
Poaching of Wildlife: Ecological damage can be magnified near labor camps if workers fell trees and engage in fishing and poaching	Erect barriers and check posts around labor camp and work sites, including the transmission line route to prevent illegal poaching, fishing, and felling of trees	Decrease in wildlife number	ECU	Monthly
Cultural Invasion: An estimated 1,500 unskilled workers plus 200 staff will be imported, mainly from India; their culture and behavior could have negative impacts on the host community	Construct separate labor camps for migrant workers and follow the construction schedule strictly to limit the length of stay for migrant workers; provide training in the local religion, culture, tradition, and lifestyle so that workers are aware of local sensitivities	Local complaints	Contractor, ECU	Monthly
Operation				
Downstream Flow Variation: The 6.6 km of river between the dam and the powerhouse will be depleted of water in the 9-month lean season. A minimum flow of 1.4 m ³ /s will be provided to sustain aquatic life and riparian vegetation. Reduced flows will encourage people to cross the riverbed, so sudden release of water could lead to loss of life and erosion of riverbed	Collect hydrological data and flow measurements Maintain the guaranteed minimum flow at all times in the diverted section and apply a start and stop procedure that provides a smooth increase and decrease in water level and flow Provide a system to warn people of changes in flow Monitor riverbed conditions and slope erosion downstream of the dam.	Flow rate	DHPP, ECU, CEM	Monthly
Reservoir Management: Inappropriate operation of the dam and reservoir could exacerbate difficulties downstream caused by variations in flow rate	Design energy dissipators to reduce downstream scour, and monitor shoreline for cracks and erosion Install warning system for emergency spillway release or gate opening when normally closed in dry season Consult community to discourage use of reservoir water for drinking or irrigation Operate reservoir to provide minimum compensation flow Vegetate shoreline to prevent erosion and sediment increase	Large variation in water level in reservoir	DHPP, ECU	Monthly

Environmental Management Plan	Monitoring Plan			
Impact	Proposed Mitigation	Indicator	Responsibility	Frequency
Downstream Water Quality: River water may be polluted by sewage, wastewater, and spills of chemicals used on site, such as fuel or oil	Prohibit discharge of untreated waste to the river; treat and disinfect drinking water, and regularly test the quality of river water and domestic water; raise workers' awareness of risks of waterborne disease; adopt best practice for storage and disposal of oil, other hazardous substances, and waste; provide effective site drainage that prevents spills entering the river	Spread of waterborne disease; loss of fish; total suspended solids; total settleable and nonsettleable solids	DHPP, ECU	Monthly
Insect Vectors of Disease: The increase in aquatic habitat provided by the small impounded area may increase the number of anopheline mosquitoes	Provide a first-aid post and dispensary on site and implement malaria control by spraying insecticide in areas where adults and larvae may be present (not in the river water)' monitor the incidence of mosquitoes every 2 weeks	Reported cases of malaria	DHPP, ECU	Weekly, Monthly

DHPC = Dagachhu HP Corporation; ECU = Environment and Community Unit of DHPC; CEM = Central Environment Monitor/NEC
Source: Asian Development Bank project preparatory technical assistance study.

E. Public Consultation and Disclosure

136. DHPC will acquire land for the construction of the facility components. Although most of the land required by DHPC is qualified as government-owned land, some land will be required from private individuals. The land acquisition exclusively concerns the access road construction. No land will be acquired at the reservoir and dam site as no human settlements are there. Public consultations were held with the affected communities settled among the prospective access roads. No activities will take place in the environmentally protected areas. The EIA approved by NEC indicates that water quality and fish migration will not be affected to the extent that family incomes (from fishery) or dietary habits of the local population will be altered. The views of the local population were solicited through open consultations organized in an informal manner creating a conducive environment for people to express their thoughts about the hydropower development. A representative from the group facilitated the consultation thus providing equal opportunity in the consultation.

137. The project preparation team (including DOE, DHPC, and consultants) had consultations with officials from the Dagana Dzongkhag Administration and affected local communities. The objective of the consultations was to provide information on the project activities and potential environmental and social impacts; and solicit public feedback, concerns, and comments to consider during preparation of the feasibility study and EIA.

138. The consultations were held according to the following schedule:

- (i) 14 July 2005 (9:30 a.m.–12:00 a.m.) with Dagana dzongkhag officials;
- (ii) 17 July 2005 (11:00 a.m.–2:00 p.m.) with the communities of Khebisa gewog;
- (iii) 18 July 2005 (9:30 a.m.–11:00 a.m.) with communities of Tsendagang gewog;
- (iv) 18 July 2005 (1:00 p.m.–3:00 p.m.) with communities of Trashiding gewog;
- (v) 20 July 2005 (5:00 p.m.–7:30 p.m.) with communities of Goshi gewog;
- (vi) 20 December 2005: additional consultation with affected communities of Goshi gewog;
- (vii) 21 July 2005 (9:30 a.m.–11:30 a.m.) with communities of Kana gewog;
- (viii) 21 July 2005 (3:00 p.m.–5:30 p.m.) with communities of Drujegang gewog; and
- (ix) 23 July 2005 (10:30 a.m.–1:00 p.m.) with communities of Rangthangling gewog.

F. Reclassification of the Dagachhu Hydropower Component

139. In March 2008, ADB reclassified the Dagachhu hydropower development component from environment category A to category B, for the following reasons:

- (i) The Dagachhu hydropower scheme is a run-of-river design, with a dam that serves to divert the water flow, but not to store it. The facility is located in a remote area that is not environment sensitive.
- (ii) Most of the common environmental impacts associated with hydropower development will not occur, and those that may occur should be reduced to no significance by mitigation measures proposed in the EIA.
- (iii) No designated or sensitive areas are near the site and no areas are of major ecological, cultural, or social significance.
- (iv) The river has good flow throughout the year so impounding of water for power generation is not necessary, and the function of the 20.5 m high dam (from the riverbed) is merely to deflect water through a tunnel to the powerhouse.
- (v) The impounded area will be small (4–5 hectares) and will cover an area of degraded mixed forest that is not inhabited, has no farmland, has no privately owned land, and has no features of special importance.
- (vi) No people will be relocated and no buildings will be removed from any location.
- (vii) A small amount of private land will be purchased under the Land Act (1998) at rates that are currently being updated; additional compensation will be paid for loss of crops and other income-generating assets.
- (viii) Water will be returned to the river about 6 km downstream of the powerhouse; the river will not be affected by variations in flow. A minimum flow of 4%–6% of the annual average will be provided to maintain ecology in the area.
- (ix) The EIA includes an EMP through which all mitigation measures will be provided and monitored.
- (x) The cost of mitigation and monitoring is estimated in the EIA and the amounts are included in the component budgets.

G. Conclusion

140. Hydropower, a renewable energy, generated by the Dagachhu hydropower development will contribute significantly to socioeconomic development of the region in particular and to the country in general. It will improve the standard of living. The construction and operation of the hydropower development will bring the following benefits:

- (i) As the hydropower development will be developed under the CDM initiative, greenhouse gas emission reduction certificates will be obtained, as energy sold to India will replace fossil fuel energy, contributing to reduced carbon emission into the atmosphere. These certified emission reductions will provide additional revenue for the development, thus promoting sustainable development energy in Bhutan.
- (ii) Approximately 500 gigawatt-hours of electricity will be supplied per annum.
- (iii) Construction and operation of the facility will have minimal impacts on the environment; these can be mitigated through a set of proposed environmental mitigation measures.
- (iv) The facility will earn annual revenue of approximately Nu750 million at the rate of Nu1.5/kWh.
- (v) Implementation of the Dagacchu hydropower development complements the Bhutan 2020 document for harnessing the potential growth of hydropower production in the country for economic growth and improvement in socioeconomic conditions.
- (vi) Bhutan is an energy surplus country; the export of hydropower to neighboring countries could be the main resource for earning foreign currency.
- (vii) By exporting energy to India the import–export disparity of Bhutan will be improved.
- (viii) The proposed generating facilities are essential to sustain economic growth and improve the standard of living of the country.

DESIGN AND MONITORING FRAMEWORK

Design Summary	Performance Targets/Indicators	Data Sources/ Reporting Mechanisms	Assumptions and Risks
<p>Impact Sustained inclusive economic growth from promoting cross-border power trade and electricity access</p>	<p>Increase in the energy sector share of GDP from 25% to 40% (2017) with annual GDP growth of at least an additional 2%–3% from 2012 to 2017</p> <p>Increase in the energy sector share of government revenue from 45% to 75% (2020), through clean energy export to India with a minimum additional 5,000 MW of electricity (2020)</p> <p>Increase in use of electric lighting (to be replaced from kerosene lamps or firewood), from 40% to 100% (2020) of rural households</p>	<p>Government statistics and census reports</p> <p>UNDP Human Development Report</p> <p>Economic reports of the Government, ADB, IMF, and World Bank</p>	<p>Assumptions Political stability Government gives high policy priority to rural development and hydropower export Stable economic growth in South Asia region</p> <p>Risks Exogenous economic and political shocks</p>
<p>Outcome Expanded coverage of clean power development</p>	<p>Increase in access to electricity by rural households, achieving a cumulative national electrification ratio from 60% to 84% (2013)</p> <p>Increase in hydropower export revenue of the total national account from 45% to 60% (2013)</p> <p>Increase in investment from the public and private sectors to hydropower development projects with minimum additional 1,200 MW (2013)</p> <p>Annual reduction of emission gas equivalent CO₂ by 250,000 tons by</p>	<p>Quarterly project progress reports and completion report</p> <p>Audit of financial accounts and reports</p> <p>National statistics</p> <p>Government's fiscal statement</p> <p>Economic reports of the Government, ADB, IMF, and World Bank</p>	<p>Assumptions Government's commitment to promote development of hydropower and rural electrification Continuation of the existing investment program and regulatory framework Promotion of a new policy for private participation Strong demand and supply shortage in India's power market Government's sustainable public debt management</p> <p>Risks Off-taker's serious default Prolonged significant</p>

Design Summary	Performance Targets/Indicators	Data Sources/ Reporting Mechanisms	Assumptions and Risks
	<p>2012 and by 500,000 tons on a cross-country basis after 2012</p> <p>Continued overall power system loss below 10% and power sector's financial health including sufficient debt service coverage (minimum 1.2) and net profit generation</p>		hydrological shortage because of natural disaster and climate change
<p>Outputs</p> <p>1. Dagachhu Hydropower Development</p> <p>2. Rural Electrification</p> <p>3. Attached CDTA: Promotion of Clean Power Export Development - Capacity building for hydropower subsector - Financial structuring study for standby hydropower projects - Preparation of documents for carbon finance</p>	<p>Construction of a 114-MW run-of-river Dagachhu hydropower plant by 2012</p> <p>Construction of a 19 km transmission line to evacuate to the grid system by 2012</p> <p>Clean and renewable energy export of additional 250 gigawatt-hours to India by 2012 and 492 gigawatt-hours after 2012</p> <p>Provision of reliable power supply and service to 8,767 rural households and 119 off-grid public institutions (schools, health clinics, and other community facilities) through subprojects by 2012</p> <p>Full operation of the Druk Green Power Corporation, through the corporate accounting policy (2009) and integrated management information system (2011)</p> <p>Implementation of the Hydropower Development Policy,</p>	<p>ADB review mission aide memoires</p> <p>Quarterly project progress reports</p> <p>Project completion report</p> <p>Withdrawal applications, and disbursement and contract award records</p> <p>Financial account audits and reports</p> <p>Government's fiscal statement</p> <p>CDM monitoring report</p>	<p>Assumptions Government's commitment to implement the Green Power Development Project Timely mobilization of counterpart funds, equities, and cofinancing Firm commercial agreement (i.e., power purchase agreement, emission reduction underwriting contract) High quality of construction contractors and equipment</p> <p>Risks Unexpected cost increases in commodities and raw materials beyond contingencies Construction delays due to slow procurement, natural disaster, or design changes Lack of sufficient and appropriate human resources and expertise</p>

Design Summary	Performance Targets/Indicators	Data Sources/ Reporting Mechanisms	Assumptions and Risks
	<p>through two sample projects with public and/or private investments</p> <p>Financial closure of Nikachhu (210 MW) and Khomachhu (326 MW) development before 2012</p>		
<p>Activities with Milestones</p> <p>Dagachhu Hydropower Component Endorsement and disclosure of the resettlement plan to affected people by June 2008 Advance procurement by July 2008 Endorsement and disclosure of the summary initial environmental examination by September 2008 Completion of physical land acquisition and compensation with revised rates by the fourth quarter 2008 Contract award by the first quarter 2009 Physical construction including testing by 2012 Commission by the second quarter 2012</p> <p>Rural Electrification Component Advance procurement by the fourth quarter 2008 Contract award by the first quarter 2009 Physical construction by 2012</p> <p>Promotion of Clean Power Export Development (CDTA) Advance selection process by the fourth quarter 2008 Contract award by the first quarter 2009 TA consultant fielding by the first quarter 2009 Completion of TA by the fourth quarter of 2010</p>			<p>Inputs</p> <p>Dagachhu hydropower component Financing (\$ million) ADB: 80.0 Bhutan public sector: 45.0 Cofinancing: 55.5 Private sector: 21.0</p> <p>Rural electrification component Financing (\$ million) ADB: 25.28 Government; 6.70 ACEF: 1.00</p> <p>Attached CDTA (\$ '000) ADB: 1,488 Government: 24</p>

ACEF = Asian Clean Energy Fund, ADB = Asian Development Bank, CDM= Clean Development Mechanism, CDTA = capacity development technical assistance, GDP = gross domestic product, GWh = gigawatt-hour, IMF = International Monetary Fund, MW = megawatt, TA = technical assistance, UNDP = United Nations Development Programme.

Source: Asian Development Bank estimates.

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 Director, SAEN

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Cost Estimation For The Rural Electrification Component

Dzongkhag	Household	Facility	Industry	Total Consumer	MV line (km)	LV ABC (km)	No of. Transf.			Total Cost (\$ million)		Cost/Consumer (\$)	
								No. of Feeders	Estimated Cost	Preliminary Estimation	After survey	Preliminary Estimation	After survey
Lhuentse	1,165	118	49	1,332	118.4	115.9	98	20	105.3	2.3	2.6	2,780	1,951
Pemagatshel ^{a,c}	1,604	133	18	1,755	157.0	184.2	134	16	169.4	1.7	4.2	3,683	2,384
Punakha	202	13	0	215	25.0	36.2	17	10	22.9	0.6	0.6	3,891	2,630
Samdrupjongkhar ^c	1,731	131	9	1,871	131.7	254.6	116	12	161.7	6.1	3.9	2,749	2,135
Sarpang ^{b,c}	1,256	38	10	1,304	115.0	150.8	82	14	103.9	4.1	2.6	2,950	1,968
Trashigang ^c	1,380	98	33	1,511	115.5	87.3	104	14	101.7	4.2	2.5	2,622	1,662
Wangduephodrang	640	126	13	779	130.0	82.9	63	13	88.2	3.8	2.2	4,054	2,796
Zhemgang	1,306	200	2	1,508	226.6	307.6	139	7	249.8	6.	6.2	4,514	4,090
Total	9,284	857	134	10,275	1,019.3	1,219.6	753	106	1,002.9	28.9	24.8	3,405	2,410

km = kilometer.

^a Pemagatshel includes a part of Mongar connected to a feeder from Pemagatshel

^b Lamoyzingkha, Deorali, and Nichula Gewogs are now shifted to Dagana but considered in the table.

^c Due to Dzongkhag Delimitation after the Rural Electrification Master Plan, number of households in Pemagatshel, Sarpang, and Samdrup Jongkhar are shifted to different Dzongkhags.

Pemagatshel: Nanong, Norbugang, Dechhenling Gewogs are added. Trashigang: Nanong Gewog is shifted. Sarpang: Dechhenling and Norbugang Gewogs are shifted.

Source: Asian Development Bank project preparatory technical assistance study.

Cost of Environmental Management and Monitoring

Dzongkhag	Environmental Monitoring Plan: Construction	Community monitoring during operation	Customer Satisfaction Survey	Review of BPC O&M and Procedures H&S	Total
Punakha	330,000.00	240,000.00	142,500.00	320,000.00	1,032,500.00
Lhuentse	660,000.00	427,500.00	285,000.00	—	1,372,500.00
Sarpang	660,000.00	427,500.00	285,000.00	—	1,372,500.00
Samdrup Jongkhar	660,000.00	570,000.00	285,000.00	—	1,515,000.00
Pema Gatshel	990,000.00	570,000.00	285,000.00	—	1,845,000.00
Trashigang	660,000.00	427,500.00	285,000.00	—	1,372,500.00
Wangdue	660,000.00	570,000.00	285,000.00	—	1,515,000.00
Zhemgang	990,000.00	570,000.00	570,000.00	—	2,130,000.00
Total	5,610,000.00	3,802,500.00	2,422,500.00	320,000.00	12,155,000.00

H&S = health and safety, O&M = operation and maintenance.

Source: Asian Development Bank project preparatory technical assistance study.

Present Land Use Of The Right-Of-Way
(kilometers)

Dzongkhag	Exposed/ Rocky	Orchards	Scrub/ Bushes	Broadleaf Forest	Conifer Forest	Sokshing (trees for domestic use)	Tsamdo (Pasture)	Wetland	Dryland	Tseri	Other	Total
Lhuentse	0.5	0.0	10.8	26.1	23.5	5.6	0.4	5.6	45.2	0.0	0.5	118.4
Pema Gatshel	0.0	9.6	6.1	60.6	4.7	0.0	0.0	0.2	75.2	0.5	0.0	157.0
Punakha	0.0	0.0	4.9	11.7	3.5	0.3	0.0	3.6	1.1	0.0	0.0	25.0
Samdrup Jongkhar	4.2	3.5	16.3	33.4	0.7	1.0	9.7	7.3	44.8	10.5	0.4	131.7
Sarpang	8.8	5.4	29.0	35.5	0.0	0.0	0.0	15.6	20.7	0.0	0.0	115.0
Trashigang	0.0	0.6	36.7	35.3	2.5	2.8	9.6	1.6	26.2	0.0	0.2	115.5
Wangduephodrang	3.1	0.0	18.1	58.1	42.5	0.0	3.1	1.7	3.4	0.0	0.0	130.0
Zhemgang	1.9	4.0	9.9	112.3	3.0	18.7	2.7	5.5	64.1	4.4	0.0	226.6
Total	18.5	23.0	131.8	373.0	80.5	28.3	25.5	41.1	280.9	15.5	1.1	1,019.3

Sokshing: area from where dried leaf litter is collected to make farm yard manure

Tsamdo: pasture land

Tseri: shifting cultivation

Source: Asian Development Bank project preparatory technical assistance study.

**LENGTHS OF MULTIPLE-VOLTAGE LINE PASSING THROUGH PRIVATE AND
PUBLIC LAND**
(kilometers)

Dzongkhag	Private	Public	Total
Lhuentse	50.6	67.8	118.4
Pemagatshel	85.7	71.3	157.0
Punakha	5.3	19.7	25.0
Samdrup Jongkhar	79.1	52.6	131.7
Sarpang	60.0	55.1	115.0
Trashigang	32.0	83.5	115.5
Wangduephodrang	5.7	124.3	130.0
Zhemgang	82.0	144.6	226.6
	400.4	619.0	1019.3

Source: Asian Development Bank project preparatory technical assistance study.

**Length Of Feeders In Protected Areas, Multipurpose
Buffer Areas, And Biological Corridors
(kilometers)**

No.	Target Dzongkhag	Inside Park	Multipurpose Buffer area	Biological Corridor	Total Length
1	Punakha	7.698 ^a	17.311	0	25
2	Zhemgang	30.327 ^b	16 ^c	12.802	226.6
3	Wangdue	9.7 ^d	0	42.23	130
4	Lhuentse	0	17 ^e	55	118.4
5	Trashigang	27.423 ^f	30.023	0	115.5
6	Samdrup Jongkhar	0	0	0	131.7
7	Sarpang	0	0	0	115
8	Pema Gatshel	0	27.5 ^g	0	157
	Total Length	75.1	107.8	110.0	1,019.2
	Percentage of total length	7.4%	10.6%	10.8%	100%

^aJigme Dorji National Park (Goenshari gewog: along farm road and access trails)

^bRoyal Manas National Park (Pangkhar and Ngangla gewog: along proposed national highway and 132 KV transmission line)

^cThrumshingla National Park (Shingkar gewog)

^dJigme Singye Wangchuk National Park (Athang gewog: covered conductor recommended for protected areas)

^eThrumshingla National Park (Jarrey gewog: buffer area)

^fSakteng Wildlife Sanctuary (Merak and Sakteng gewog: along access route)

^gRoyal Manas National Park (Norbugang gewog: buffer area)

Source: Asian Development Bank project preparatory technical assistance study.

