Department of Agriculture
Ministry of Agriculture and Forests
The Kingdom of Bhutan

DATA COLLECTION SURVEY
ON
STRATEGIC AGRICULTURAL WATER SUPPLY
AND MANAGEMENT
IN SOUTHERN BHUTAN

FINAL REPORT

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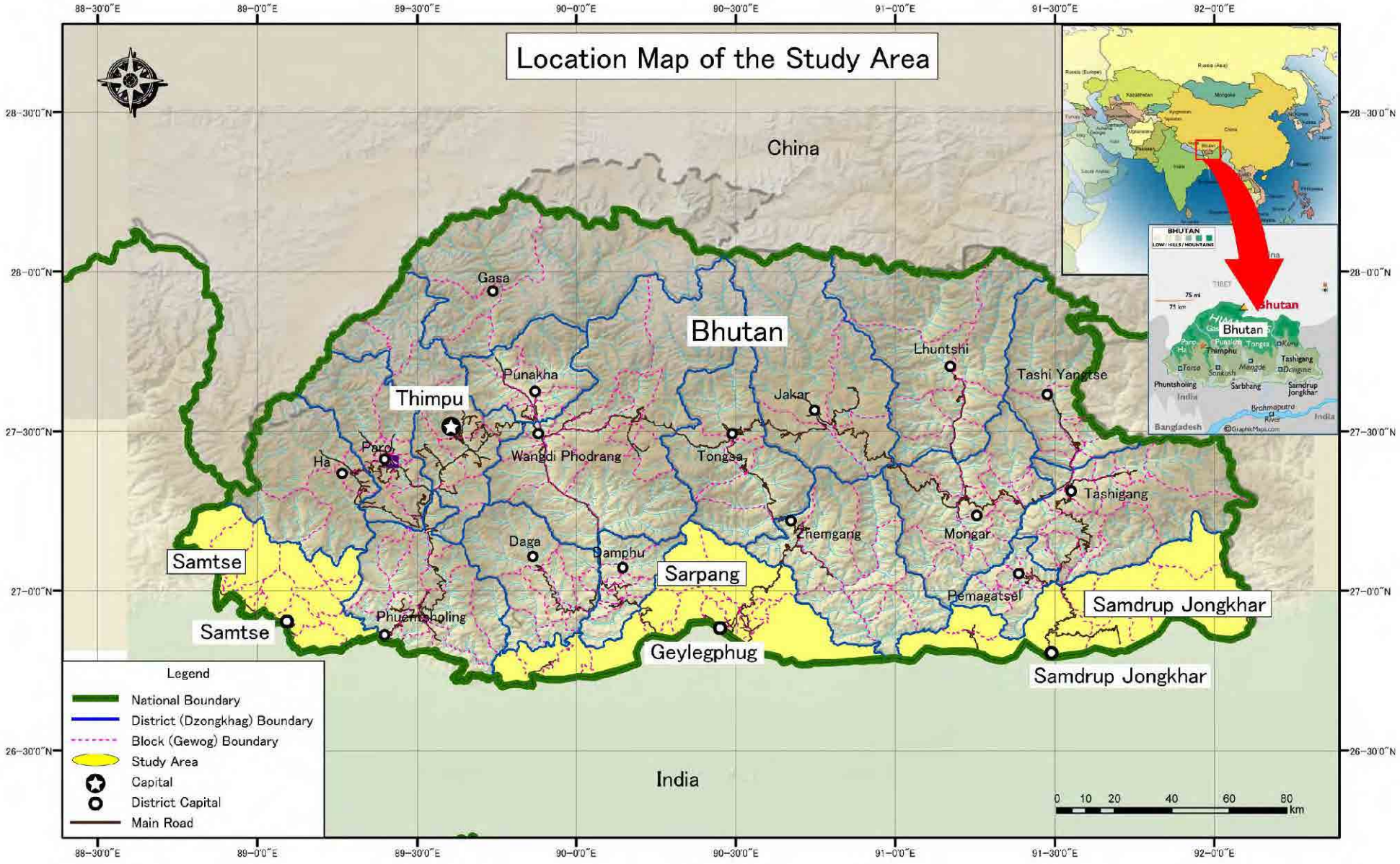
Japan International Cooperation Agency (JICA)
SANYU CONSULTANTS INC.

Location Map of the Survey area



EXECUTIVE SUMMARY

CHAPTER 1 INTRODUCTION OF THE STUDY

1.1 BACKGROUND AND OBJECTIVE OF THE SURVEY

(1) The agricultural sector in Bhutan is a key industry that employs 69% of Bhutan's population and provides 14% of GDP. Bhutan is an entirely mountainous country. Agricultural land area is limited to only 7 to 8% of the country's land. Under this situation, the Royal Government of Bhutan (RGoB) developed a food security policy in which the self-sufficiency level for rice is set to improve to 75% and vegetables to 90% by the year 2023.

(2) The southern zone of three *dzongkhags* of Sarpang, Samdrup Jongkhar and Samtse has relatively extended flat plains with more favorable climatic conditions for cereal production than the other regions. However, the southern zone is behind in agricultural development.

(3) The objective of this Survey is to collect and analyze data/ information and prepare appropriate recommendations for a strategic agricultural water supply and management plan for southern Bhutan. The overall goal of this Survey is to contribute to the government's food security policy aiming to improve the rice and vegetable self-sufficiency levels through improvement of irrigated agriculture.

1.2 COUNTERPART AGENCY AND WORKING SCHEDULE

(4) The Counterpart Agency in Bhutan is the Department of Agriculture (DoA), Ministry of Agriculture and Forests (MoAF) and three Dzonkhag Administration offices (DAO). This survey was conducted from April to September in 2012.

CHAPTER 2 ADMINISTRATIVE FRAMEWORK AND ORGANIZATIONS RELATED TO THE SURVEY

2.1 ADMINISTRATIVE FRAMEWORK

(5) The on-going National Development is the 10th Five Year Plan (July 2008-June 2013). RNR sector prescribes Four GNH Pillars in the Plan. Out of them, in the Theme 1.1 "Food Security", a numerical development target is set in the fields; "Self sufficiency in rice", "Cereal production including paddy increased" and "Portion of wetland with dry season irrigation increased". MoAF provided the 29 development programs to reach these targets. Out of them, DoA provided the 17 programs. Out of the 17 programs, programs closely related to this data collection survey are the "Commodity/ Cereal Development Programme" and the "Irrigation and Water Management Programme".

(6) The mid-term review of the 10th five-year plan has been conducted. The 11th five-year plan is in the process of drafting. In the 11th five-year plan, a production volume of the cereal is set to increase at 195,000 mt/year up by 35% from the present volume of 143,638 mt/year. To reach this target, it is emphasized that provision of irrigation system is prioritized.

(7) According to the sector budget for the financial year 2011-12, total budget for the RNR sector is 13 % of the total outlay. Largest allocation is given to the share of farm roads, 38% of the total.

Irrigation sector is only 2%.

(8) Laws/ regulations related to water are the "Bhutan Water Vision 2025", "Bhutan Water Policy 2003" and "Water Act of Bhutan 2011". As for the trans-boundary water issues, the issue of “Flood Warning” has been agreed with India. However, other issues related to “Water Use” and/or “Water Rights” have not been discussed among neighboring counties. The survey area is located on the Indian border. If a large-scale water use scheme that changes current water flow regimes is planned, cross border water sharing agreements with India may be needed.

(9) The revised "National Irrigation Policy (NIP)"(2011) is intended to provide policy direction in the irrigation sub-sector. The Engineering Division of the DoA is assigned as the lead agency for execution of this NIP.

2.2 RELEVANT ADMINISTRATIVE ORGANIZATION

(10) The Engineering Division, DoA under the MoAF supported by three Research and Development Centers (RDC) are responsible for provision of agricultural infrastructure including irrigation. The RDC under the DoA is responsible for providing engineering support to the *dzongkhag*’s Engineering Divisions and central programs within their regions. RDC-Bhur is mandated to cover Sarpang and Samtse, and others. RDC-Wengkhar is responsible for Samdrup Jongkhar. These organizations face capacity limitations such as lack of qualified staff, equipment and facilities for undertaking their mandated works.

(11) Dzongkhag Administration Office (DAO) is responsible for overall administration duties including agriculture at the district level.

2.3 SOUTHERN ZONE IRRIGATION DEVELOPMENT RECONNAISSANCE MISSION REPORT BY FAO

(12) FAO conducted the "Southern zone irrigation development reconnaissance survey" based on a request from the RGoB. The mission report was submitted in April 2010. The mission recommended that “An integrated wetlands productivity and production program approach” be used for irrigation development in the southern zone.

CHAPTER 3 SURVEY AREA

3.1 NATURAL CONDITION

(13) Bhutan is a Himalayan landlocked country. 72% of the total land area is covered by forests. Based on altitude zones, the southern three *dzongkhags* are located in the lower elevation zone ranging from about and elevation (EL.) of 150 m to EL. 2,000 m. The southern zone belongs to the two of Humid Subtropical and Wet Subtropical zones, which are considered to be suitable for double cropping.

(14) Agricultural land exists only in limited small areas on the foothills near the Indian border and in valley along rivers and on hillsides. Bhutan is classified into four geological belts bounded by major faults (thrusts). Out of the four, the southern zone is occupied by the Lesser Himalayan Zone, where poor rock mass with schistosity and fault fractures develops. The slope where an

irrigation canal runs is vulnerable to land slides and erosion. Such instability certainly brings difficulty in maintaining constructed irrigation facilities.

(15) Annual rainfall in the southern zone is much from 3,500 mm to 5,500 mm. Maximum monthly rainfall is recorded in July and from November to February there is almost no rainfall. As for temperature, the maximum from 28 to 29 degrees occurs in June to August and the minimum from 23 to 24 degrees in December to January. There are no river discharge observation stations in which permanent staff are stationed. During the lean flow season, from January to March, staff goes to the observation spots and measures the discharge. To study the future development direction of irrigation agriculture, observation stations should be extended to accumulate relevant discharge data.

(16) A total of ten "National Protected Areas" and inter-connected "Biological Corridors" are delineated as protected areas in Bhutan. New settlements are not allowed and new development of agricultural land is prohibited. New water resource development within the area is required to get approval. Four areas are located in Sarpang and three areas in Samdrop Jonkhar. In case that irrigation rehabilitation and new water resources development is planned around the area, it is required to confirm that the plan would not bring a negative impact to the protected areas.

3.2 SOCIETY AND ECONOMY

(17) District (*Dzongkhag*) administration consists of sub-districts (*Drungkhag*) and Blocks (*Gewog*). Each block comprises sub-blocks (*Chiwog*) and villages. Three divisions of RNR, Agriculture, Forestry and Livestock are in charge of DAO. *Gewog* extension staff are responsible for support and promotion of the operation and maintenance of irrigation facilities and provision of support for farming practices. However, organizational capacity is not sufficient to promote extension activities, because of scattered irrigation sites, lack of extension staff and no equipment and facilities for extension activities. The *dzongkhag*'s budget for irrigation field is also limited as well as in the national budget.

(18) In 2010, the population of Samtse Dzongkhag was 65,000, Sarpang Dzongkhag 41,000 and Samdrup Jongkhar Dzongkhag 37,000. The total population of three *dzongkhags* was 144,000, which makes up 21 % of the total population (696,000) of Bhutan. The total number of households in the three *dzongkhags* was 27,000. The average number of household members in the three *dzongkhags* was 5.4, which was more than the national average, 5.0 persons/ household.

(19) According to the DAO in Sarpang Dzongkhag, about 90 percent of agricultural land is the farmers' own land and 10 percent is leased land. About a half of the leased land is national land and the other half is private land. An annual tax is imposed on farmland.

(20) The average proportion of persons who are engaged in agriculture in the three *dzongkhags* is 52 %, which is 7 % higher than the national average. The agriculture sector is the key industry employing the *dzongkhag*'s labor force. For maintaining stable employment, provision of agriculture infrastructure such as irrigation and farm roads are key subjects. In addition, provision of living conditions for the *dzongkhag* administration is required.

(21) RGoB has supported farmers who live in the northern/ central areas and want to resettle to the southern areas since the latter half of the nineteen-nineties. The Government provides land for them free. In Sarpang Dzongkhag, eleven *gewogs* excluding Dovan Gewog have resettlers. Support for agriculture, especially for provision of irrigation infrastructure has a high need, which is also important from the viewpoint of living security for resettlers.

(22) Electrification has progressed in rural areas rapidly in recent years. Based on the plan of the Bhutan Power Corporation Ltd., it seems that almost all households in the three *dzongkhags* will be electrified by the end of the fiscal year 2012. Therefore, for agricultural development planning in remote areas, it is recommended to investigate the existence of non-electrified households and power supply plans for such households by the Power Corporation Ltd.

(23) Drinking water for households in the irrigation sites is taken from the same river as the irrigation water source. River discharge rapidly decreases in the dry season. In irrigation development plans, the number of households who use the same river water source as irrigation and the amount of their consumptive uses should be surveyed to put their data on the water use balance study.

3.3 AGRICULTURE

(24) According to the land use in the three *dzongkhags* in 2010, the proportion of forest area to the total area of the three *dzongkhags* is 85 % and the proportion of shrubs 5 %, cultivated land 7 %, and water bodies 2 %. Agricultural land in the three *dzongkhags* is divided into wet land (paddy field), dry land (ordinary field) and cash crop land (orchard). The results show that the share of paddy field in the three *dzongkhags* is 20%, ordinary field 66%, and orchard 14%.

(25) Various crops are cultivated in the southern three *dzongkhags*. As for cereal crop production, paddy and corn occupy 90% of the total cereal production. The remainder is comprised of wheat/ barely, millets and buckwheat. Total production of paddy is 14,760 mt (occupying 21% of the whole country); corn is 13,451 mt (23% of area). However, the yield is lower than the average of whole country. Constraining factors that have encumbered improvement of agricultural productivity are poor soil fertility, lack of irrigation facilities and associated low level of nitrogen, and lack of access to high quality seeds. In addition, paddy production is limited due largely to low cropping intensity, and crop loss to pests and wild animals.

(26) Other cultivated crops in the country are potato, chili, radish, beans, tomato, carrot, cabbage, ginger and garlic. Potato is the most important cash crop, exported to Bangladesh and India. Production area is located mostly in mid and higher altitude zones, not the southern zone. At the national level, other cash crops include chili, ginger, apples, oranges and cardamom. In the southern zone, ginger and cardamom are the crops with the most potential.

(27) Mandarins/ oranges and apples are the major cash fruits in the country, exported to India and Bangladesh. In the southern zone, mandarin is the major fruit, occupying 27% of the country's production in 2010. Mango and banana are also produced under the southern sub-tropical climatic conditions. Areca nuts in the southern zone is ranked as the top industrial crop, occuping 79% of the country's production in 2010.

(28) Irrigation sites are scattered in the mountainous areas. According to the inventory of irrigation areas of each DAO, irrigation area is shown as below. These irrigation areas were screened by application of two selection criteria for economic/ financial feasibility requirement in which command area was no less than 5 ha and beneficiary was no less than 10 households. The average scale of irrigation area was also estimated as shown in the table below. As for the number of irrigation areas, Sarpang has the largest number.

Dzongkhag		Number	Total canal length (km)	Total command area (ha)	No. of beneficiaries HH
Sarpang	*(1)*	*300*	*429*	*3,064*	*3,255*
	(2)	79	206	2,324	2,449
	(3)	Average	2.6	29	31
Sumdrop Jonkhar	*(1)*	*42*	*109*	*956*	*956*
	(2)	25	79	608	847
	(3)	Average	3.2	24	34
Samtse	*(1)*	*32*	*88*	*1,533*	*1,682*
	(2)	31	85	1,520	1,676
	(3)	Average	2.7	49	54

(1); Original data from the inventory. (2); Screened ones, (3); Average of screened ones (per one site).

(29) All irrigation systems use gravity irrigation. Irrigation water is taken from neighboring rivers/ streams along the peripheral terraced farmlands. Irrigation facilities such as irrigation canals and intake facilities are operated and managed by related community/ villagers on their farmland. Often multiple canals are constructed on a single river system.

(30) In Sarpang, irrigation sites have been surveyed. Survey results related to agricultural water supply and management are summarized as follows; 1) Infiltration rate is high since soil in the paddy fields contains gravel, sand/ silt. 2) Soil and water loss is caused by plot-to-plot irrigation. 3) The sites with registered water user associations (WUAs) is only 3 sites, but, water use groups who cooperatively operate/ manage and repair the irrigation facilities by their own labor contribution are organized in every site. On the other hand, in cases where irrigation facilities are so seriously damaged that they cannot be repaired by the farmers own manual labor, the damaged irrigation works are not repaired. As a result, the damaged facilities are left and irrigation agriculture is often abandoned.

(31) DoA plans to execute irrigation development projects in two (2) sites in Sarpang, 1 site in Samtse (bidding process for construction was conducted in June to July 2012.). An FAO mission report shows 26 irrigation sites in the three *dzongkhags* that are included in the irrigation sites covered by this survey.

(32) The total length of roads including highways/ *dzongkhag* roads, farm roads and feeder roads in three *dzongkhags* is 660 km, equivalent to 129 meter per km^2 of *dzongkhag*'s land area. Provision of roads is the top priority in the country. The total number of rice mills in the three *dzongkhags* is 117. Half of them are distributed in Sarpang Dzongkhag. CAFCO（Chuzagang Agriculture

Farmers Cooperative） established 2010 in Sarpang, deals in processing and marketing of rice. Their activities have just started. It is required to monitor their activities and outcomes, to anticipate market oriented irrigation agriculture in the southern zone.

CHAPTER 4 CURRENT SITUATION ANALYSIS ON AGRICULTURAL WATER SUPPLY AND MANAGEMENT

4.1 ANALYSIS ON THE EFFICIENCY AND FEASIBILITY OF THE EXISTING IRRIGATION SYSTEM

(33) Since the many rivers used as agriculture water sources in the three *dzongkhags* have small catchment areas and steep river gradients, rainfall runs off quickly into the rivers. River flows are readily influenced by the pattern of precipitation. Due to small rainwater storage capacity in the river basin, many drying up rivers are observed as the dry season progresses. As for geology of the rivers, vulnerable ground foundation develops with schistosity and faults. Rolling stones are often accompanied with heavy discharges in torrentially inundated chute rivers. These are the large limiting factors in planning and maintaining irrigation facilities.

(34) Agricultural water is taken by the natural intake method. Due to this method, intake quantities greatly rely on fluctuations of water levels of the rivers. Intake facilities often do not function once the water level and riverbed at the intake point is drawn down. As to canals, there was observed some non-functional ones due to collapse of canal sections as well as deposited sand/ mud/ stone. During the wet season, river flow is more than enough to intake. Water intake and delivery loss do not affect the efficiency. However, during less water flow in early and late wet seasons, higher efficiency irrigation system to prevent water loss is needed.

(35) An engineering manual on the planning and design of irrigation facilities has been provided in Bhutan, but it covers homogeneously all the territory as a whole and thus contains no detailed technical guidelines based on the regional natural conditions. It is required for the southern zone to prepare a manual taking into full consideration the local conditions such as the amount of rainfall, flooding and vulnerable slope and geology.

4.2 PRESENT CONDITION OF IRRIGATION WATER DEMAND AND SUPPLY

(36) In the southern three *dzongkhags*, irrigation paddy cropping is practiced in wet land from June to November. No irrigation is done in the dry season. Corn and vegetables are cultivated in part of the wet lands in the dry season. Although a few fishery ponds exist in some of the wet land, the number is very limited and the water supply amount from irrigation canals is very limited.

(37) The current irrigation water requirement in the wet land areas was estimated by using the Penman method. Percolation water is much because of silty and sandy soil in the surface soil layer. It is considered from the estimate that irrigation is indispensable even in the high rainfall season due to a large amount of infiltration water.

(38) According to the inventory of Sarpang, there are two types of rivers that serve as irrigation water sources; permanent rivers and seasonal rivers. Out of the 79 irrigation sites, 35 sites have permanent rivers expecting to take water in the dry season. Run-off discharges in the seasonal

rivers are sharply depleted and often dry up. Total river discharge amount in the wet season is more than enough to supply intake irrigation water. However, according to interview surveys, during the land preparation and transplanting period from June to July and in October for the pre-harvesting season, a shortage of river discharge takes place in some years. As a result, available intake water is extremely decreased.

4.3 Economic Feasibility of Existing Irrigation System

(39) Nine models of existing irrigation schemes were made from three types of canal length (1.5km/ 2.5km/ 5.0km) and three types of command areas (15ha/ 30ha/ 60ha) to analyze the economic validity of the irrigation schemes, based on the average size of the 79 sites.

(40) The cost is the canal construction cost and the regular maintenance cost including repair. These are estimated based on the canal length. From the data analysis, the construction cost was estimated at Nu.370,000/km and the annual maintenance cost at Nu.55,500/km. Benefit is calculated based on the paddy price at the farm gate. The unit yield of paddy production, 2.15 ton/ha of Sarpang Dzongkhag, is applied. The average purchasing price of CAFCO at farmers' houses, 17 Nu./kg was applied. Working cost of the paddy cultivation was calculated on the assumption of a farmer who cultivated paddy on a hectare plot.

(41) The benefit ratio to the cost (B/C) was calculated on the condition that the service life of the irrigation facilities was 10 years. In case of a small command area and a long canal, the B/C tends to be low. In this calculation, amount of the cost largely influences the value of the B/C. Economically speaking, the benefit is generated through maximum utilization of labor at a bargain price and reducing the costs.

4.4 DATA COMPILATION BY GIS

(42) Collected data was compiled on GIS to make use of it for future development planning.

CHAPTER 5 ANALYSIS ON VALIDITY OF IRRIGATION AGRICULTURE DEVELOPMENT AND REHABILITATION PROJECT OF IRRIGATION SYSTEM

5.1 CONSIDERATION ON AGRICULTURE DEVELOPMENT DIRECTION

(43) Agriculture of the southern zone is practiced on mountainous topography and local geological conditions. Agriculture zoning is totally made on such local topo-geological features. It is roughly classified into three zones; hill agriculture zone, terrace agriculture zone and alluvial fan agriculture zone. Agricultural features of the zones are characterized based on their own natural conditions such as rainfall, soil texture, access to agricultural water and access to marketing. In general, the hill agriculture zone located at higher altitude is characterized as subsistence farming in which various crops are cultivated for home consumption. Terrace and alluvial fan agriculture zones located at lower altitudes are considered as a market oriented agriculture rather than the subsistence one, although wet paddy is the major crop.

(44) The surveyed 79 irrigation system sites were classified into the five agriculture zones; Hill, Fan, Higher Terrace, Lower Terrace and Lowland River Terrace. Agricultural zones located along the border of the Bhur and Gelephu Gewogs are classified into the fan agriculture zone. On the other

hand, those located in the northern Gewogs of Dovan and Jigmecholing are characterized as the hill agriculture zone in high altitudes ranging around 900 m to 1,500 m. For all practical purposes, the zones are mixed in the topographic and soil conditions.

(45) The strategy to ensure agricultural water supply and management should be formulated in line with the national development policy; "improvement of agricultural productivity of rice and other crops" and "shifting from subsistence agriculture to market oriented agriculture". The basic agricultural development direction of each zone was prepared based on such policy. In order to materialize the development direction, expected development components are: “Water resources development”, “Rehabilitation of irrigation system”, “Provision of farm roads”, “Promotion of vegetable and cash crop cultivation”, “Establishment of farmers organization”, “Promotion of processing and marketing of cultivation crops”, “Improvement of farm land (soils and soil layers)”, “Improvement of paddy cropping technology”, “Introduction of double cropping”, “Introduction of livestock and inland fishery development plans”, “Establishment and strengthening of water users association”, “Strengthening on-farm water management”, “Value chain improvement of rice and vegetable”. Those projects are needed overall in all zones. However, their development intensity is differs for each agricultural zone. They should be applied flexibly based on the local conditions and problems confronted.

(46) Among the project list mentioned above, development effect of some projects may be further generated from mutual linkages during project implementation. Therefore, the project implementation should be well designed with a long-term time schedule. To design it, it is necessary to draft an overall development scenario for each zone by conducting more detailed study and analysis. On the other hand, it is recommended that priority projects may be selected and implemented so that a quick development effect can be generated. From the effects that would be generated during the implementation process of the priority projects, the next project and the overall project implementation schedule may be guided.

(47) Based on the above concept, the priority project was selected from the project component list. Screening items to select the priority project are: “Is it expected to obtain quick and certain effects "increase of crop production" by short term inputs?”, “Can the administrative implementation organization body provide enough capacity to lead the priority project?" and “Are beneficiary farmers ready for working with the project? By screening the listed projects, the project "Rehabilitation of existing irrigation system" is selected as the priority project.

5.2 APPROACHES TO PROVIDING EFFECTIVE/ EFFICIENT IRRIGATION SYSTEM

(48) Although annual precipitation has a high level in the southern areas, its distribution is mainly concentrated in a period from July to September. Run-off patterns from rivers are largely dependent on rainfall patterns, so river discharge sometimes is depressed in irrigation requirement time. This implies a limitation of utilizing river water as a stable water source. In terms of ensuring water source development, a strategy is required to seek development possibility to construct water storage facilities as well as to effectively utilize groundwater.

(49) Water storage facilities are effective to procure a stable source of agricultural water. These are; i) Dams to store river water by enclosure with a traversing structure, ii) Regulation ponds installed outside river courses to store surplus river water in the rainy season, iii) Reservoirs/ ponds installed inside or adjacent to an irrigation area to store rainwater and run-off water from a watershed, iv) Ponds to collect and store return flow from upper farmland. To find the development possibilities of those storage facilities, it is required to prepare a topography map and conduct detailed topo-geology surveys of the river basin and irrigation areas.

(50) As the survey result in Sarpang Dzongkhag, it is judged that groundwater development is possible in the area surrounding an alluvial fan. (Maochu basin in the northwestern part of Gelephu City is tentatively proposed as an expected site.) It is recommended to construct a test well to grasp knowledge of the existence of an aquifer and the development potential of pumping water.

(51) Long-term study and analysis is required to identify the development possibility of storage facilities and groundwater as mentioned above and realize those ideas. It is inevitable for short-term development to rely on river water to obtain agricultural water.

(52) Under the current situation, it is costly and a labor burden to repair and maintain damaged intake and canal facilities. In order to secure stable intake water, for a short term, it would be recommended to reinforce the present intake structures and/or introduce new intake facilities to reduce regular operation and maintenance works.

(53) Applicable intake methods are ; 1) Natural intake, 2) Intake weir, 3) Water cushion type, 4) Bar-screen, intake beneath the bar, 5) Bar-screen, intake at rear part, 6) Overflow intake weir at angle of drip type, and 7) Underflow collecting gallery. For planning which method is applicable in the local sites, it should be considered to cope with the river and geological conditions such as steep riverbed gradient, large fluctuations of rider discharge and run-off with sand, gravel and stone. It is not easy to introduce a suitable intake method so that it can meet with all of such conditions both technically and economically. Therefore, during the planning stage, it is required to examine the applicability of the recommended method under real conditions. It is proposed to install the prospective intake facility tentatively in the selected site and verify its efficiency and effectiveness.

(54) Unification of the existing intake facilities constructed in the same river is a possible way to provide an effective intake and irrigation system. By extracting possible sites from the list of inventory in Sarpang Dzongkhag, 13 sites are identified as those that have the possibility of intake unification. To identify those sites, further investigation based on topographic maps is required in the next formulation stage of the concrete rehabilitation plan.

(55) As other approaches to providing an effective/ efficient irrigation system, it is required to reduce water loss. These methods are to reinforce delivery canal structures and to improve farmland conditions such as improvement of soil/ soil layers, establishment of on-farm water management and studying the feasibility of land readjustment. Besides such structural measures, it is also important to study non-structural measures to make water use effective. These include

establishing suitable cropping patterns and water saving irrigation under limited water source and meteorological conditions such as temperature and short hours of sunshine.

5.3 PRELIMINARY ANALYSIS ON THE VALIDITY OF REHABILITATING THE EXISTING IRRIGATION SYSTEM

(56) Out of 79 existing irrigation sites, 35 sites have permanent rivers as water sources where dry paddy cropping may be introduced. It is hard to estimate the dry paddy cropping area of each site, since no river discharge is measured in the rivers. In this survey, however, the available water amount was estimated from the discharge measured by the JICA survey team. On the other hand, the irrigation water requirement of dry paddy was calculated. The irrigable area for the dry paddy was calculated from a rough water balance study between the estimated available irrigation water amount and the irrigation water requirement. Total dry paddy irrigable area was estimated at 220 ha, except five sites in Chuzagang Gewog (Taklai project).

(57) Development potential of the 79 sites including double cropping was evaluated. An evaluation method was designed to pick the items for screening, set the criteria to screen them and assess them. The designed items were; 1) canal length, 2) command area, 3) access to traffic worthy road. As the evaluation result, the number of high potential site is counted as 16 sites. These sites may be considered as the priority sites for promoting rehabilitation of the existing irrigation systems. (In the case of new water resources development and unification of intake sites, a new evaluation should be applied.)

(58) Besides the development potential assessment as mentioned above, economic validity was analyzed. Method was the same as used in the Section 4.3. For the cost, reinforcement cost of the intake facility was added to canal construction cost. Benefit is estimated based on the average paddy yield of three dzongkhags, 2.28 ton/ha (2010). Project life was set as 20 years on the structure type of irrigation facility. IRR is calculated for the 74 sites except the five sites in Chuzagang Gewog.

(59) Calculation of IRR fluctuated largely on the amount of cost and/or benefit. In this calculation, especially, the cost is estimated under uncertain conditions. Accordingly, the calculated IRR should not be directly applied to judge the economic validity of each site. Judging from the calculated IRR value, the number of sites whose economic validity may be judged high, is counted as 25. By overlapping those sites with the 16 higher development potential sites as mentioned in Section (57), thirteen sites are picked. Those sites may be considered as the priority sites for a rehabilitation project of the existing irrigation system with higher development validity.

(60) The IRR calculation in this survey is based on an existing irrigation site basis. Target of paddy yield is expected to be generated from only the rehabilitation of the existing facilities. Therefore, for future rehabilitation project planning, detailed economic analysis should be conducted based on the development plans including unification of the intake sites, introduction of new intake methods and water resources development, and setting prospective yield targets through dissemination of paddy cropping technology.

(61) Damaged intake and canal structures are repaired by beneficiary farmers group/ water users associations. Considering this current situation, it is easy for them to participate in the project implementation process by their labor contribution.

(62) Judging from the on going water charge collection system and existence of water users groups, it is considered feasible to establish sustainable operation and maintenance systems including water charge collection systems by organizing beneficiary farmers.

(63) According to the location map of the irrigation sites, some irrigation farmlands overlap with the National Protected Areas in Sarpang and Sumdrop Jongkhar Dzongkhags. According to regulations, small-scale rehabilitation activities may be allowed in the overlapping areas. However, large-scale development projects such as new water resources development and land development cannot be undertaken in protected areas. It should be confirmed that no negative impacts might be caused by development activities. From the viewpoint of social considerations, it is emphasized that provision of agricultural infrastructure is crucial for maintaining social security and a stable life for settlers.

CHAPTER 6 STRATEGIC PLAN FORMULATION FOR REALIZING AGRICULTURE WATER SUPPLY AND MANAGEMENT

6.1 PROBLEM ANALYSIS AND POSSIBLE MEASURES FOR ENSURING AGRICULTURE WATER SUPPLY AND MANAGEMENT

(64) As a basic approach for providing a strategic plan for realizing agriculture water supply and management, related subjects such as problems and basic approachs to solutions and possible measures for solutions are analyzed.

(65) In the project formulation, it is important to deal with the risks, which are expected to occur during the implementation of the project. Major expected risks include: 1) Natural/ Engineering risks, such as drastic fluctuation of river beds and large scale collapse of slopes, 2) Social risks, such as abandonment of farming in non-targeted project sites, crop damage by intrusion of wild animals, abandonment of irrigation agriculture due to a failure of the operation/ maintenance works of the irrigation facilities, and collapse of water charge collections due to a failure in paddy production, 3) Economic risks, such as the heavy burden of project cost and existence of irrigation sites whose economic feasibility is low, and 4) Risks on social and environmental consideration, such as expansion of the economic gap between project sites and non-project sites and the impact of a new water resources development plan. Possible counter measures to deal with these risks were considered in the process of the plan formulation.

6.2 APPROACHES TO STRATEGIC AGRICULTURAL WATER SUPPLY AND MANAGEMENT PLAN FORMULATION

(66) Possible measures are grouped into the three kinds of projects for ensuring agricultural water supply and management. Grouped projects are categorized as: 1) study; "Agriculture Development Study in Southern Bhutan" to draw agriculture development vision, 2) activity; "Irrigation Agriculture Pilot Project in Southern Bhutan" to establish a development model in the

irrigated agricultural fields, 3) human resources development, "Capacity Development for Irrigation Engineers" to improve irrigation engineering capacity of DoA. These projects should be tackled strategically in line with national policy and current local conditions.

(67) The southern zone has high crop production potential for rice and other crops. Agricultural development projects in the southern zone should be formulated in line with national policy; Food security, Improvement of crop productivity and Shifting from subsistence farming style to market oriented farming one. Grouped projects for ensuring agricultural water supply and management should be consistent with the agriculture development vision and development direction led from the national policy.

(68) Large scale development ideas such as storage dam construction and groundwater development may be shown to ensure access to water sources. However, to realize such ideas, long-term study and analysis is required. Many subjects in engineering, social and administrative fields shall be dealt with in the development process. Considering these, short term realistic development targets to ensure agricultural water supply may be put on the improvement project of the existing irrigation system. Validity and priority of such projects should be evaluated in the formulating process of overall development direction.

(69) Current natural intake methods should be reinforced and/or new intake methods should be introduced to ensure agricultural water. However, to provide intake methods in Southern Zone, it is required to deal with the physical constraints characterized by the collapse of slopes and debris flows with stone and gravel. Some typical ideas of the intake methods are shown in this survey. Such ideas should be further studied whether applicable or not under the physical constraints. In the study process, it is proposed to introduce prospective ideas for intake methods tentatively into the “Pilot Project” to examine and verify their effects and efficiency.

(70) Rehabilitation of the existing irrigation facilities may be prioritized in order to increase paddy production. However, crop production increase cannot be realized by only the rehabilitation. It is necessary to improve cropping technology suited to the local soil and water conditions. Accessibility to water is relies on river conditions. For poor water access sites, it may be suitable to shift from paddy to other less water consumptive use crops. For these sites, selection of the crops and dissemination of their cropping technology are the important issues. To approach this situation, it is required to conduct an overall development study in which selection of suitable crops based on local conditions of land, soil and meteorology such as the short-term sunshine period would be studied and analyzed.

(71) To practice and disseminate cropping technology, it is required to construct a pilot farm so that it can be utilized as a trial farm to demonstrate, practice and display cropping technology of candidate paddy/ vegetables/ other cash crops. It is recommended to guide the pilot farm in the “Pilot Project” in cooperation with the regional RNR centers.

(72) Physical and natural conditions in topography, geology, water resources and agro-meteorology of three *dzongkhags* are similar to each other. The development process used for tackling Sarpang

may extended to the other two d*zongkhags.*

(73) It is indispensable for the DoA to develop their organizational capacity to execute the mandated irrigation development. The proposed project "Capacity development of irrigation engineers" should be prioritized to meet capacity development requirements. This project is expected to run in parallel with the "Pilot Project". If running parallel, the project effect can be significantly multiplied.

(74) DoA will be able to obtain the necessary capacity to realize water supply and management after the three projects. DoA is expected to prepare project formulation for the southern zone and implement its project with their own capacity. Considering the government's financial limitations, it may be difficult to procure project funds in full scale from the national budget. For this situation, discussions with related donors may be held to seek financial cooperation.

(75) It is recommended to implement the following projects including three projects in the two development stages.

The first stage

This stage is considered as the preparation stage for developing full-scale project formulation for southern Bhutan. It is required to establish technical cooperation with related donor agencies to conduct this stage.

1) Agriculture Development Study in Southern Bhutan
2) Capacity Development Project for Irrigation Engineers
3) Irrigation Agriculture Pilot Project

Second stage

Based on the lessons learned and experience obtained from the first stage, a full-scale project for irrigation agriculture development is formulated and materialized in each site. Financial cooperation with related donor agencies will be discussed if necessary.

1) Feasibility Study (F/S) for Communal Irrigation Agriculture Development Project
2) Communal Irrigation Agriculture Development Project

The overall time frame of project implementation is planned to be as follows.

Project	Yearly implementation								
	1	2	3	4	5	6	7	8	9
First stage									
Preparation/ administrative arrangements									
1) Agriculture Development Study in Southern Bhutan									
2) Capacity Development for Irrigation Engineers									
3) Irrigation Agriculture Pilot Project									
Second stage									
1) F/S for Communal Irrigation Agriculture Development Project									
2) Communal Irrigation Agriculture Development Project									

6.3 FUTURE CANDIDATE PROJECTS LINKED WITH PROSPECTIVE COOPERATION FIELDS WITH JICA

(76) Based on the project needs for realizing water supply and management and JICA's accumulated experience and technology/ lessons learned from other similar projects, future prospective cooperation fields are identified.

(77) **Improvement of agriculture production in unfavorable hilly agricultural land:** Japan has accumulated advanced knowledge and technology learned from past experience in developing irrigation agriculture in unfavorable hilly and sloped areas where there is difficulty in access to irrigation water. JICA has conducted the technical cooperation projects in many countries aiming to provide small-scale irrigation systems and improve paddy cropping under the unfavorable conditions of land and access to water similar to the southern zone. Related knowledge and technology accumulated through implementation of such projects can be applied to the southern zone. By making full use of them, it is considered to be possible to lead to a paddy production increase in southern Bhutan.

(78) The Southern Zone has technical and economical risks to deal with weak geologic conditions. Although it is hard to solve both risks, an important point is to take any prospective measures to provide for the risks. The Southern Zone has various crop production potential except paddy. Therefore, an important point is to seek any potential crops suited to the local water and soil conditions, in line with the southern agricultural development direction and promote its production. JICA has accumulated related knowledge and experience to draw agriculture development vision under various natural/ social conditions. By making full use of them, it is possible to draw an agricultural development direction and seek profitable crops in southern zone.

(79) **Capacity development for the irrigation engineering sector:** JICA has conducted many technical cooperation projects aiming to improve irrigation systems, and as a result, has accumulated related knowledge and technology. Japan has experienced provision of irrigation facilities under the severe topographic, geologic and river conditions similar to the Bhutanese ones. It is possible to make full use of them for improvement of DoA's engineering capacity, technology and skill.

(80) Related donor country who supports development activities in Bhutan is India, Denmark, Switzerland and Netherlands and international agency is WB, ADB, EU and UNDP. For RNR sector, EU, IFAD and WB are supporting to the RGoB in line with the 10th Five Year Plan (2008-2013). Major supporting activities focus on the fields of increase of crop production and improvement of post-harvest processing and marketing. However, the activities do not include the development fields for ensuring agricultural water supply and irrigation. There is no other support or cooperation with related donor countries and organizations targeting southern three d*zongkhags.*

(81) As seen in the above survey results, the following projects are recommended as candidate projects linked with cooperation fields with JICA:

- Agriculture Development Study in Southern Bhutan
- Capacity Development Project for Irrigation Engineers
- Irrigation Agriculture Pilot Project

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Abbreviations

ADB	Asia Development Bank
AMC	Agricultural Machinery Centre
CMU	Central Machinery Unit
DANIDA	Danish International Development Agency
DAO	District Agriculture Office
DoA	Department of Agriculture, MoAF, RGoB
DoH	Department of Horticulture, MoAF, RGoB
DoE	Department of Energy, MoEA, RGoB
EC	European Commission
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GNH	Gross National Happiness
GNHC	Gross National Happiness Commission
IFAD	International Fund for Agricultural Development
JICA	Japan International Cooperation Agency
MoAF	Ministry of Agriculture and Forests, RGoB
MoEA	Ministry of Economic Affairs, RGoB
NGO	Non Governmental Organization
O&M	Operation and Maintenance
RGoB	Royal Government of Bhutan
RNR	Renewable Natural Resources (Agriculture, Livestock & Forestry)
UNDP	United Nations Development Program
WB	World Bank
WFP	World Food Programme
WHO	World Health Organization
WUA	Water Users' Association
WUG	Water Users' Group

Local Terminologies

Dzongkhag	Administration unit (district)
Drungkhag	Second administration unit (sub-district)
Gewog	Third administration unit (block)
Chiwog	Fourth administration unit (sub-block)

Exchange rate (as of July 2012, JICA designated rate): 80.48YEN/ US$

1.639YEN/BTN (Bhutan Ngultrum: Nu.)

Unit: 1.0 ha = 0.405 Acre (Ac)

CHAPTER 1 INTRODUCTION OF THE STUDY

1.1 BACKGROUND AND OBJECTIVE OF THE SURVEY

1.1.1 Background

Agricultural sector in Bhutan is the key industry which employs 69% of Bhutan's population and occupies 14% of GDP. It has a substantial share of the country's rural poor population, so that poverty reduction is placed as the top priority in the National Development Plan.

Bhutan is totally a mountainous country. Agricultural land occupies only 7 to 8 % of the country's land. Furthermore, each agricultural land holding area and each farm plot of farmers are limited to small size, due to terrace farming in the steep topography. Accordingly, expansion of food production is limited. Rice self-sufficiency level is not met with the country's demand. Under such situation, Royal Government of Bhutan (RGoB) provided the food security policy in which the rice self-sufficiency level is set to improve at 75% up to the year 2023 and 90% of self-sufficiency in vegetables. In compliance with this policy, Ministry of Agriculture and Forests (MoAF) is now tackling to improve the country's rice and vegetable production through improvement of irrigation facilities, promotion of farm mechanization and introduction of paddy double cropping.

MoAF recognizes that it is necessary for increase of rice production to improve land productivity and make farming system more effective. Furthermore, as a development potential area of rice production, MoAF expects to be the southern zone of three Dzongkhags of Sarpang, Samdrup Jongkhar and Samtse, which has relatively extended flat plains with more favorable climatic conditions for cereal production than the other regions. However, the southern zone is behind in agricultural development, mainly, due to irrigation constraints. Although the three Dzongkhags have a total agricultural land of 921 km^2 (occupied about 30% of the country's total agriculture land), their agricultural land use is considered to be less productive than in the other Dzongkhags. According to the FAO's Reconnaissance Mission Report prepared in 2010, it is estimated more than the half of them are not under cultivation, and even if cultivated, it is considered to be under a single rainfed cropping land. Although high development potential with more blessed topographic and climatic conditions which may allow for double cropping of rice, present average paddy yield is limited to about 2.0 ton/ha, lower than the average 3.5 ton/ha of western zone such as Paro, Punakha and Wangdue.

Under such situation, MoAF identified three problems for improvement of agricultural production in the southern zone: i) insufficient farming technology, ii) inadequate crop and variety, and iii) insufficient irrigation system caused by lack of intake and irrigation facilities. Related to these problems, MoAF is promoting a nation wide paradigm which aims to shift agricultural norm from conventional self-sufficient one to market oriented commercialized one. In order to realize this situation, it is also required to solve those problems. Under such considerations, MoAF is now tackling to deal with the two problems of the i) and ii) for improvement of farming technology and crops/ variety. However, for the iii), it is required to deal with specified engineering field such as analyzing hydrology data/ information for planning irrigation system. However, capacity of MoAF and relevant government organizations is not enough to conduct this kind of analysis. MoAF has need of any

support from external aid agencies to cope with this problem. (FAO conducted reconnaissance survey on the irrigation system in the southern zone in 2009. Present conditions of the 26 irrigation system were investigated.)

1.1.2 Objective of the Survey

Objective of this Survey is to collect and analyze data/ information and prepare appropriate recommendations for providing strategic agricultural water supply and management plan in southern Bhutan. Overall goal of this Survey is to contribute to the government's food security policy aiming to improve rice and vegetable self-sufficiency level through improvement of irrigational agriculture. Based on the recommendation, it is expected to promote an irrigational agriculture development in southern Bhutan.

1.1.3 Scope of the Work

- To collect data/ information in the fields of agriculture and irrigation water supply and management in the central and the southern zone levels from existing books/ reports/ documents,
- To conduct a field survey in Sarpang Dzongkhag,
- To analyze collected data/ information for making agricultural water supply and management effective for developing irrigational agriculture,
- To prepare recommendation for ensuring agricultural water supply and management including zoning of irrigation development potential area and preparing candidate project long-list for improvement of irrigation system,
- To identify future possible projects/ plans/ studies linked with cooperation fields with JICA.

1.1.4 Survey Area

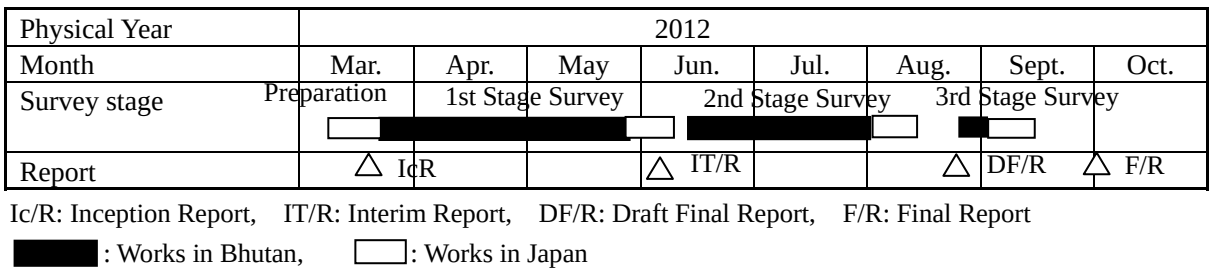
Survey area covers the three Dzongkhags: Samtse, Sarpang and Samdrup Jongkhar. Data collection survey is conducted in the three Dzongkhags by entrusting to the local consultants hired by JICA survey team. However, field survey to lead further analysis is conducted only in the Sarpang which is expected to play as a model of irrigation agriculture development in the southern zone considering geographical condition and future marketability of agricultural products.

1.1.5 Counterpart Agency

Counterpart agency in Bhutan is expected to be the Department of Agriculture, Ministry of Agriculture and Forests (MoAF).

1.2 WORKING SCHEDULE

Working was scheduled as follows.



Ic/R: Inception Report, IT/R: Interim Report, DF/R: Draft Final Report, F/R: Final Report

■: Works in Bhutan, □: Works in Japan

Figure 1.2.1 Whole Working Schedule

CHAPTER 2 ADMINISTRATIVE FRAMEWORK AND ORGANIZATIONS RELATED TO THE SURVEY

2.1 ADMINISTRATIVE FRAMEWORK

2.1.1 National Development Plan

(1) The Tenth Five Year Plan

"Bhutan 2020: A Vision for Peace, Prosperity and Happiness" drawn extensively on the philosophy and concepts that have been articulated by His Majesty King Jigme Singye Wangchuck is prepared as a principle of the country's development direction by the Planning Commission in 1999. Under its principles, National Development Plan is prepared by the GNHC. On-going National Development is the 10th Five Year Plan (July 2008-June 2013). RNR sector's plan in the on-going the 10th Five Year Plan is prescribed as follows.

The RNR sector plays a vital role in the growth, balance and stability of the country's economy as reflected in its share of GDP and employment activity. The policy objectives of the RNR sector are to:

- *Enhance sustainable rural livelihoods through improved agricultural and livestock productivity and expansion of commercial prospects of agriculture and other natural resource endowments;*
- *Conserve and promote sustainable commercial utilization of forest and water resources;*
- *Promote sustainable utilization of arable agriculture and pasture land resources;*
- *Enhance Food Security through sustainable and enhanced food production and availability, improved access to food and enabling effective distribution, marketing and import of food; and*
- *Transform subsistence agriculture to small scale commercial agriculture without compromising food security.*

The major targets and milestones have been linked and aligned to the various themes ultimately contributing to the realization of GNH. The major targets and its linkages to GNH pillars for the RNR sector are reflected in the box as follows.

GNH Pillar 1: Equitable & Sustainable Socio-Economic Development
Theme 1.1: Food Security
- *Self sufficiency in rice increased from 50% to 65%, from the present level of 54,325 MT per year to 62,474 MT per year* - *Cereal production including paddy increased from 140,000 to 150,000 MT per year* - *Portion of wetland with dry season irrigation increased from 40% to 70%* - *Prime agriculture land identified and maintained purely for agriculture production* - *Loss of crop damage by wildlife reduced from 40% to 20%* - *At least 30-40% of farmers practice sustainable land management* - *. . .*
Theme 1.2: Income generation
Theme 1.3: Employment Generation
GNH Pillar 2: Environmental Conservation
GNH Pillar 3: Preservation and Promotion of Culture
GNH Pillar 4: Good Governance

Four GNH Pillars are provided as the RNR Targets. Out of them, Theme 1.1 "Food Security" of the GNH Pillar 1 is directly relevant to this data collection survey. RNR sector is executing the related development policies in line with this Theme.

Related to the Theme 1.1, "Self-sufficiency through commercialization" is the top development theme in the country. No data/ information indicated the development progress of this theme was published yet. But, an informal comment on the rice self- sufficiency was published by MoAF in the form of newspaper (it was extracted from the newspaper KUENSEL dated on Wednesday April 18, 2012).

Last year, Bhutan spent almost Rs 4,000 Million on agricultural imports, which comprise meat items, dairy products, coffee, tea, rice, edible oil and sugar.
Bhutan imported rice (cereals) worth Nu 1,166.4 Million last year (2011), the highest imported food items (30% of the total account of imported food items). Agricultural officials said, "We'll never be able to produce all the rice we require, because we have limited wetland, But, we can at least increase by another 20-30 percent by increasing irrigation".
Rice production in the country was also severely affected when the government removed the irrigation engineers in the '90s. That decision resulted in irrigation schemes going defunct.
Farm mechanization is another way to boost rice production. In places where tractors cannot reach, power tillers or other processing equipment would be placed to increase mechanization.
Land fragmentation has posed another challenge, which is why the ministry has started forming farmers' groups and cooperatives to commercialize production.
But going for 100 percent rice sufficiency would also not be "economically in Bhutan's favors", officials said. Arable land is about five to six percent of the country's landmass, much lower than what was initially recorded. Of this, rice is grown on 58,000 acres (23,500 ha).
Given the choice, people would like to convert all their rice fields into other forms of land and orchards, because rice has the least returns, compared to other crops.
In the 11th Plan, the ministry is targeting to achieve 65-70 percent rice self sufficiency, from about 50 percent today.

MoAF provided the 29 development programs to materialize the RNR sector's plan. Out of them, the 17 programs are provided by DoA as the agricultural development parts.

MoA/01:	*Commodity/ Cereal Development Programme*
MoA/02:	*Post Harvest Management Programme*
MoA/03:	*Integrated Pest Management Programme*
MoA/04:	*Irrigation and Water Management Programme*
MoA/05:	*Seed and Plant Development Programme*
MoA/06:	*Horticulture/Cash crop Development Programme*
MoA/07:	*Organic/National Agriculture*
MoA/08:	*National Medicinal and Aromatic Plants Programme*
MoA/09:	*Integrated Soil Fertility & Sustainable Land Management Programme*
MoA/10:	*Rural Access Programme*
MoA/11:	*Farm Mechanization Programme*
MoA/12:	*Extension Coordination and Information Management Programme*
MoA/13:	*Feed & Fodder Development Programme*
MoA/14:	*Livestock Health & Laboratory Services Programme*
MoA/15:	*Livestock Breeding and Input Supply Programme*
MoA/16:	*Livestock Production Programme*

MoA/17:	*Targeted Highland Livelihood Support Programme*

Out of the 17 programs, the MoA/01, MoA/04 and MoA/06 are closely related to this data collection survey. Major description of the MoA/01 and MoA/06 is extracted as follows.

MoA/01:	***Commodity/ Cereal Development Programme***
Overview	*Expected Results/Targets:* *Production of rural households in poverty reduced from 30.9% to 20% through enhanced food security, increased rural income and employment generation while ensuring effective environmental conservation. Increase national rice self sufficiency level to 65% and national food self-sufficiency to 70% and raise mean annual rural household cash income from Nu. 10,700 to above Nu. 35,000.*
Results Framework	*Output:* *Improved crop management (Rice production increased from 54,325 MT per year to 62,474 MT per year)*
MoA/04:	*Irrigation and Water Management Programme*
Overview	*Expected results:* *Portion of wetland with dry season irrigation increased from 40% to 70%.*
Strategy	*Strategy will include the exploring of water sources and adoption of appropriate technologies to improve access to water and efficiency in the use of water resources. More resources will be invested in areas where there is potential for increased production of paddy through wetland expansion and improved irrigation water supply. The potential fro groundwater development in the southern belt will also be explored.*
Results Framework	*Output:* - *Takali Irrigation channels renovated* - *Alternative water sources/ technologies explored* - *Studies/policy review conducted & database developed* - *Water User Associations formed and their capacity strengthened* - *Extension agents/ trained on NIP modules* *Projects/Activities* - *Renovation of Irrigation Channels in emergency* - *Renovation of Takali Irrigation Channel(*1)* - *Water Harvesting & Irrigation of Cash Crop(*2)* - *Drip & Sprinkler Irrigation trials* - *Feasibility Study of large scale irrigation and groundwater* - *Policy Review & Database Development* - *Establishing and strengthening of Water User Associations*

Note: noted by JICA survey team.

1): Takali irrigation system renovation project is on-going, funded by JICA.

2): Rooftop rain water harvesting was initiated in Chuzergang Geog of Sarpang Dzongkhag to facilitate irrigation of cash crop with financial support (Nu.1.6 million) form Government of India. The Program consisted of five reinforced concrete tanks that will store rainwater collected from rooftop for irrigating vegetable crops in winter. The construction was completed in 2012.

This data collection survey is conducting in line with the political framework as mentioned above.

(2) Review of the Tenth Five Year Plan

The mid-term review of the 10th Five year plan was conducted. Related with the Theme 1.1 Food Security, it was reviewed as follows.

The Target for Food Security	*Comments in Mid-Term Review*
1. Self-sufficiency in rice increased from 50% to 65%, from the present level of 54,325 Mt per year to 62,474 Mt per year *2. Cereal production including paddy increased from 140,000 to 150,000 Mt per year* *3. Portion of wetland with dry season irrigation increased from 40% to 70%* *4. Prime agriculture land identified and maintained purely for agriculture production* *5. Loss of/from crop damage by wildlife reduced from 40% to 20%* *6. At least 30-40% of farmers practice sustainable land management*	*7. Achieved 50% rice self-sufficiency; will achieve 55% rice self-sufficiency by end of the 10th plan.* *5. Implemented the Human-Wildlife Conflict Management Strategy.*

The review remarked that the self-sufficiency rate would be reach up to 55% by 2013.

(3) The Eleventh Five Year Plan (2013-2018)

The eleventh five year plan is in process of drafting. For the drafting, GNH commission prepared a guideline that sets the overall goal as “Self-Reliance and Inclusive Green Socio-Economic Development”.

The key objectives of the RNR sector under the guideline are to i) Enhance food and nutrition security, ii) Improve Rural Livelihood iii) Accelerate and sustain RNR sector growth and iv) Promote sustainable management and utilization of natural resources. A production volume of cereal shall be planned to increase to 195,000 Mt/year by 35 % from the present volume of 143,638 Mt/year.

As for the development for RNR sector, DoA is preparing the following three development programs as the draft for 11th Five Year Plan (FYP).

(1) Agriculture Infrastructure Development Program
（Farm roads, Irrigation facilities, etc.）
(2) National Field Crop Commodity Development Program
（Rice, Maize, Other cereals, Oil seeds and Legumes）
(3) National Horticulture Commodity Development Program
（Vegetables, Citrus, Potato, Fruits and Nuts, etc.）

Detail of development program is under preparing. Among the three programs, for the program (1) "Agriculture Infrastructure Development Program" relevant to this data collection survey, the program profile is provided by DoA, as follows.

A. Program Summary
.....

4. Plan Target (Baseline) Targets

Outcome	*Outcome Indicators*	*Unit*	*Baseline*	*11th Plan Target*
Improved Agriculture Infrastructure	*Increased paddy field area under assured irrigation*	*Ha*	*28000 ha**	*32000* ***(1150)***
	Install new irrigation systems for horticulture (cash) crops	*Ha*	*0*	*200*
	Reduced percentage of households living more than one hour walking distance from a road head	*HH %*	*42.70%*	*30%*
	Increased proportion of existing farm roads under pliable condition	*%*	*NA*	*100%*
	Increased terraced area for horticulture and field crops production	*Ha*	*NA*	*500*

** The Baseline of 28000 ha includes all wetland that has some irrigation canals feeding the area whether it is functional or not. Practically, only about 50% to 60% of these areas will have assured irrigation.*

5. Total Cost (Nu. In Millions)

Outputs	*Current*	*Capital*	*Total*
Increased paddy field area under assured irrigation	*10.40*	*590.00*	*600.40*
Install new irrigation systems for horticulture (cash) crops			
Reduced percentage of households living more than one hour walking distance from a road head	*50.20*	*300.00*	*350.20*
Increased proportion of existing farm roads under pliable condition			
Increased terraced area for horticulture and field crops production	*250.00*	*5.50*	*255.50*
Grand Total	***310.60***	***895.50***	***1206.10***

B. Program Justification

‥A huge investment for irrigation is the basic requirement of crop production, and also to a lesser extent for livestock development.‥Importance and priority will also be given to the development of irrigation facilities for cash crops like orange, vegetables, apple, etc.

The importance of farm roads requires no emphasis. Dzongkhags may continue to build new farm roads as per their needs and available resources, but the Department would focus more on improvement, maintenance and long-term sustainability of the existing farm roads.

C. Implementation Strategy:

‥ Even in the traditional method of construction of irrigation canals, due importance will be given to incorporate better technologies, proper feasibility studies, survey and design. One mitigation measure to ensure water availability during the critical stages is to pilot and demonstrate the feasibility of small reservoirs, wherever appropriate.‥ The strategy to contribute towards improving the income of the rural communities is through improvement of irrigation facilities of horticulture (cash) crops. To explore new water sources, the feasibility of ground water sources will be explored in the appropriate places.

For farm roads, the department would focus more on consolidating the existing roads all over the country. Most of the earlier roads were built at very low costs and almost with no minimum required structures. It is now timely to improve them to bring to the minimum required standard and ensure that they are all all-weather roads, rather than seasonal roads. In the meanwhile the Dzongkhags and Geogs will continue to build new farm roads wherever needed and with their available resources.

The development and improvement of steep and erosion-prone agriculture land into terraced fields is one strategy.

Another strategy To ensure the long-term sustainability of both farm roads and irrigation is to establish, strengthen and revamp the Water User Associations and the Road User Groups.

The Geogs and Dzongkhags will continue to play the main part in the implementation of the program. However, it is envisaged that the RDCs and the Engineering Division will also play greater role in the 11th Plan. Major activities, especially irrigation, will be spearheaded from these centers. The Central Machinery Unit will support the program through the use of their well maintained fleets of earth moving and other types of machines.
The engineers in the Dzongkhags will be continuously trained and backstopped by the engineers from the center. There will have to be a well organized and competent group of engineers for this program to be successful.

D. Risk Assessment:
- The main risk is whether we will be able to get enough engineers especially at the RDCs.
- The other risk is fund.
- Another risk is how successfully we can work with the Dzongkhags and Geogs. The main sector responsible for implementation is the Dzongkhag Engineering Sector. The DES is organizationally under the Dzongkhag administration and the MoWHS, and we have no direct control over them.
Risk Mitigation and Adaptation
- The proposal for additional manpower at the RDCs will be put up to the Ministry and beyond if required.
- It is expected that there will be adequate budget under the projects. If there is funding gap, it is expected to be covered from the RGOB
- Adequate consultations will be carried out with the Dzongkhag administration in order to have clear plans, targets, and implementation strategies.

Data source: Program Profile for 11th FYP Agriculture Infrastructure prepared by DoA

Drafting 11th plan emphasizes the importance and prioritization of irrigation infrastructure for developing the RNR sector. Considering the program profile, this data collection survey is consistent with development framework in the next coming 11th development plan.

(4) RNR Sector Budget for the FY 2011-12

According to the sector budget for the financial year 2011-12, the sector-wise allocation is shown in the Table 2.1.1. Total budget for the RNR sector is Nu. 5,362.130 m. and is 13 % of the total outlay.

Table 2.1.1 Sector Budget for the FY 2011-12

Unit: Nu. In millions

Sectors	Current	Capital	Total	Percent
Social Services	5,598.367	4,318.388	9,916.755	24
Economic and Public Services	3,374.163	12,246.908	15,621.071	37
RNR(Agriculture)	*1,813.824*	*3,548.306*	*5,362.130*	*13*
Culture Services	576.653	820.037	1,396.690	3
Law and Order Services	2,494.631	1,092.813	3,587.444	9
General Public Services	3,255.841	2,356.711	5,582.552	13
National Debt Services	1,915.654	4,154.574	6,070.228	14
Total	17,185.309	24,989.431	24,174.740	100

Source; National Budget for the Financial Year 2011-12

Breakdown of the RNR sector budget is Farm roads: Nu.2,018 millions, RNR centres: Nu.180 m, Promotion of co-operatives and farmers: Nu.47 m, Construction of irrigation channels: Nu 50 m, Renovation and maintenance: Nu. 50 m and Farm mechanization: Nu.21 m, etc. The largest allocation is put on the farm roads, 38% of the total. Irrigation sector is only 2%.

2.1.2 Bhutan Water Vision 2025 and Bhutan Water Policy 2003

Bhutan Water Vision 2025

"Bhutan Water Vision 2025" stated that water is the key element for Bhutanese livelihood. Major statement related to this survey is extracted as follows.

> ***Vision:*** *Water is the most important natural, economic and life-sustaining resource and we must ensure that it is available in abundance to meet the increasing demands. Present and future generations will have assured access to adequate, safe and affordable water to maintain and enhance the quality of their lives and the integrity of natural resources.*
> ***Strategies:*** *To achieve the Vision water must be used and managed sustainably, efficiently and equitably while preserving the environmental, social, cultural and economic value and uses of water*
> *To this end, all water users, planners and decision-makers shall be adequately informed, educated and encouraged to value and protect water in all its form and uses.*
> ***Goals and Targets:*** *・・・ Agriculture: Increased agricultural productivity and production through improved water use efficiency*

Bhutan Water Policy 2003

"Bhutan Water Policy 2003" stated the Need for Water Policy and the Policy Statement, to achieve the Water Vision for Bhutan. The Policy principles are thematically grouped into: i) Water user's interests and priorities; ii) Principles for water resource development and management; iii) Institutional development for water resources management; and iv) International waters. Related to this survey, the Policy emphasizes the principle on conservation of water resources, integrated resources management and water allocation to the agricultural sector. Some related statements are extracted as follows.

> ・・・
> ***5. Water Users Interests and Priorities***
> *5.3 Water for food production*
> *5.3.2 Agriculture consumes the highest percentage of water. ・・・. In order to address seasonal and local water shortage, other sources of water like groundwater and rainwater harvesting shall be promoted wherever feasible.*
> ***6. Principles of Water Resources Development and Management***
> ・・・
> ***7. Institutional Development for Water Resources Management***
> *7.4 Human Resources Development*
> *7.4.1 For efficient management and development of water resources, sufficient human resources, their skills and knowledge are important prerequisites. ・・・*
> *7.5 Applied Research in Water Resources Development and Management*
> *7.5.2 The following areas need special attention: i) ・iv) Ground water hydrology and recharge, v) Water harvesting, vi) Crop water requirements and cropping systems,*

2.1.3 Water Act of Bhutan 2011

This Water Act was stipulated in 2011 to apply all issues related to the water resources of this country. The Act consists of 17 chapters. Main statement related to the agricultural water or irrigation is abstracted as follows.

. . .

Chapter 2 Principles

Purpose

4. The purpose of this Act shall be:

a) To ensure that the water resources are protected, conserved and/or managed in an economically efficient, socially equitable and environmentally sustainable manner; and

b) To establish suitable institutions.

Community Based Water Resources Management

7. Communities shall participate in the integrated management of water resources pursuant to this Act, and beneficiaries shall be consulted in the manner set out in this Act.

. . .

Chapter 3 Functions and Powers of Authorities

National Environment Commission

12. The National Environment Commission shall be an independent authority established by an Act of Parliament and shall exercise the powers and discharge the functions conferred under this Act.

Powers and functions of the Competent Authorities

15. Specific responsibility for implementation including submission of the periodical report to the Secretariat shall vest the following agencies ・・・:

. . .

d) The Ministry of Agriculture, for land-use and irrigation, watershed management, water resources in forests, wetlands and protection of catchment areas;

. . .

Chapter 7 Water Abstraction and Use

Approval for feasibility studies

31. A Person intending to abstract water shall seek an approval from the Commission prior to conducting feasibility studies.・・・

Water use priorities

38. a) In dealing with applications under preceding sections, the Commission shall observe the following order of priorities:

i. water for drinking and sanitation; ii. Water for agriculture;・・・vi. Water for other uses.

. . .

Chapter 9 Specific Requirements and Procedures for Various Water Uses

Irrigation water

44. a) Water from an irrigation channel shall be allocated either through mutual understanding or in accordance with existing practices, depending on the size of land holdings and the quantity of water in the channel, and subject to the constitution and bye-lows of the relevant Water Users' Association.

. . .

Wetlands

Harvesting of Water Resources

47. The relevant Competent Authority shall facilitate harvesting of ground water, rain water, fog and other sources to prevent local and seasonal water scarcity.

. . .

Chapter 11 Water Users' Association

Formation of water users' association

Registration of water users' association

Functions of water users' association

Federation of water users' association

As for international water issues, "Bhutan Water Policy 2003" prescribes "*Trans-boundary water issues shall be dealt in accordance with international law and conventions to which Bhutan is a signatory.*". The issue "Flood warning" has been agreed with India. However, other issues related with "Water use" and/or "Water right" has not been discussed among neighboring counties. Survey area is located on the Indian border. If large scale water use scheme so as to change current water flow regime will be planned, cross border water sharing agreement with India may be needed under the National Environment Commission authorized by the Water Act of Bhutan 2011.

2.1.4 National Irrigation Policy (NIP) (Revised 2011)

The revised "National Irrigation Policy (NIP)" is intended to provide policy direction in the irrigation sub-sector to address its current and future issues. Relevant statements to this survey are extracted as follows.

3. Problem Statement

2. Support by the DoA in capacity building for scheme management is inadequate and hence many water users associations are not well organized・・・.

3. Many irrigation structures are poorly designed and constructed mainly due to shortage of engineers for proper planning, designing and adequate supervision. ・・・・. Irrigation schemes are also often washed away during natural calamities ・・・.

4. There is limited technical knowledge, awareness and capacity leading to poor design and construction, and hence unsustainable irrigation schemes.

・・・

7. Objectives

1. To accelerate investment in the irrigation sector for the achievement of national food self-sufficiency and food security goals;

2. To empower beneficiaries through a farmer-centered approach for effective participation at all levels (planning, implementation, operation and maintenance);

3. To pursue new approaches to sustainable irrigation infrastructure development and maintenance;

4. To pursue environmentally sustainable IWRM (Integrated Water Resources Management) approach in irrigation development;

5. To ensure reliable and efficient water use for intensification and diversification of irrigated crop production;

6. To delineate institutional roles and strengthen institutional capacity at all levels for the planning, implementation of irrigation development;

7. To strengthen technical support services and to develop, promote and disseminate new practices, innovation and technologies that are appropriate, manageable and affordable;

8. To strengthen implementation of Monitoring & Evaluation system.

・・・

9. Implementation Arrangements

Stakeholders and their roles and responsibility are stipulated.

10. Way Forward

On approval of the NIP, within 2011, the following tasks will be implemented by the Department of Agriculture led by the Agriculture Division with support from the Engineering Division:

1. Drafting Guidelines to operationalize the NIP

2. Revision of the NIP Procedural Manual

3. Sensitization at all levels on the revised NIP
4. Training of implementing agency staff on NIP and irrigation development
5. Implementation of NIP

Engineering division of the Department of Agriculture (DoA) is assigned as a leading agency for executing this NIP.

Under such policy frameworks, the Engineering Division is making effort to materialize the NIP. But, the Division has faced with the difficulties such as limited organization capacity including shortage of engineers and their technical knowledge and incomplete engineering manuals.

2.2 RELEVANT ADMINISTRATIVE ORGANIZATION

2.2.1 Ministry of Agriculture and Forests (MoAF)

Ministry of Agriculture and Forests (MoAF) is organized by 5 departments plus others. Department of Agriculture (DoA) covers overall agriculture development field (see Figure 2.2.1).

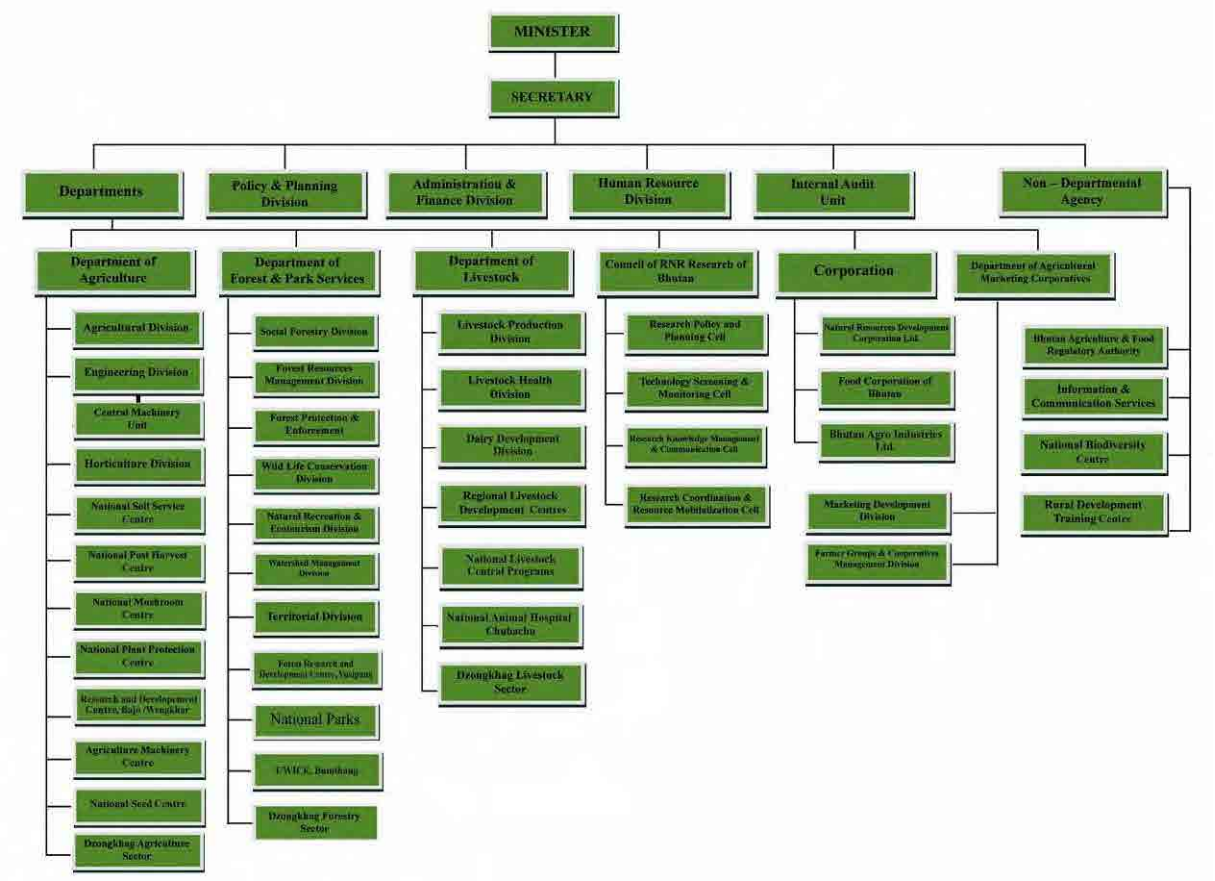


Figure 2.2.1 Organization Structure of Ministry of Agriculture and Forests (MoAF)

The budget of MoAF including the capital from related donor agencies is planned through the mid review, as follows.

Table 2.2.1 MoAF Budget (FY 2010-11)

Unit：Nu.millions

Ministry	Current	Capital	Total
MoAF	1,286.629	964.550	2,251.179

Source: Ministry of Finance, Bhutan National Administration Management

2.2.2 Department of Agriculture (MoA)

Department of Agriculture (DoA) under the MoAF has three divisions. Engineering Division at Thimpu, supported by three Research and Development Center (RDC) are responsible for provision of agricultural infrastructure including irrigation, farm roads and other related infrastructural facilities (see Figure 2.2.2).

(1) Engineering Division

Engineering Division is organized by total 15 staff including one Chief Engineer and three Executive Engineers who are responsible for planning and designing of irrigation system, farm roads and related agricultural facilities that are under by central programs. The Division is faced with the capacity limitation such as lack of qualified staff and necessary equipment and facilities for leading their mandated development fields.

As described in the NIP, to promote nationwide irrigation project, it is required to revise the present Irrigation Engineering Manual so that it can deal with the physical conditions of each region. New engineering technology should be included in the revised manual.

The budget for DoA and engineering division is allocated as shown in Table 2.1.3.

Table 2.2.2 Allocated Budget for DoA and Engineering Division（2011-2012）

(Nu. In Millions)

Name/ Item/ Title	Appropriations					Financing				Total
							External			
	Current	Capital	Lending	Repayment	Total	RGOB	Grant	Loan	Total	
Department of Agriculture	311.694	436.259			747.953	436.435	310.368	1.150	311.518	1,495.906
Agriculture Services	77.145	288.088			365.233	129.043	236.190		236.190	730.466
Central Administration & Direction Services	77.145	288.088			365.233					
Direction Services	63.391	65.282			128.673					
Operation & Management Services (Engineering)	7.239	0.200			7.439					
Construction under SDP (Small Development Project)		124.376			124.376					
Construction of Farm Road		42.626			42.626					
Construction of Irrigation Channels		81.750			81.750					

Souce: Ministry of Finance, Budget Summary by Prpgram Fiscal Year 2011-2012, Revised Estimates

Budget allocated to the engineering division is to apply to the administration and management of the division. Construction under SDP (Small Development Project, funded by India) is incorporated into the budget. Budget for provision of irrigation system planned to be incorporated into the RNR sector budget. But, its amount for irrigation is very limited. Largest share is given to the farm roads sub-sector (referred in 2.1.1, (4)). For promotion of large scale construction/ renovation of irrigation system, its budget would rely on capital from related donors.

(2) Research & Development Center (RDC)

The regional Research & Development Center (RDC) under the DoA is responsible for providing engineering support to Dzongkhag's Engineering Division and central program within their regions. Three RDCs are established in the country. For southern three Dzongkhags, RDC-Bhur is mandated to cover Sarpang, Samtse and Zhemgang, RDC- Wengkhar for Samdrup Jongkhar. Some Dzongkhags are directly covered by the central Engineering Division of the DoA. Each RDC is supposed to be assigned by from three to five engineers. But, the number of actual staff assigned is limited to only the two who are too hard to lead Dzongkhag wise agricultural engineering fields. In addition, RDC has no equipments and facilities to lead suitable planning and designing works.

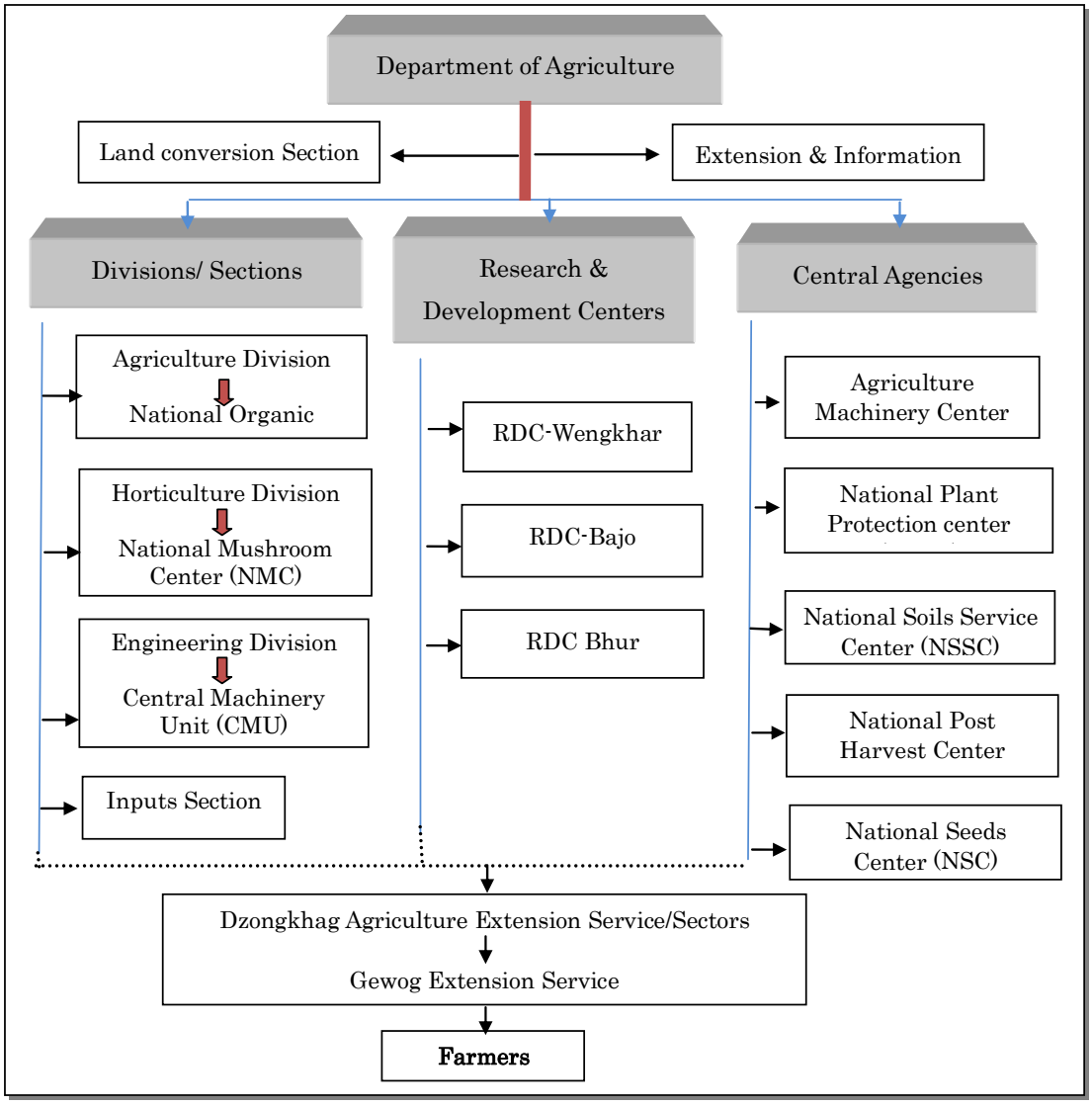


Figure 2.2.2 Organization Structure of Department of Agriculture (DoA)

2.2.3 Dzongkhag Agriculture Office (DAO)

Dzongkhag Administration Office is responsible to perform overall Dzongkhag administrative duty, which is organized by related sectors such as Administration Sector, Finance Sector, Planning Sector and Education Sector. Out of them, Agriculture Sector, Dzongkhag Agriculture Office (DAO) who is

supported by 20 staffs, is responsible for overall agricultural development fields including RNR engineering part. An Engineering Sector is supposed to support the DAO in surveying/ planning/ designing and supervision of irrigation, farm roads and other related agricultural infrastructure facilities.

Department of Engineering Services under the Ministry of Works and Human Settlement is administratively involved in the implementation stage of the engineering fields (see Figure 2.3.1).

2.3 SOUTHERN ZONE IRRIGATION DEVELOPMENT RECONNAISSANCE MISSION REPORT BY FAO

Southern zone irrigation development reconnaissance survey was conduced by FAO based on a request from the RGoB for support from FAO to explore the feasibility of irrigation to increase paddy production (to meet an enhanced share of domestic needs) in the Southern Zone of Bhutan. The Mission report submitted in April 2010. It is summarized as follows.

> *The mission undertook a field trip to Sarpang, Samdrup Jongkhar and Samtse Dzongkhags in November- December 2009. Twenty six irrigation schemes were visited. ・・・*
> *The mission concluded that while there is potential for irrigation development in these districts, there is an overriding requirement for improvement of water and agronomic management practices to realize the productive potential of the existing schemes. ・・・*
> *It was found that irrigation development in Bhutan is very demanding in terms of both capital investment per unit areas and operation and maintenance costs mainly because the construction has to be robust enough to withstand the force of rivers having steep gradients and minimize the impact of landslides in geologically unstable situation. Therefore, the investments required and the returns that can be derived need to be assessed carefully in order to ensure that economically viable investments are made. ・・・*
> *On the other hand, the Southern Zone of Bhutan was found to have the following advantages : the climate is favorable for cultivation of sub-tropical crops, groundwater may be available, there is potential for multiple use of water, soils are will suited to micro irrigation and a number of high value crops, there is potential to improve productivity, markets are available (though need to be targeted) and water user associations are functioning.*
> *The mission recommended that an **integrated wetlands productivity and production program approach** be used for irrigation development in the Southern zone; this would include irrigated as well as rainfed wetlands. This program would target rice and other wetland crops in an integrated farming systems approach.*

(quoted from the Mission Report by the survey team)

Reconnaissance results, analysis and recommendation of the mission report are put on this report.

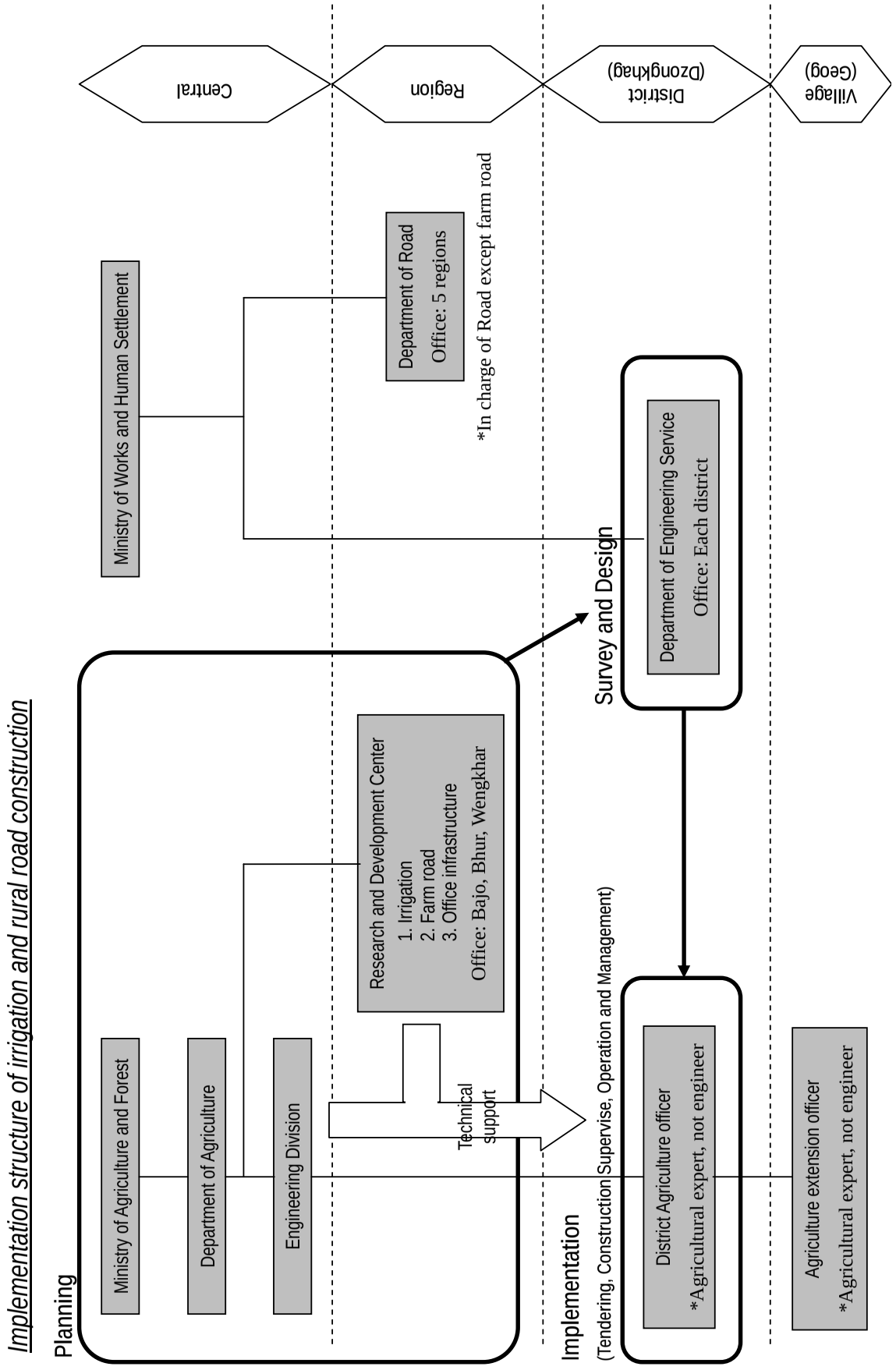


Figure 2.3.1 Implementation Organization Related to the Construction of Irrigation System

CHAPTER 3 SURVEY AREA

3.1 NATURAL CONDITION

3.1.1 Topography and Climate

(1) Topography

Bhutan is a Himalayan landlocked country. The elevation declines from about 7,000 meters in the north to about 150 meters in the south. Based on the topography, the country can be divided into three altitude zones: The Sub-Himalayan Foothills; The Inner Himalayas; The Greater Himalayas. The Sub-Himalayan Foothills is about 50 km wide with altitude ranging from about 150 m to 2,000 m above sea level. Inner Himalayas is about 70 km wide with the altitude ranging from 2,000 m to 4,000 m. The Greater Himalayas lie over 4,000 m measuring about 30 km in width.

Three Dzongkhag in the southern zone is located in the low altitude zone. Altitude at the dzongkhag center is ranged below 1,000 meters. Almost of the land is located below altitude 3,600 meters.

Table 3.1.1 Altitude Zones of the Dzongkhags

Dzongkhag	Altitude at Dzongkhag centre (El.m)	Total area of Dzongkhag		Altitude zones (EL.m)			
				0-3,600		>3,600	
		Percent	Area (km2)	Percent	Area (km2)	Percent	Area (km2)
Bumthang	2,690	6.8	2,611	37.2	971	62.8	1,640
Chukha	2,220	4.5	1,728	96.6	1,669	3.4	59
Dagana	1,520	3.5	1,344	95.4	1,282	4.6	62
Gasa	3,695	11.0	4,223	8.3	351	91.7	3,873
Haa	2,712	4.3	1,651	51.8	855	48.2	796
Lhuentse	1,460	7.2	2,764	58.6	1,620	41.4	1,144
Mongar	1,620	4.9	1,881	98.6	1,855	1.4	26
Punakha	2,280	2.4	921	81.6	752	18.4	170
Paro	1,200	3.2	1,229	56.4	693	43.6	536
Pemagatshel	1,220	1.3	499	100	499	0	0
Samdrup Jongkhar	160	5.8	2,227	99.6	2,218	0.4	9
Samtse	390	3.9	1,497	99.1	1,484	0.9	13
Sarpang	210	5.7	2,188	99.8	2,184	0.2	4
Thimphu	2,320	4.8	1,843	41.1	757	58.9	1,085
Trashigang	1,040	5.7	2,188	81.7	1,788	18.3	400
Trashiyangtse	1,830	3.6	1,382	67.7	936	32.3	446
Trongsa	2,180	4.5	1,728	82.8	1,431	17.2	297
Tsirang	1,620	1.6	614	99.4	611	0.6	4
Wangdue	1,260	10.0	3,839	62.6	2,403	37.4	1,436
Zhemgang	1,916	5.3	2,035	97.3	1,980	2.7	55
Bhutan		100.0	38,394	68.6	26,338	31.4	12,056

Source：Estimated based on the Statistical Yearbook of Bhutan 2010

Based on the altitude zone, the three Dzongkhags are located in the lower elevation zone, below 1,800 meters. Out of the three Dzongkhags, Sarpang relatively lies in the lowest altitude dzongkhag and the area below 1,200 meters is occupied around 60 % of the dzongkhag's total area.

Table 3.1.2 Altitude Zones of the Southern three Dzongkhags

Dzoggkhag	Total area	Altitude zoning (EL.m)													
		0-600		600-1200		1200-1800		1800-2400		2400-3000		3000-3600		>3,600	
	(km2)	%	(km2)	%	(km2)	%	(km2)	%	(km2)	%	(km2)	%	(km2)	%	(km2)
Samdrup Jongkhar	2,227	25.6	570	27.6	615	23.1	514	14.4	321	6.5	145	2.4	53	0.4	9
Samtse	1,497	17.0	255	25.5	382	24.3	364	18.8	282	11.0	165	2.5	37	0.9	13
Sarpang	2,189	31.1	681	29.4	643	21.1	462	14.6	320	2.9	63	0.7	15	0.2	4

Source：Estimated based on the Statistical Yearbook of Bhutan 2010

(2) Land area

Bhutan has a total land area of about 38 thousand km^2. Out of this area, 72 % is covered by forest, 7.7 % by agricultural land, 3.8 % by pasture and 15.6% by others such as perpetual snow, rock outcrop, landslips/ eroded areas (see Table 3.1.3).

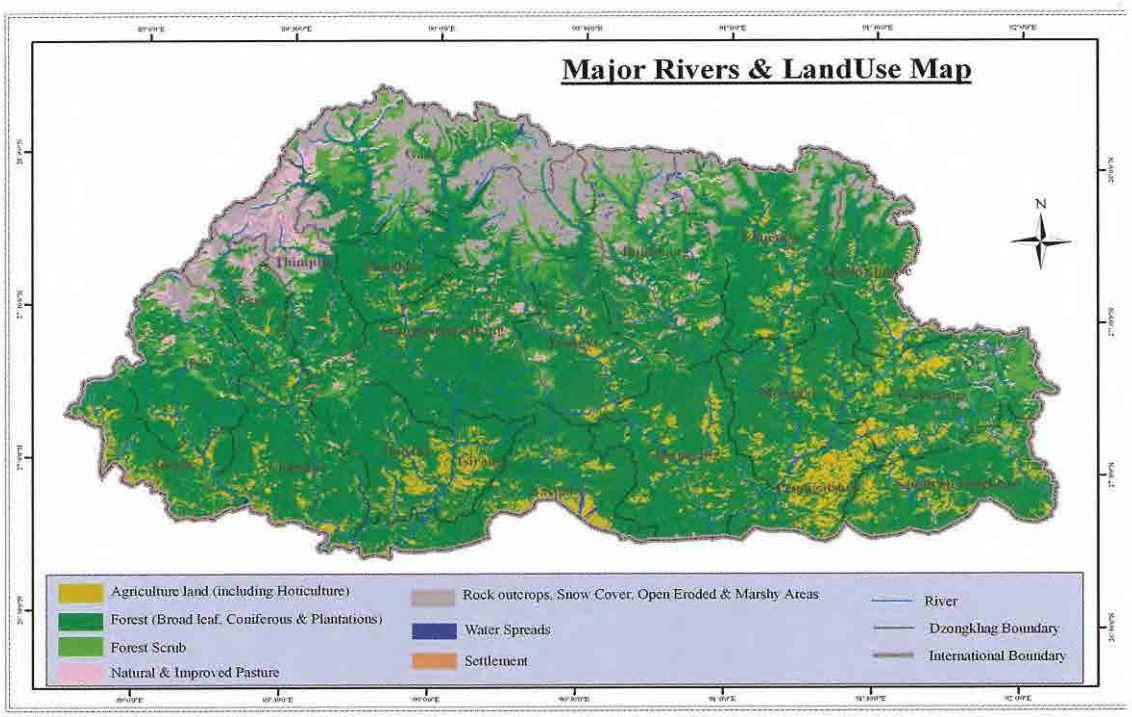


Figure 3.1.1 Land Use and Vegetation Types

Table 3.1.3 Land Use of the Southern Three Dzongkhags

Dzongkhag	Dzongkhag		Forest		Pasture		Agriculture		Horticulture/ Settlement/ Others	
	%	Area (km2)	%	Area (km2)	%	Area (km2)	%	Area (km2)	%	Area (km2)
Bumthang	6.8	2,611	4.5	1,728	0.6	230	0.1	38	1.6	614
Chukha	4.5	1,728	3.9	1,497	0.1	38	0.4	154	0.1	38
Dagana	3.5	1,344	2.8	1,075	0.0	0	0.4	154	0.1	38
Gasa	11.0	4,223	3.6	1,382	0.6	230	0.0	0	6.8	2,611
Haa	4.3	1,651	3.4	1,305	0.3	115	0.1	38	0.5	192
Lhuentse	7.2	2,764	5.4	2,073	0.2	77	0.3	115	1.2	461
Mongar	4.9	1,881	4.3	1,651	0.0	0	0.5	192	0.0	0
Punakha	2.4	921	2.2	845	0.0	0	0.1	38	0.1	38
Paro	3.2	1,229	2.1	806	0.2	77	0.2	77	0.7	269
Pemagatshel	1.3	499	0.7	269	0.0	0	0.6	230	0.0	0
Samdrup Jongkhar	5.8	2,227	4.5	1,728	0.0	0	1.1	422	0.2	77
Samtse	3.9	1,497	3.2	1,229	0.0	0	0.6	230	0.1	38
Sarpang	5.7	2,188	4.8	1,843	0.0	0	0.7	269	0.2	77
Thimphu	4.8	1,843	2.7	1,037	0.8	307	0.1	38	1.2	461
Trashigang	5.7	2,188	4.5	1,728	0.3	115	0.8	307	0.1	38
Trashiyangtse	3.6	1,382	2.7	1,037	0.1	38	0.3	115	0.4	154
Trongsa	4.5	1,728	3.9	1,497	0.2	77	0.3	115	0.1	38
Tsirang	1.6	614	1.2	461	0.0	0	0.3	115	0.0	0
Wangdue	10.0	3,839	7.4	2,841	0.4	154	0.2	77	2.1	806
Zhemgang	5.3	2,035	4.6	1,766	0.0	0	0.6	230	0.1	38
Bhutan	100.0	38,394	72.4	27,797	3.8	1,459	7.7	2,956	15.6	5,989

Source：Estimated based on the Statistical Yearbook of Bhutan 2010

(3) Climate

Although Bhutan is a small country, its altitude ranges from 150 m in the south to the highest peak 7,561 m of the Gangkhar Puesum in the north. Depending on such large variation of its altitude, Bhutan experiences a wide range of climatic conditions from hot and humid subtropical conditions to perpetual ice and snow of the high Himalayas.

Climatically, Bhutan can be divided into six agro-ecological climatic zones: Alpine, Cool Temperate, Warm Temperate, Dry Subtropical, Humid Subtropical and Wet Subtropical as shown in Table 3.1.4. Zones of the three southern Dzongkhags belong to the two of Humid Subtropical and Wet Subtropical zones where are considered to be suitable climate for double cropping.

Table 3.1.4 Agro-ecological Zone of Bhutan

Agro-ecological zone	Altitude（EL.m）	Annual rainfall (mm)	Average temperature (℃)
Alpine	3,600-4,600	<650	5.5
Cool Temperature	2,600-3,600	650-850	9.9
Warm Temperature	1,800-2,600	650-850	12.5
Dry Temperature	1,200-1,800	850-1,200	17.2
Humid Subtropical	600-1,200	1,200-2,500	19.5
Wet Subtropical	150-600	2,500-5,500	23.6

Source: RNR sector Tenth Plan (2008-2013)

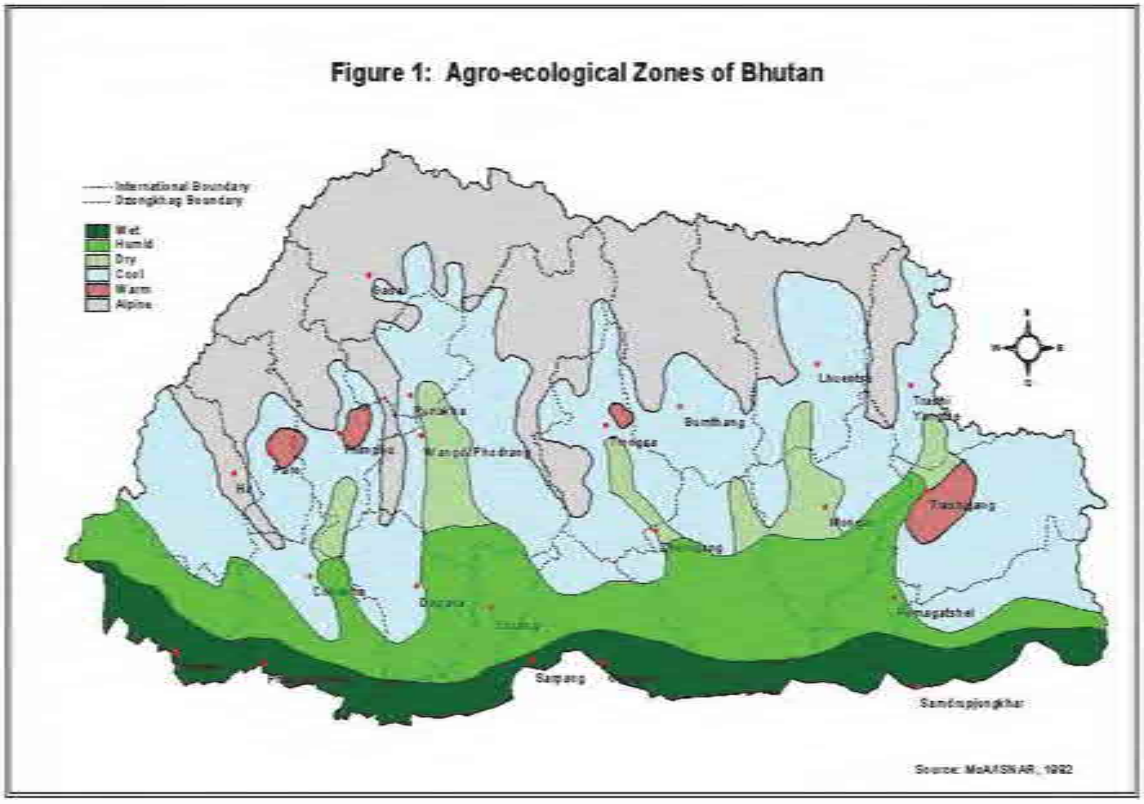


Figure 3.1.2 Agro-ecological Zones

(source: Bhutan Water Vision and Bhutan Water Policy)

3.1.2 Topography, Geology and Groundwater

(1) Altitude and ground gradient

Bhutan is located in large variations of the altitude and ground gradient (see Figures from 3.1.3 to 3.1.10 and Table 3.1.5).

Bhutan has various altitude zones ranging from about 100 m to 7,300 m, but more than 70% land area is occupied by the mountain range higher than 1,800 m. The altitude of Bhutan is the lower to the southern Indian side, whereas the higher to the northern Chinese side. The three Dzongkhags are located in the southern area bordering India. More than 70% of their land is the under 1,800 m in altitude. Land area lower than 600 m in altitude occupies only about 5% of whole country, about the half of it distributes in the southern three Dzongkhags.

On the maps of the ground gradient, the area with gradient less than 10 degrees (1:0.18) is painted in green-based colors (see Figures 3.1.4, 3.1.6, 3.1.8, 3.1.10). Agricultural land suitable for paddy cropping should have a gentle gradient like this. According to these maps, however, such land exists only in limited small areas on the foot hills near the Indian border and in valley along rivers and on hill sides. Among the three dzonkhags, two Dzongkhags of Sarpang and Samtse have such gentle gradient land located in a relatively wider area along the mountain foot near the Indian border. On the other hand, in Samdrup Jongkhar Dzongkhag, such land rarely distributes.

Table 3.1.5 Area of Classified Altitude Zones in Bhutan and the Three Dzongkhags

Altitude (m)	Whole Country		Samtse		Sarpang		Samdrup Jongkhar		Three Dzongkhags		
	Area (km^2)	Ratio (%)	Area (km^2)	Ratio (%)	Area (km^2)	Ratio (%)	Area (km^2)	Ratio (%)	Area (km^2)	Ratio (%)	Ratio to Whole Country (%)
100 - 600	2091	5.4	258	19.8	425	25.7	420	22.4	1103	22.8	52.7
600 - 1200	3926	10.1	366	28.0	418	25.2	433	23.1	1217	25.1	31.0
1200 - 1800	5052	13.0	301	23.0	406	24.5	481	25.6	1187	24.5	23.5
1800 - 2400	5344	13.8	223	17.1	320	19.3	328	17.5	871	18.0	16.3
2400 - 3000	5756	14.9	123	9.4	64	3.9	152	8.1	339	7.0	5.9
3000 - 3600	5282	13.6	26	2.0	17	1.0	55	3.0	98	2.0	1.9
>3600	11305	29.2	9	0.7	6	0.4	7	0.4	22	0.5	0.2
Total	38758	100.0	1305	100.0	1655	100.0	1877	100.0	4837	100.0	12.5

Source: JICA survey team. Calculated with SRTM 90m DEM and the boundary shape files provided by MoAF.

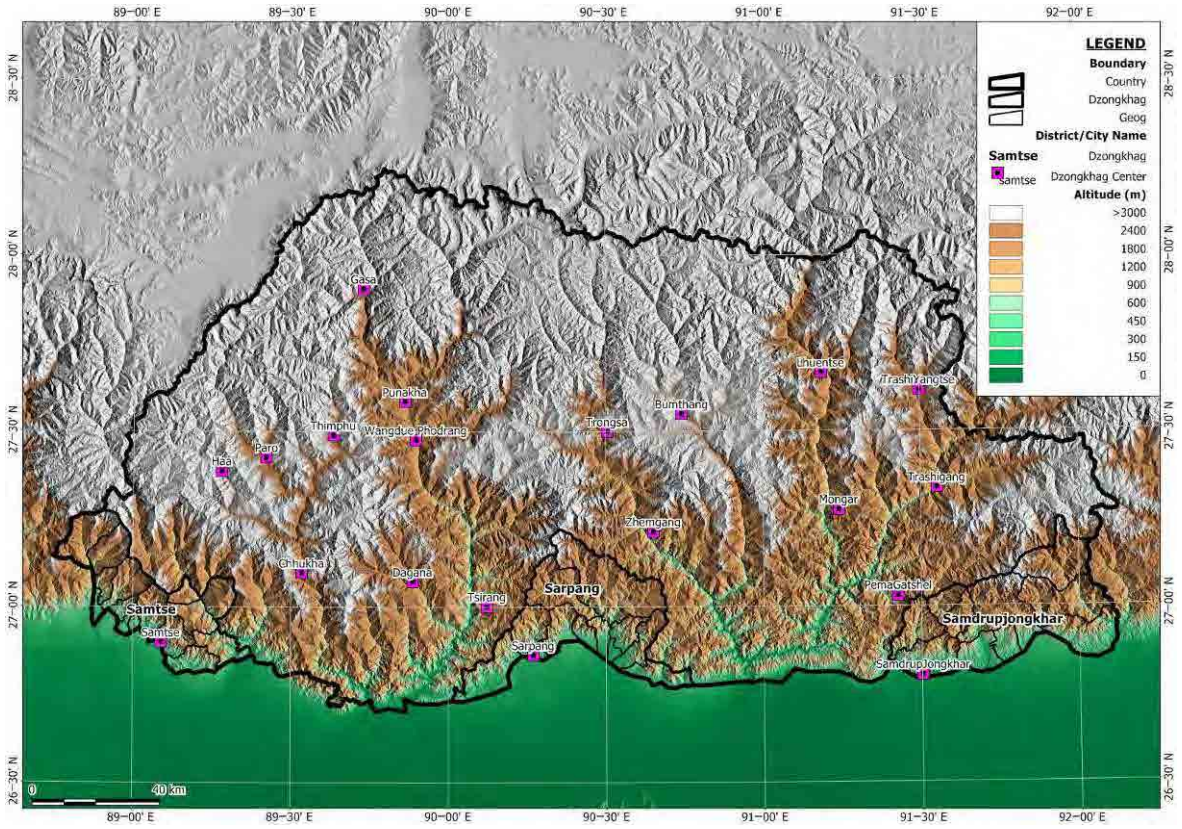


Figure 3.1.3 Altitude Distribution in Whole Bhutan (by SRTM 90m DEM)

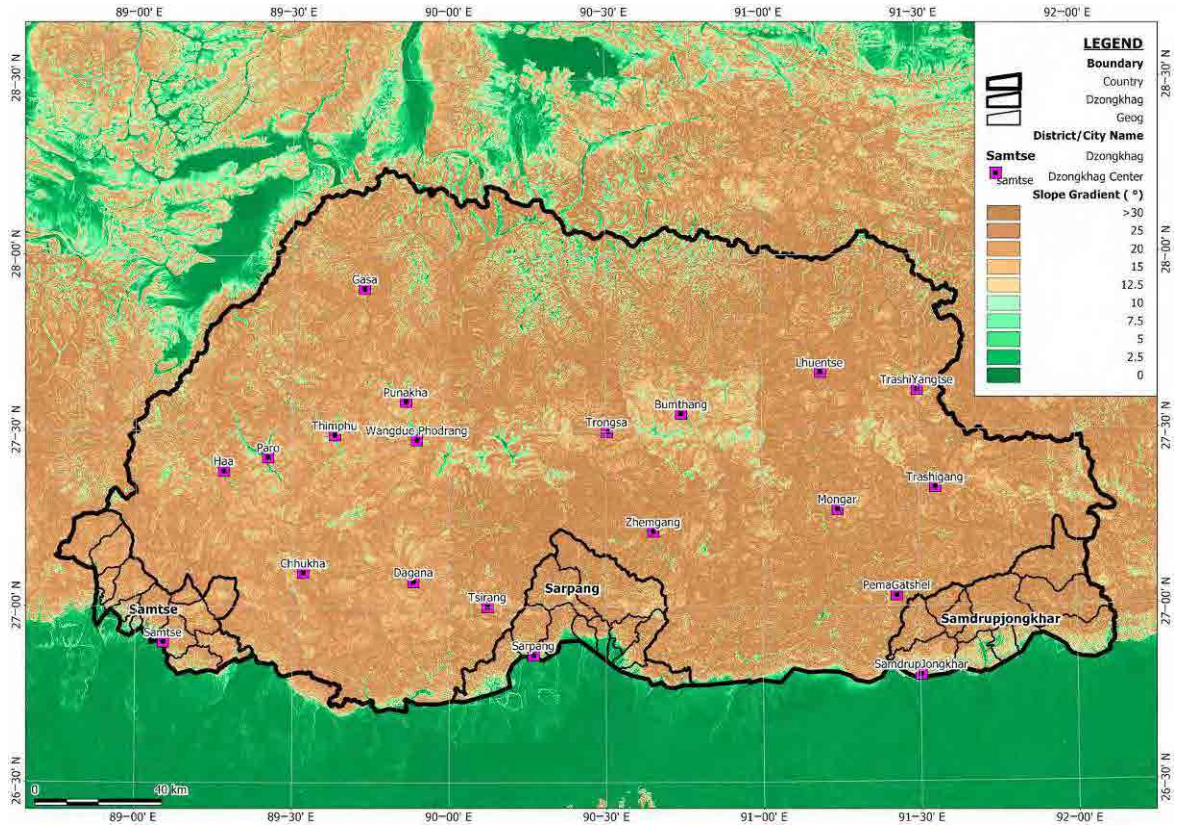


Figure 3.1.4 Ground Gradient Distribution in Whole Bhutan (by SRTM 90m DEM)

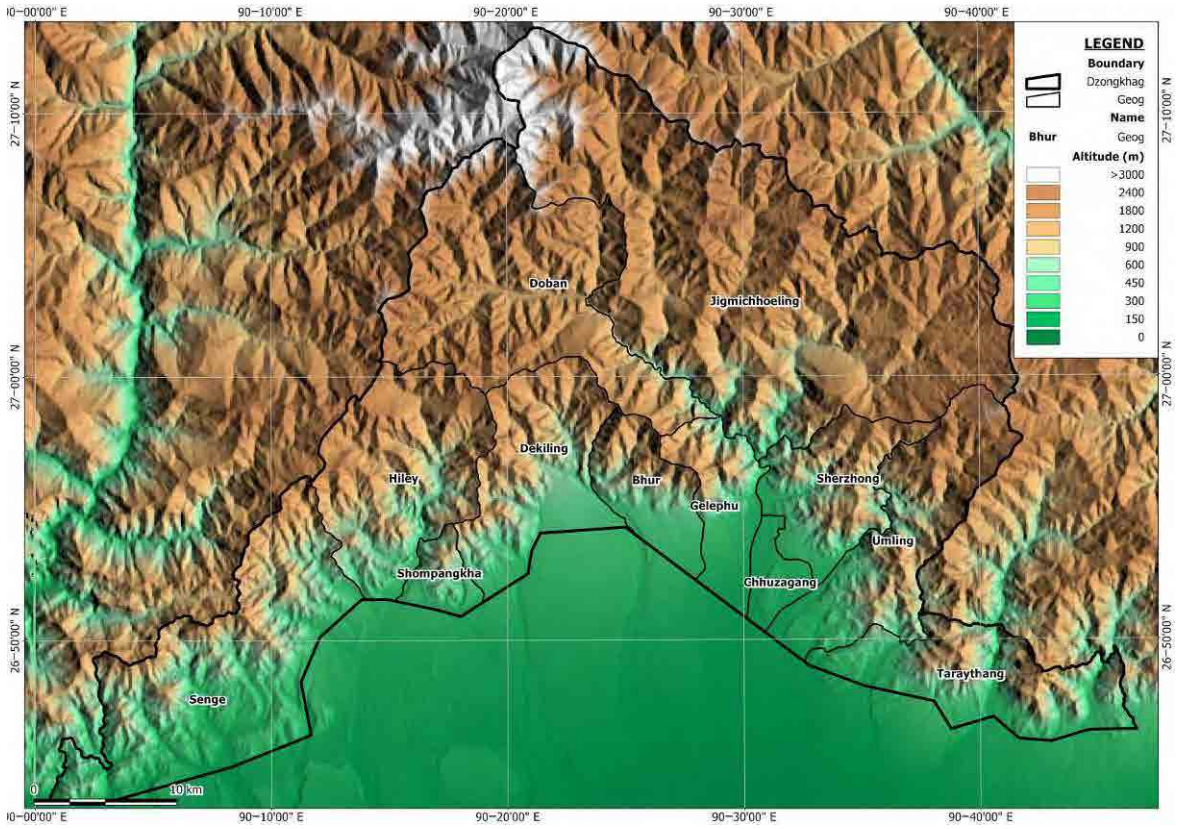


Figure 3.1.5 Altitude Distribution in Sarpang Dzongkhag (by SRTM 90m DEM)

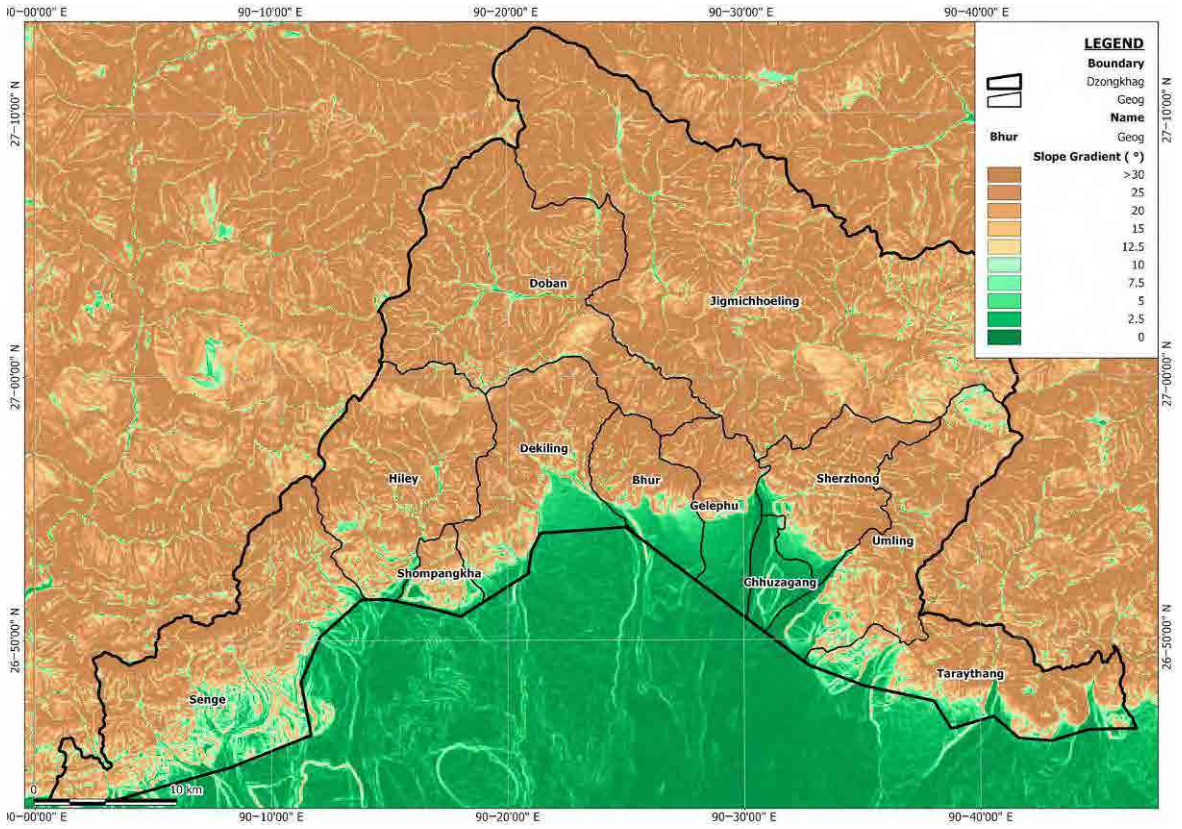


Figure 3.1.6 Ground Gradient Distribution in Sarpang Dzongkhag (by SRTM 90m DEM)

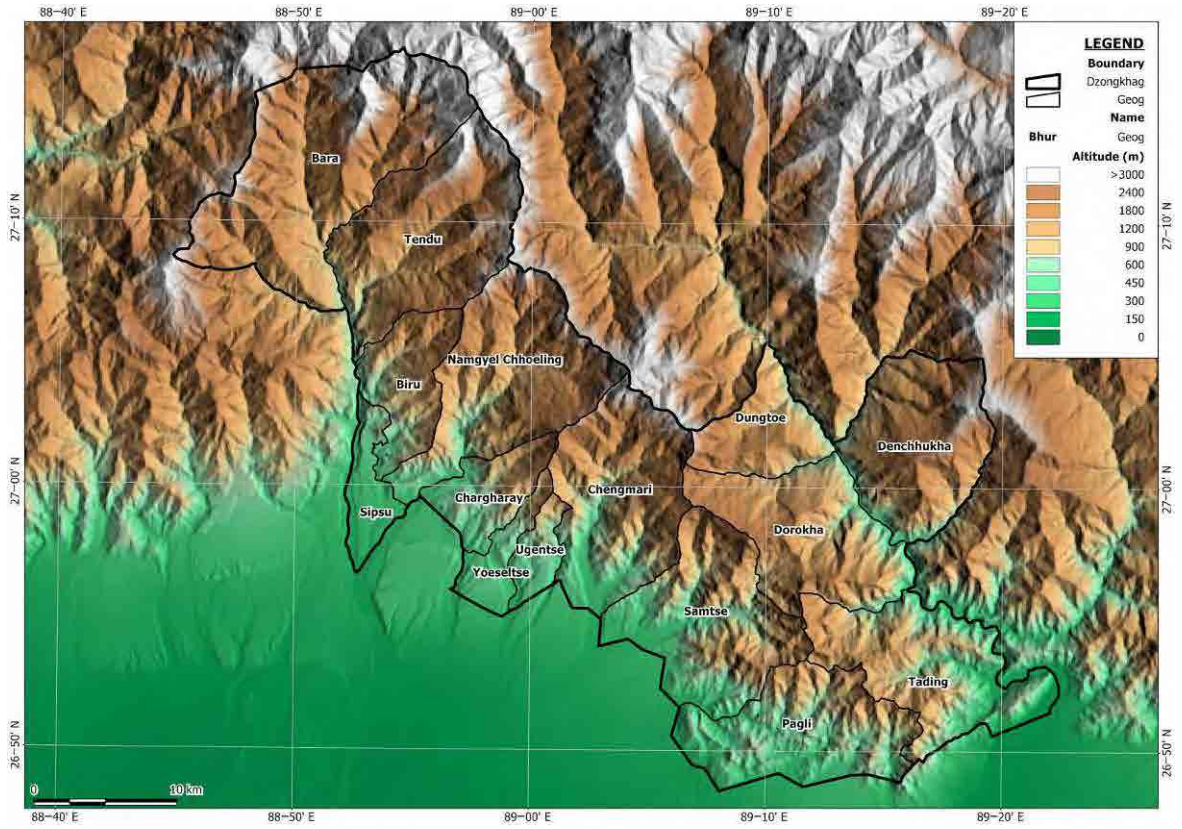


Figure 3.1.7 Altitude Distribution in Samtse Dzongkhag (by SRTM 90m DEM)

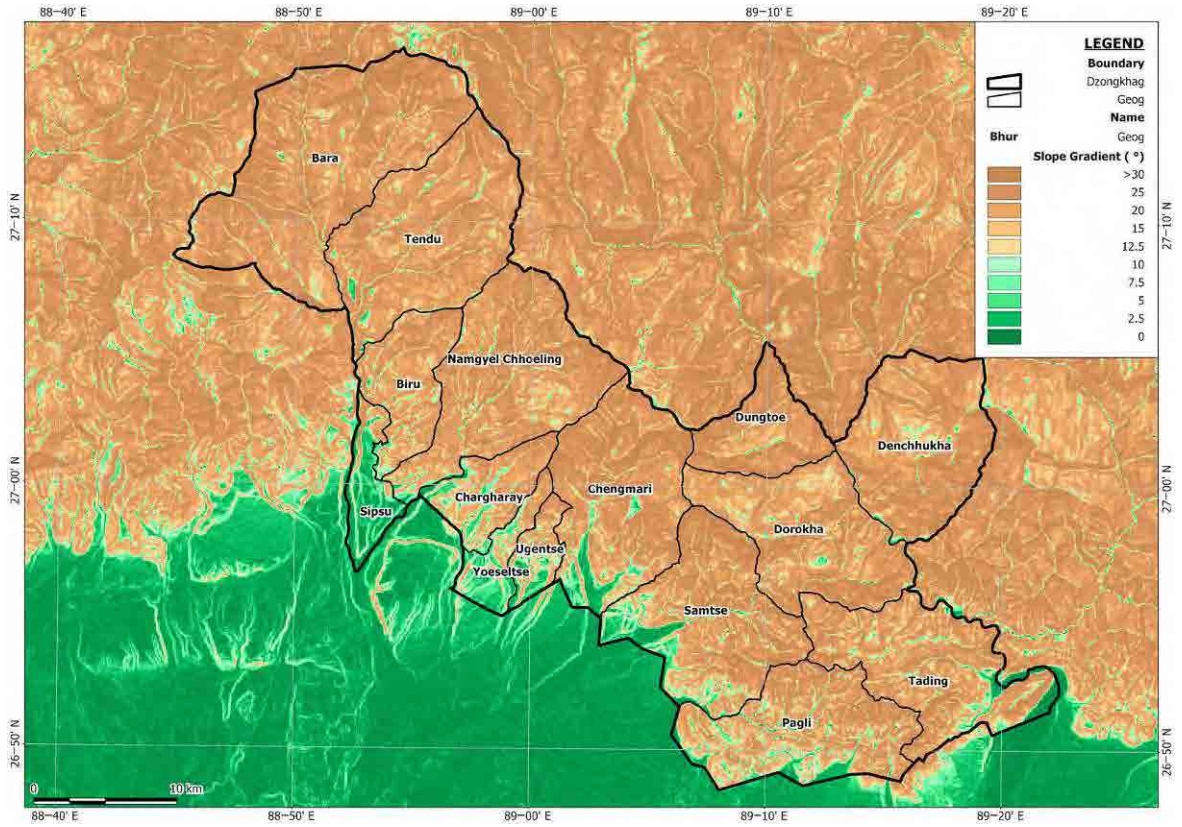


Figure 3.1.8 Ground Gradient Distribution in Samtse Dzongkhag (by SRTM 90m DEM)

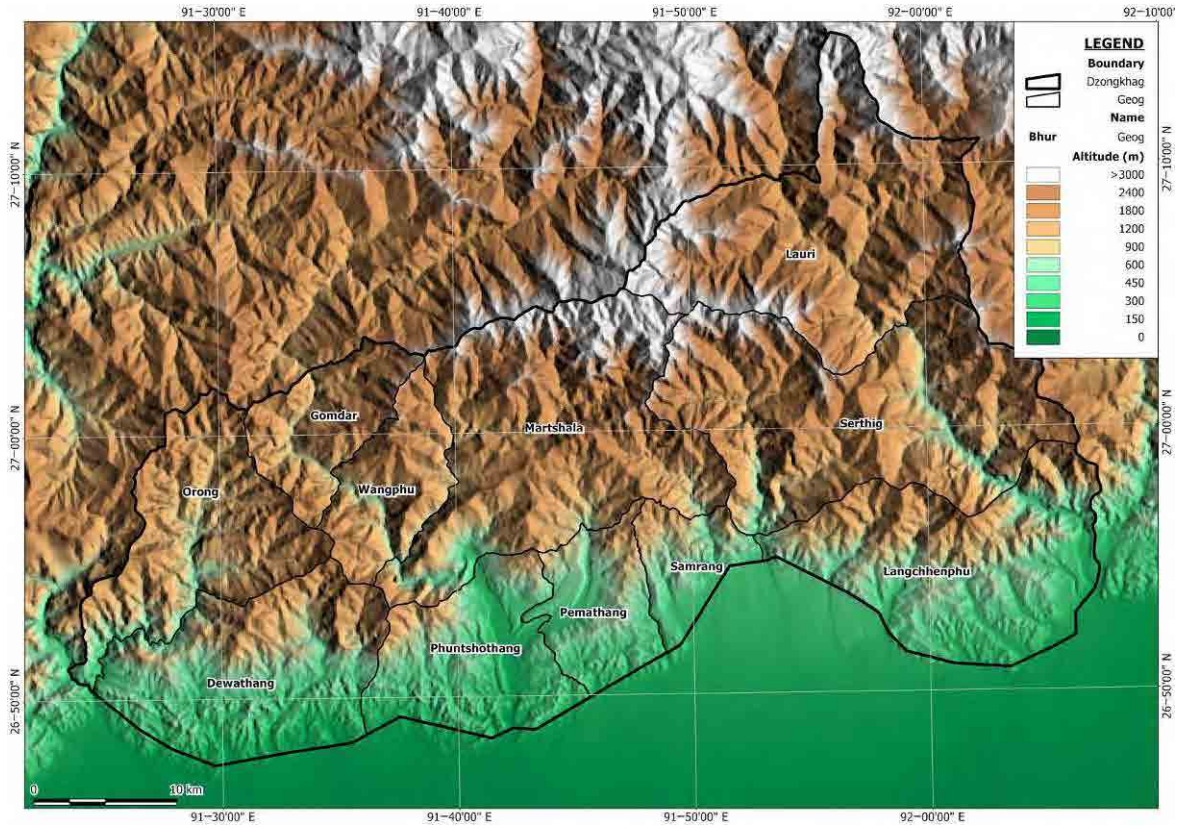


Figure 3.1.9 Altitude Distribution in Samdrop Jongkhar Dzongkhag (by SRTM 90m DEM)

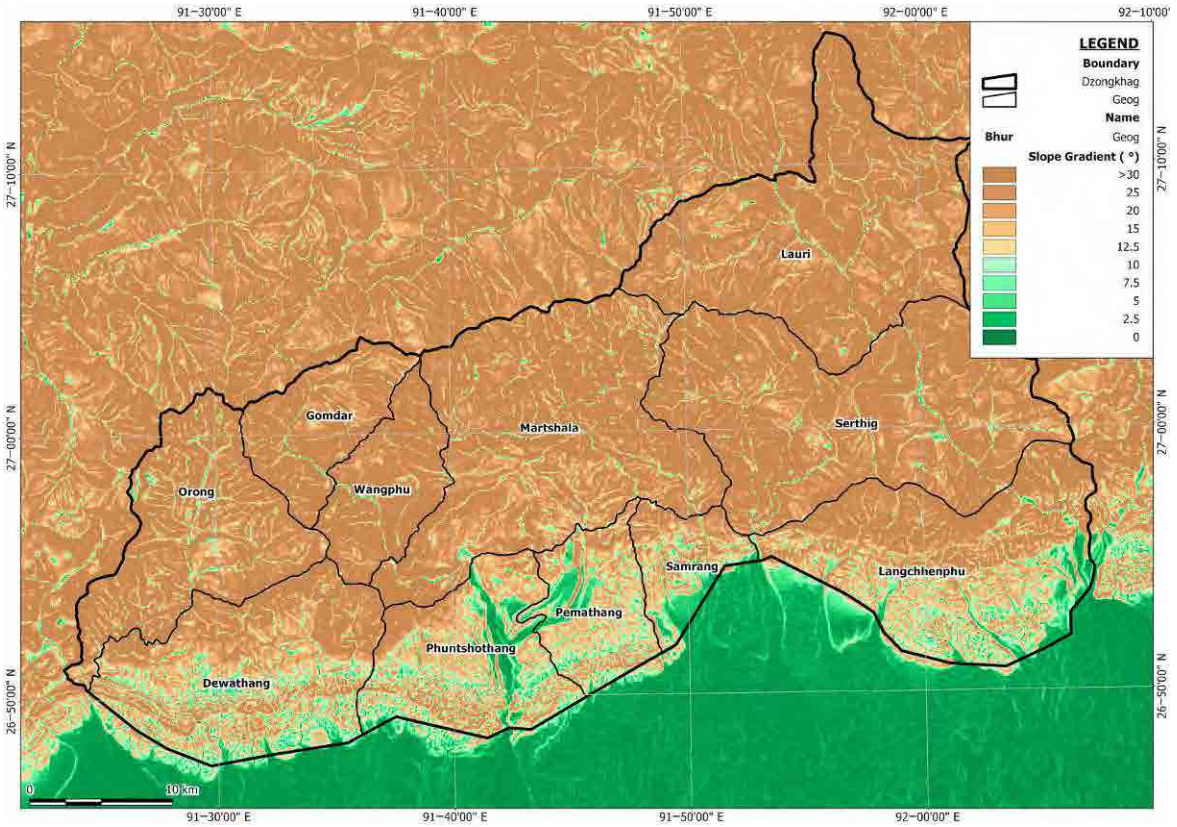


Figure 3.1.10 Ground Gradient Distribution in Samdrup Jongkhar Dzongkhag (by SRTM 90m DEM)

(2) Geology

Bhutan's geology is shown on the geologic map (see Figure 3.1.11). As a geologic feature of the three Dzongkhags, existence of the faults is offered (see Figures from 3.1.12 to 3.1.14). Geology of Bhutan is described as outlined in Table 3.1.6.

Bhutan is classified into four geology belts bounded by major faults (thrusts). Most of Bhutan lies in Greater Himalayan Zone with good rock mass of crystalline rocks. However, in the southern three Dzongkhags, Lesser Himalayan Zone occupies most area, where poor rock mass with schistosity and fault fractures develops. Quaternary unconsolidated sediments underlie alluvial fans and terraces and create lower gradient land near the Indian border.

Note: Alluvial fan often has a scarp along a river and it is difficult to discriminate it from terrace. Here, topography which shows an apparent fan shape with a little larger gradient is defined to be "fan", and one which extends long as a platform with smaller gradient is regarded to be "terrace". Based on relative height between terrace surface and nearby riverbed, terraces are classified into lower (less than 10m), middle (between 10m and 30m) and higher (more than 30m).

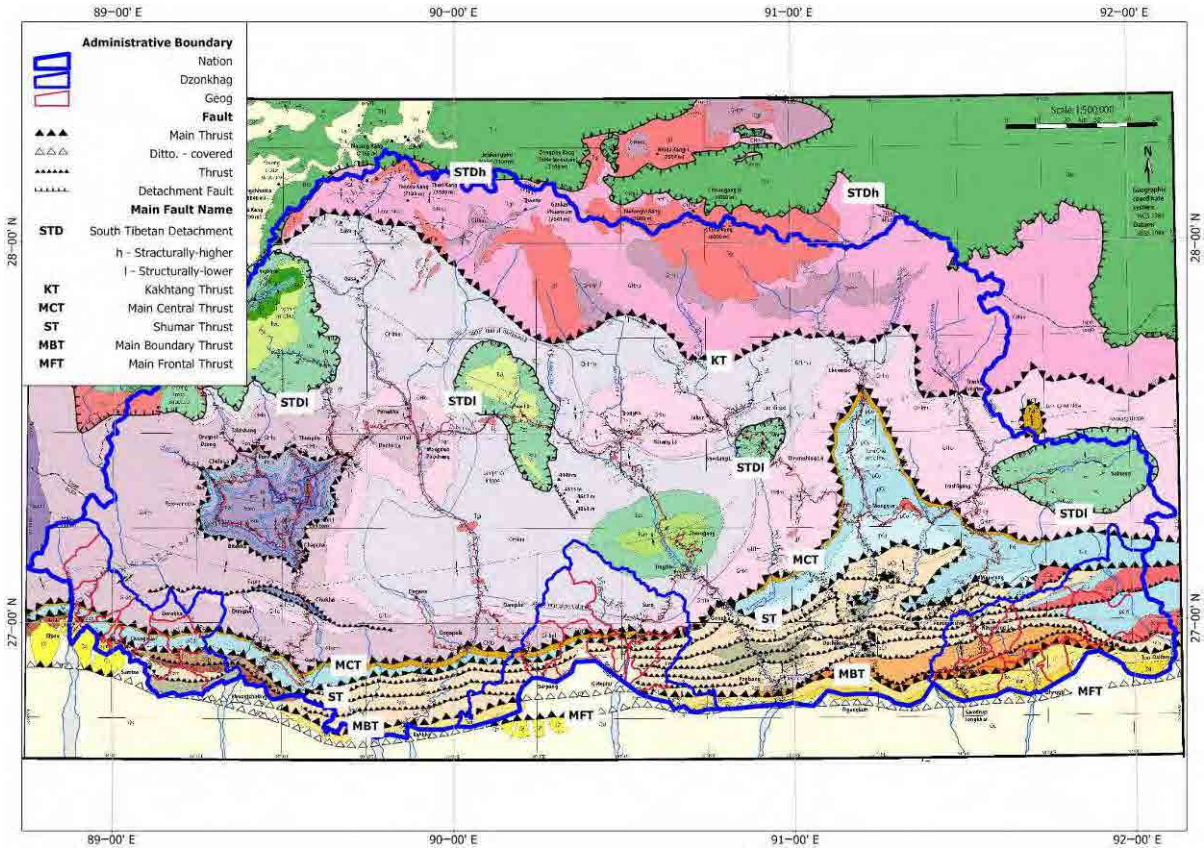


Figure 3.1.11 Geologic Map of Bhutan (Long et al., 2011; retouched)

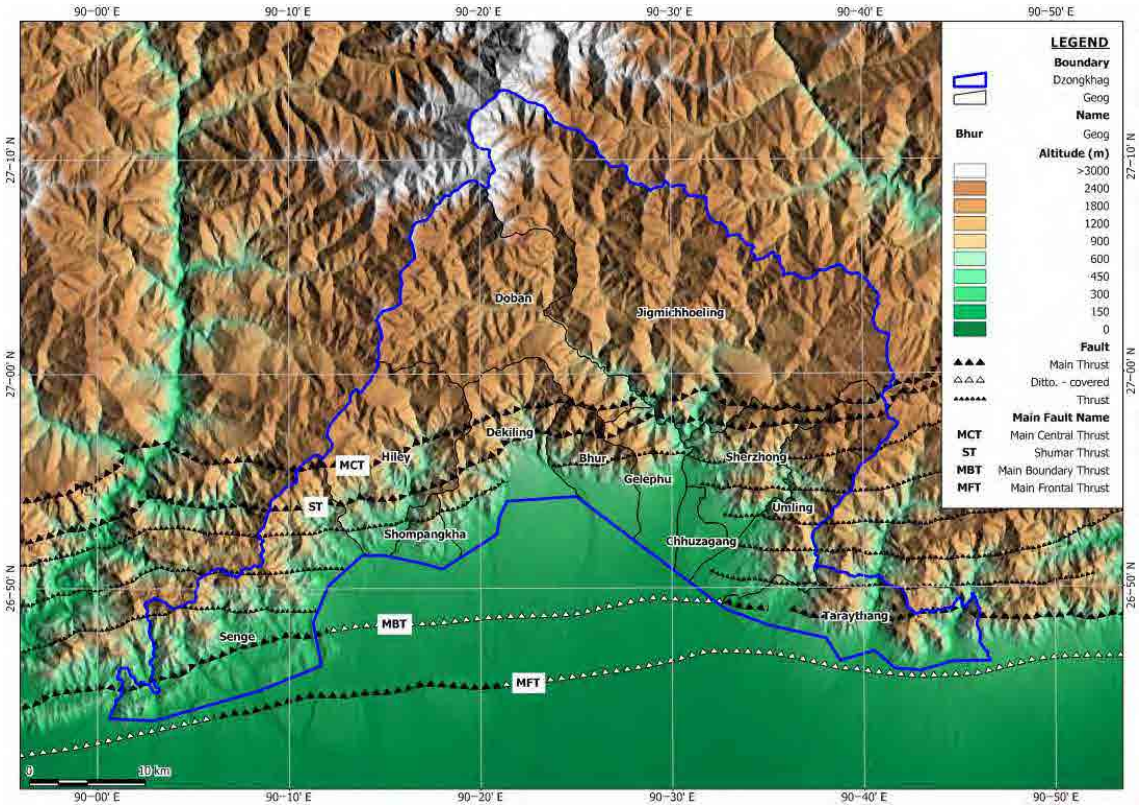


Figure 3.1.12 Location of Major Thrusts in Sarpang Dzongkhag (Copied from Long et al., 2011)

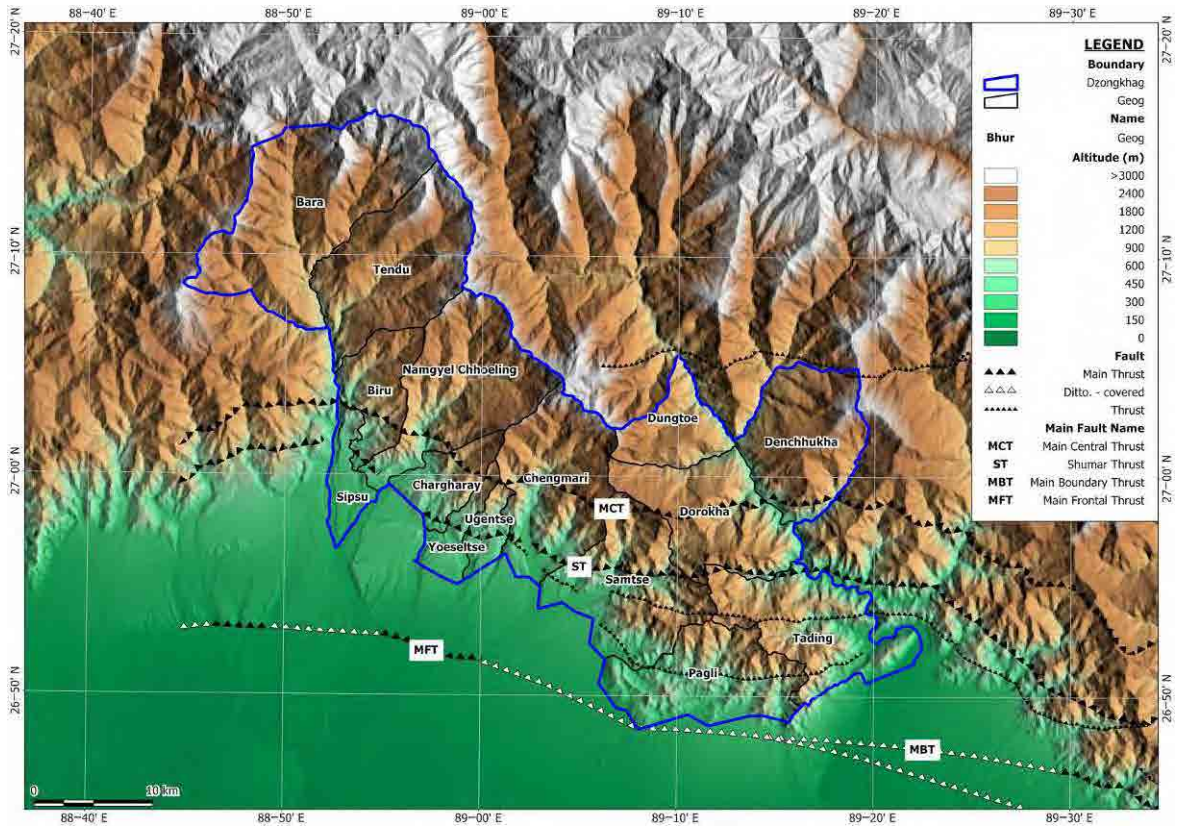


Figure 3.1.13 Location of Major Thrusts in Samtse Dzongkhag (Copied from Long et al., 2011)

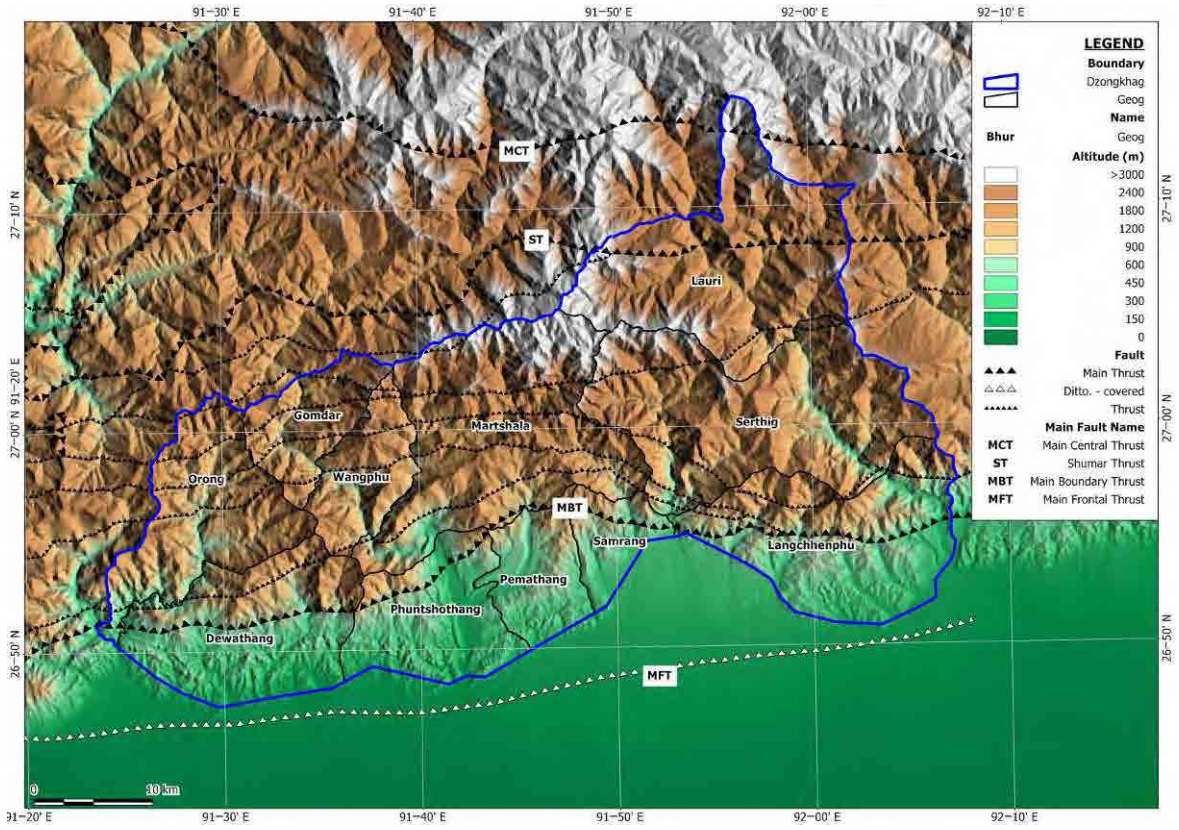


Figure 3.1.14 Location of Major Thrusts in Samdrup Jongkhar Dzongkhag (Copied from Long et al., 2011)

Table 3.1.6 Geology Outline of Bhutan

Boundary Fault	Geology Zone	Distributing Geology	Geologic Age	Distribution and Topographic Feature	Rock Mass Condition	Agricultural Land
	Ⅰ. Tethyan Himalayan Zone	Shale, sandstone, limestone, schist	Palaeozoic & Mesizoic	Mainly distributed in Tibet. Partially distributed in Bhutan.	Consolidated rock	
STD						
(South Tibetan Detachment)	Ⅱ. Greater Himalayan Zone	Crystalline rocks (gneiss, granite, crystalline schist etc.)	Pre-cambrian ～ Palaeozoic (high-temperature metamorphic rocks) & Tertiary (protruded granite)	Occupying most Bhutan mountainous area.	Hard rock	River terrace, flat ridge and gentle slope of mountain
MCT						
(Main Central Thrust)	Ⅲ. Lesser Himalayan Zone	Schist, phyllite, slate, limestone, dolostone	Pre-cambrian ～ Palaeozoic	Distributed in low hilly area of southern edge belt of Bhutan as well as along Kuri river valley. Hot springs found near along ST (Shumar Thrust).	**Schistosity developes; Many faults run and rock mostly crushed between ST and MBT; Slope failure and gully erosion found here and there.**	River terrace, flat ridge and gentle slope of mountain
MBT						
(Main Boundary Thrust)	Ⅳ. Subhimalayan Zone	Conglomerate, sandstone, siltstone (Siwalik Formation)	Tertiary	Hilly area along the boundary to India in Sarpang to Sandrup Jongkar Dzongkhags.	Soft rock	Flat land on hill
MFT						
(Main Frontal Thrust)	Ⅴ. Quaternary sediment (on the southern mountain foot)	Gravel, sand, silt	Quaternary	Alluvial fan and terrace developing on the mountain foot along the boundary to India. Also covering a part of Lesser Himalayan and subhimalayan zones.	Unconsolidated	Alluvial fan and terrace

Note: Compiled based on the geological map by Long et al. (2011) with consideration of survey results in Sarpang Dzongkhag by the JICA survey team.

There exists distribution of alluvial fans and terraces in the three Dzongkhags (see Figures from 3.1.15 to 3.1.17). In Sarpang, some fans develop in the central area. Middle and higher terraces also develop well in the eastern side along the Indian border. In Samtse, middle and higher terraces are developed well, but the fan is rarely found. In Samdrup Jongkhar, both of the fans and the terraces are rarely developed. Surface layer of the fan and the lower terrace mainly consists of gravel as shown in Figure 3.1.18, whereas those of the middle and higher terraces often comprises thick fine soil as shown in Figure 3.1.19.

Note: The fine soil mainly consists of silt and doesn't contain gravel. This implies that the material wasn't conveyed with water and might be brought with wind. The origin may be "loess" in the glacier age.

Figure 3.1.20 and Figure 3.1.21 show outcrops of fracture zone of Lesser Himalayan Zone in Sarpang Dzongkhag. Because water sources for agricultural land along the Indian border (above-mentioned alluvial fans and terraces) are located in Lesser Himalayan Zone, the slope where an irrigation canal runs is vulnerable to land slide and erosion. Such instability of the slope certainly brings difficulty in maintaining constructed irrigation canals.

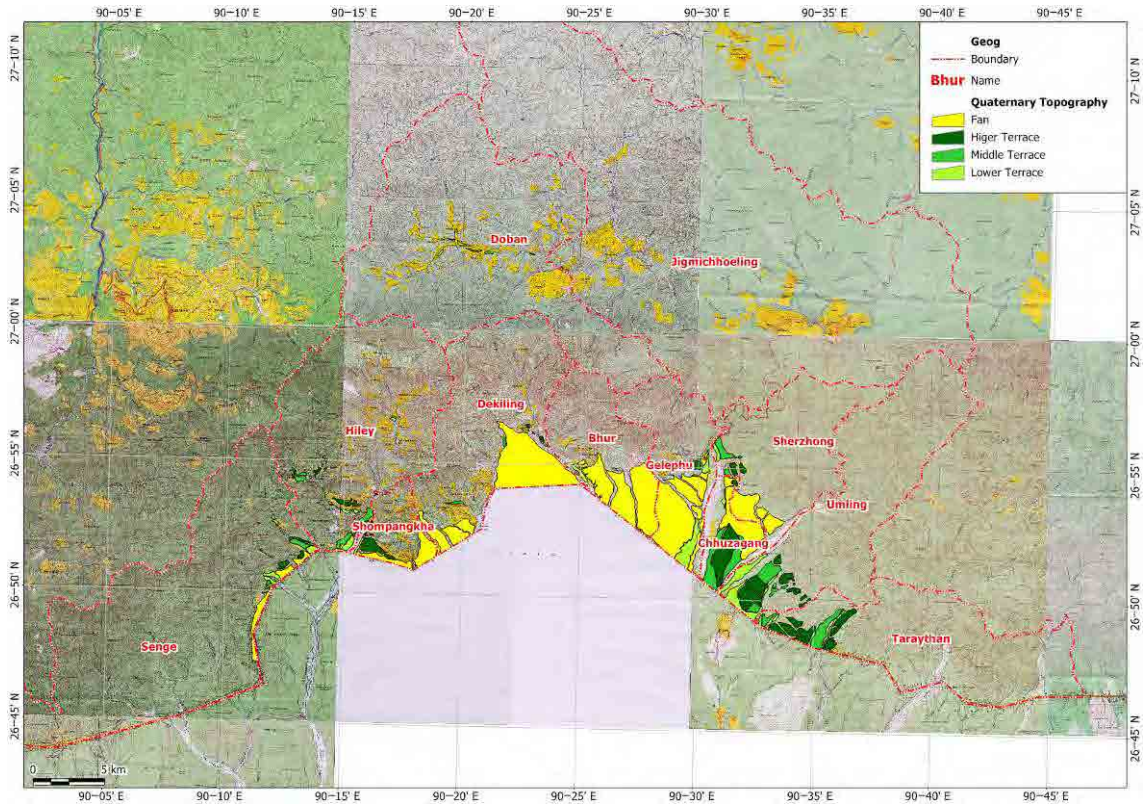


Figure 3.1.15 Alluvial Fan and Terrace in Sarpang Dzongkhag (Identified on Google Earth image)

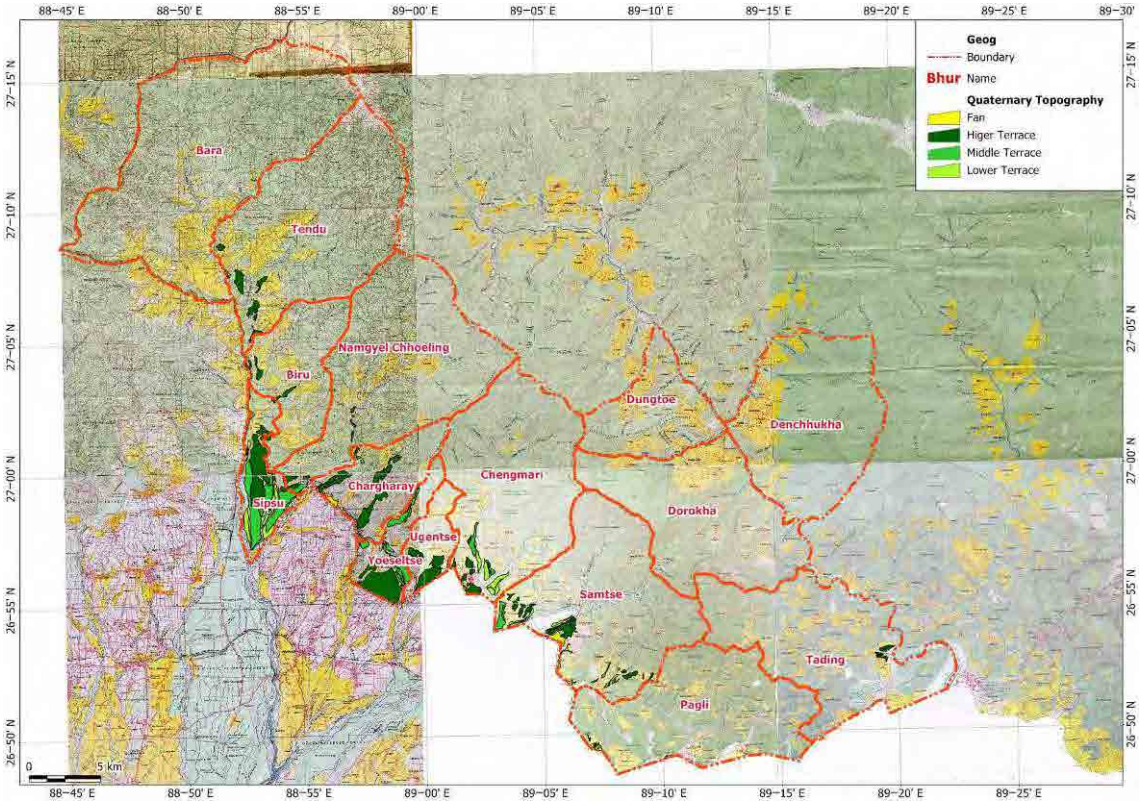


Figure 3.1.16 Alluvial Fan and Terrace in Samtse Dzongkhag (Identified on Google Earth image)

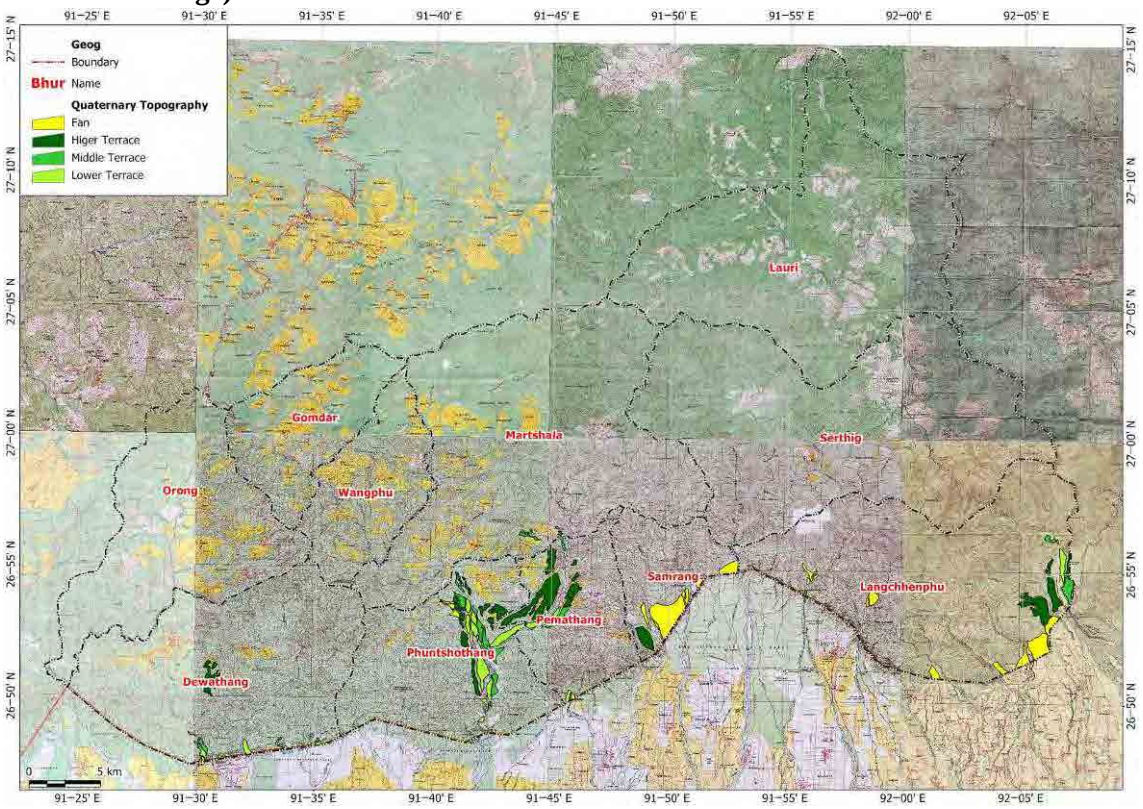


Figure 3.1.17 Alluvial Fan and Terrace in Samdrup Jongkhar Dzongkhag (Identified on Google Earth image)


(Dekilling Gewog, Sarpang)

Figure 3.1.18 Surface of Alluvial Fan


(Chuzaghang Gewog, Sarpang; loamy soil)

Figure 3.1.19 Top-soil of Higher Terrace


(Bhur Gewog, Sarpang)

Figure 3.1.20 Eroded Fracture Zone in Lesser Himalayan Belt


(Gelephu Gewog, Sarpang)

Figure 3.1.21 Outcrop of Fracture Zone – Compacted Soil with Small Rock Fragments

(3) Groundwater

Most water sources in Bhutan are of surface water, because there is much river water flowing from mountainous area. Drinking water is mainly taken from intake pipe installed on an upstream river bed (called “spring”) and delivered by gravity flow through plastic pipe to tap.

Besides the gravity system, two sites of groundwater source are located in Gelephu city of Sarpang Dzongkhag. As for one sites, collector pond is excavated in the river bed of Mao River and distributing drinking water to the city after disinfection (see Figure 3.1.22). The other is the facility that Gelephu Distillery of Army Welfare has one tube well in the factory (see Figure 3.1.23). Pumped water is used as a supplemental water source in dry season. The well is the size of 8 inches in diameter and 180 feet in depth. The pumping discharge is designed by 14 lit/sec.

According to the information collected from Samdrup Jongkhar Dzongkhag, one infiltration gallery for drinking water supply is installed nearby the riverbed in Samdrup Jongkhar. In Samtse Dzongkhag, a test well with about 100m in relative height was excavated on a higher terrace to a nearby river by DoA for irrigation use. It is said that the excavated well failed in production of groundwater, because it could not reach an aquifer. (Detail is not known, because the final report is not submitted to date.)

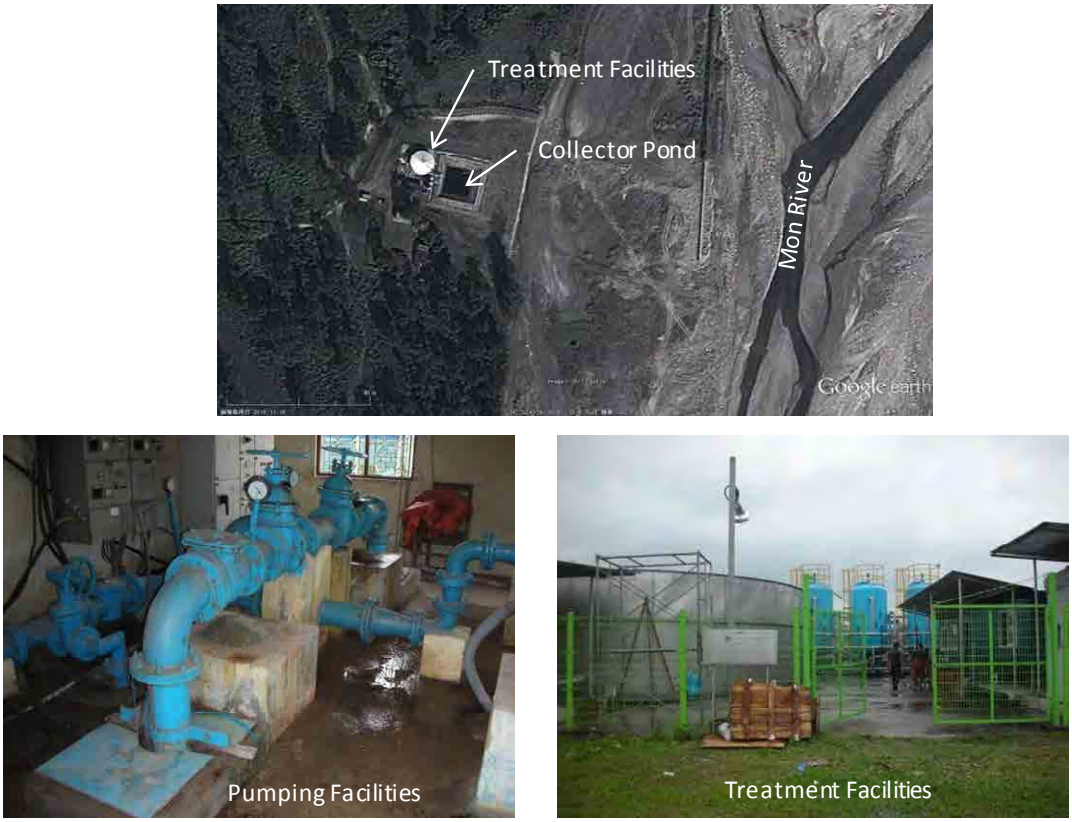


Figure 3.1.22 Water Supply Source of Gelephu City – Collector Pond and Treatment Facilities

Figure 3.1.23 Tube Well of Distillery in Gelephu

Judging from the collected information and field observation survey, groundwater could be developed in areas along the river and at the foot of alluvial fan where a thick gravel layer is expected to exist.

To promote such groundwater development, some test wells should be drilled to grasp geological condition and available pumping water. In addition, based on the investigation, it should be discussed about basic policy for groundwater use and its operation and management organization. Especially for irrigation purpose, it is important to clarified responsibility of operation and maintenance (O/M) and sharing its expenditures between beneficial farmers and administration side.

3.1.3 Meteorological and Hydrological Condition

(1) Meteorological condition

Location of observation station and items being observed

There are 2 classes of observation stations for meteorological condition (hereinafter referred to as Met-station). Items being observed at each class of station are mentioned in the table below. Additionally, at some of hydrological observation stations (hereinafter referred to as Hydro-station), daily rainfall is being observed. Location of these stations is shown in the figure below.

Table 3.1.7 Items Being Observed at Met-station

Class	Class A	Class-C
Observed items	Daily rainfall (mm/day) Maximum Temperature (˚C) Minimum Temperature (˚C) Relative Humidity (%) Wind Speed (m/s) Wind Direction Sunshine (hr) Cloud Cover (oktas)	Daily rainfall (mm/day) Maximum Temperature (˚C) Minimum Temperature (˚C)

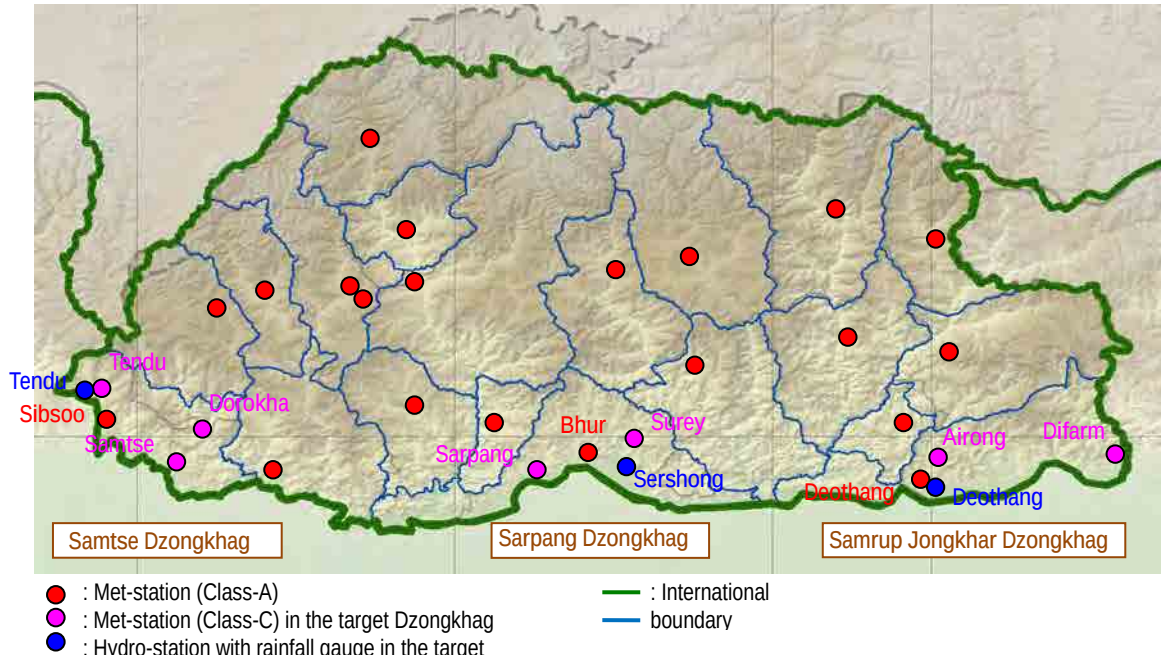
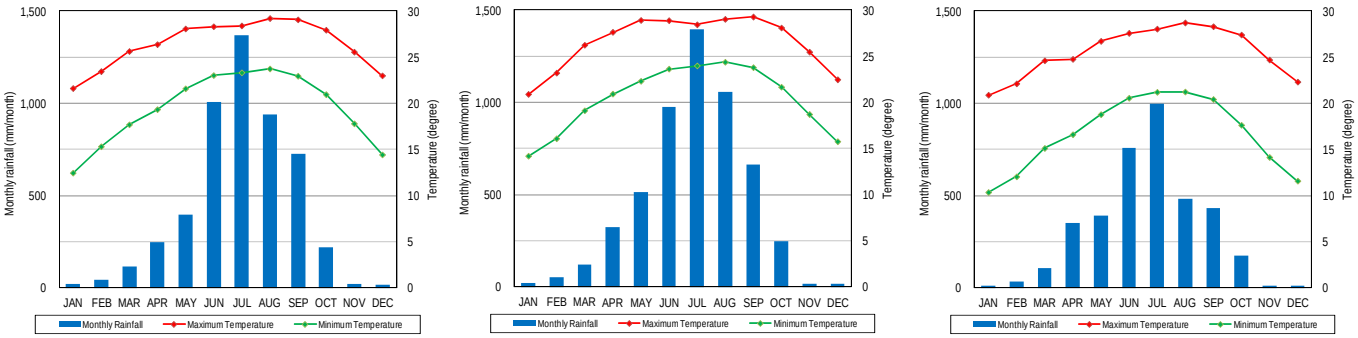


Figure 3.1.24 Location of Met-stations and Hydro-stations

Outline of meteorological condition in the target Dzongkhags

The Figure shown below indicate general meteorological conditions at class-A stations located in each Dzongkhag. As for the rainfall, maximum monthly rainfall in a year is recorded in July and from November to February there is almost no rainfall. As for the temperature, maximum temperature is recorded from July to August and minimum one is recorded in December or January (Observed Meteorological data is shown in the Appendix-C).



Sarpang Dzongkhag
Bhur Station
(Average annual rainfall: 5,121mm)

Samtse Dzongkhag
SibsooStation
(Average annual rainfall: 5,479mm)

Samdrup Jongkhar Dzongkhag
Deothang Station
(Average annual rainfall: 3,764mm)

Figure 3.1.25 Outline of Meteorological Condition in the Target Dzongkhags

Agency in charge of observation

Met-stations are under Department of Hydro-Met Services, Ministry of Economic Affairs (hereinafter referred to as DHMS). Each station has an observer temporally employed by DHMS. They observe manually one time in everyday and record its result on the designed format. They submit the filled format to the head quarter of DHMS once a month.

Hydro-stations which have rainfall observation equipment are also under DHMS and locate near the main rivers flowing into India. At those stations, DHMS has their own office and allocates staff of DHMS. They observe manually and inform the result to the head quarter of DHMS through radio communications every day because the result of observation should be reported to India every day. In other hand, they record the result on the format and submit it to head quarter once a month.

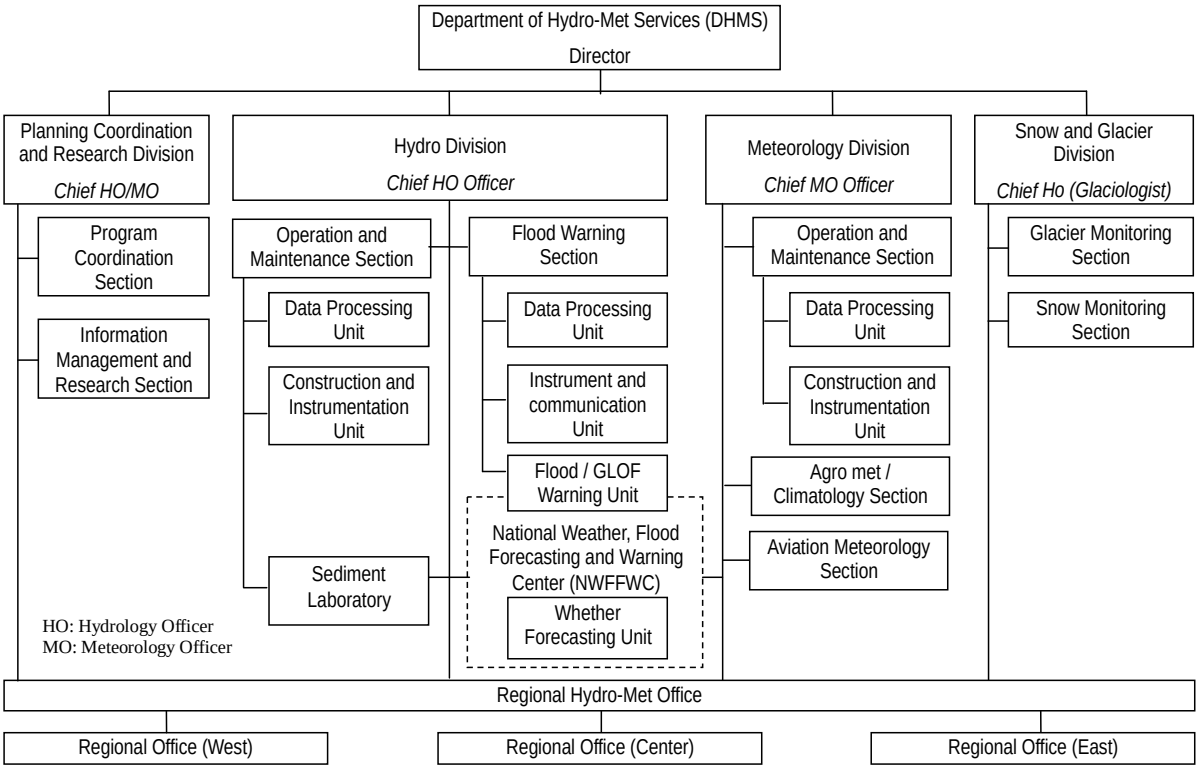


Figure 3.1.26 Organization Structure of DHMS

Observation equipment

Observation is done using manual observation equipment. Additionally, at Class-A and Hydro-stations, there are automatically recording equipments to check the manually observed records.

Daily rainfall is observed using rainfall gauge with plastic bottle. According to some observers, plastic bottle at some Met-stations are not big enough to store, and sometimes overflow after heavy rain. Under this condition, rainfall in the flood season cannot be measured properly so bottle should be changed to bigger one.

Class-A
Bhur Station

Class-C
Surey Station

Rainfall gauge at Hydro-station
Sershong Station

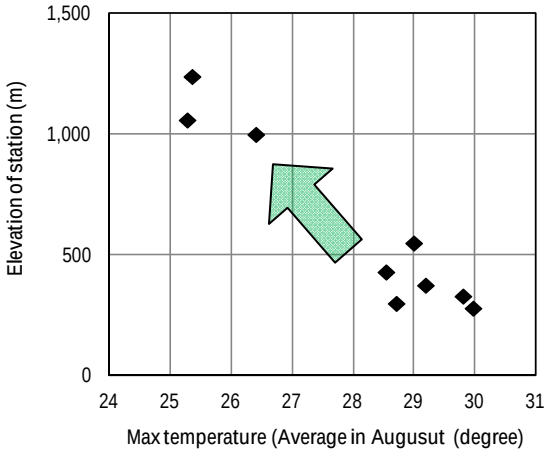
Figure 3.1.27 Observation Equipment

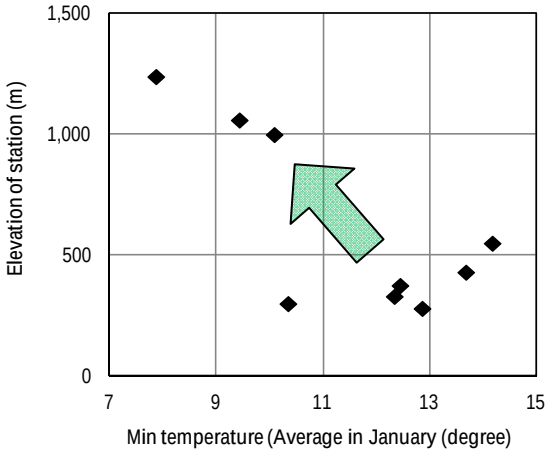
Tendency of Meteorological condition

The data analysis from Met-stations, some trends were found.

- Temperature

The average daily maximum temperature occurs in August with minimum in January for the three Dzongkhags for the last 10 years as mentioned in the figure below. In all the three Dzongkhags, the max and min temperatures decreases lower as elevation increases.



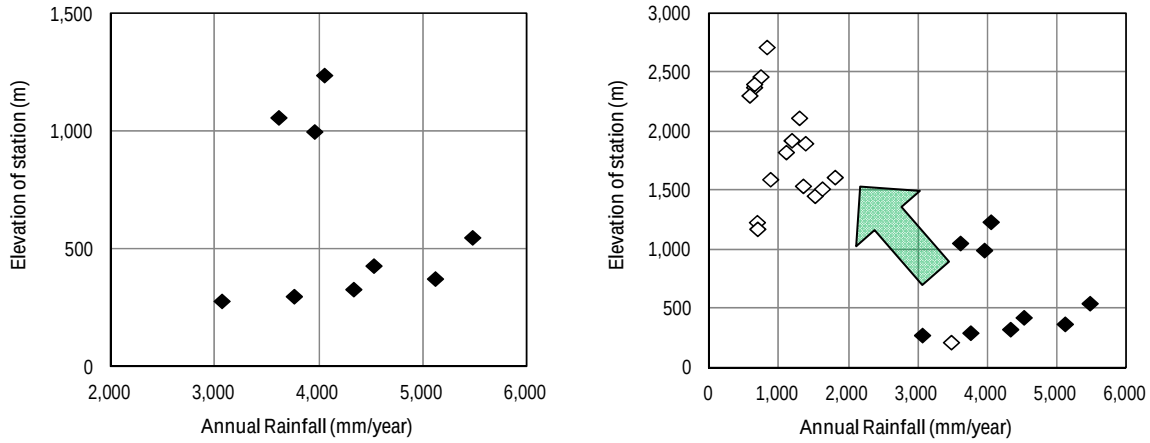


*Doroka Met-station in Samtse Dzongkhag began its observation from 2005 and number of data is supposed not enough. Therefore, data from this station is excepted from the target for analyzation.

Figure 3.1.28 Average Temperature at Met-stations in Target Dzongkhags for Last 10 Years

➢ Rainfall

Average annual rainfall for the last 10 years is mentioned in the figure below. In the three Dzongkhags, No relationship between annual rainfall and elevation can be found. But, from the data plus other Dzongkhags, it is analyzed that annual rainfall decreases lower as elevation increases. Although there is no higher elevation Met-stations in the targeted three Dzongkhag, assuming the same trend as in the lower right figure, it is inferred that rainfall in the higher elevation area might be less than in the lowland, even in the targeted three Dzongkhags.



Target Dzongkhags　　Including other Dzongkhags

◆ :data at met-stations in target Dzongkhags (Class-A and C)　◇ :data at met-stations in not target Dzongkhags (Class-A)

*Doroka Met-station in Samtse Dzongkhag began its observation from 2005 and number of data is supposed not enough. Therefore, data from this station is excepted from the target for analyzation.

Figure 3.1.29 Average Annual Rainfall at Met-stations for Last 10 Years

(2) Hydrological condition

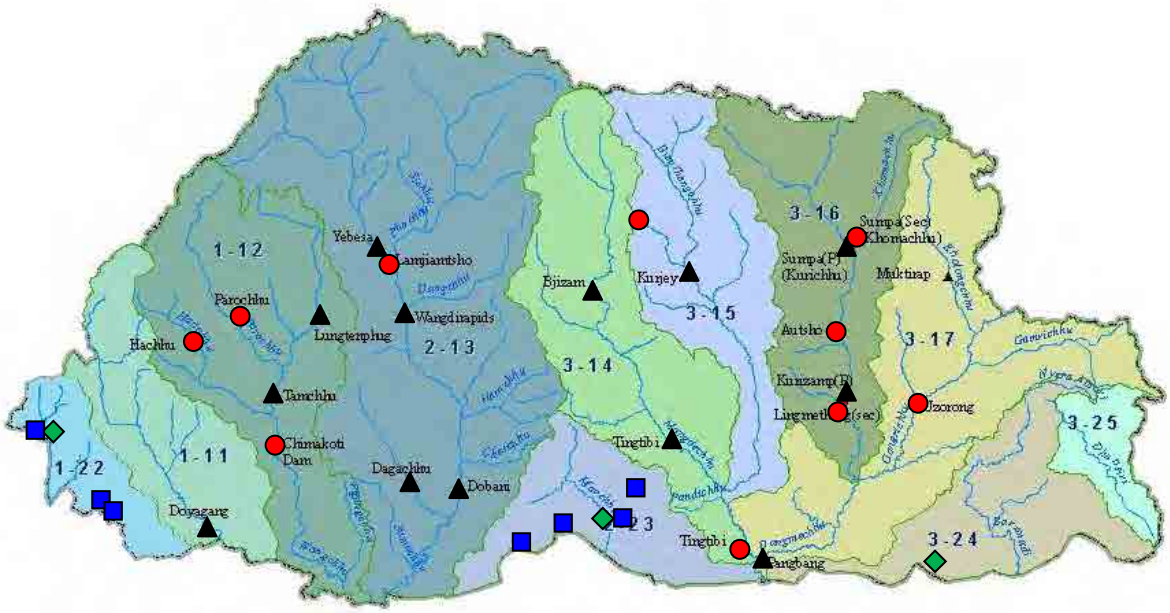
Location of observation station and items being observed

There are 4 kinds of Hydro-stations. Specification of each kind and location of the stations are shown in the following table and figure.

Table 3.1.8 Specification of Each Kind of Hydro-station

Kind	Observed items	Equipment	Frequency of observation	Reporting
Principal Station	Water level	Water level gauge	Twice a day (9:00 and 15:00)	Observation results are reported to headquarter every month.
	River discharge	Propeller type current meter	Once a week	
	Sedimentation	Gauge and Discharge Reader	Every day	
Secondary Station	Water level	Water level gauge	Once a day (9:00)	Observation is done during lean season. Observation results are reported to headquarter every month.
	River discharge	Float type current meter	Once a day	
Spot Low Flow Measurement	River discharge	Handy type current meter	Once a year	

Kind	Observed items	Equipment	Frequency of observation	Reporting
FWS	Water level	Water level gauge	Flood season Every hour Dry season 4 times a day (8:00, 9:00, 13:00 and 18:00)	Equipment is installed by Central Water Commission (CWC), an agency of Indian Government. Observation results are reported to headquarter every day (15:00) through radio communications and headquarter reports to Indian Government.
	River discharge	Propeller type current meter	Once a week	



*Add spot low flow measurement and FWS on the figure quoted from "Surface hydrological data of Bhutan Year book 2009"

▲ : Principal Station
● : Secondary Station
■ : Spot Low Flow Measurement in the target Dzongkhaags
◆ : FWS in target Dzongkhags

Figure 3.1.30 Location of Hydro-stations

Agency in charge of observation

Hydro-stations are under Department of Hydrology & Meteorology Services (DHMS). At Principle Station, Secondary Station and FWS, DHMS has their own office and staff of DHMS stationed.

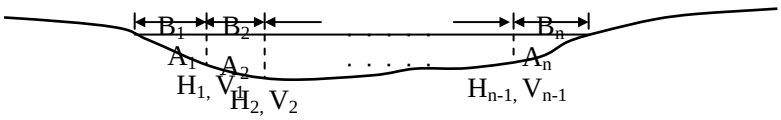
On the other hand, Spot Low Flow Measurement has no office and staff. During the lean flow season, from January to March, staff of DHMS goes to the observation spot and measures the discharge. Although some regional offices are incorporated in the observation organization structure, those regional offices are being established. Therefore, staff for measuring is presently dispatched from DHMS head quarter in Thimphu. After the establishment, DHMS has a plan to dispatch the staff from those offices.

Measuring and calculation method

At each measuring, cross section of river bed is confirmed and river discharge is calculated by using velocity and water depth mentioned in the figure below.

Cross section of river bed is frequently changed by flood. Present measuring and calculation method

are deemed suitable for this situation.



Hn: Water depth
Vn: Velocity *at the point of 0.6Hn
Bn: Width

Figure 3.1.31 Calculation method of river discharge

Trend of decreasing river discharge in dry season

At present, river discharge observation is done primally for flood forecasting. However, for irrigation development purpose, discharge in dry season is a critical factor. Additionally, size of irrigation command areas in the targeted Dzongkhags is very small and many of them take irrigation water from secondary streams, not main rivers where discharge is being observed. Therefore observed data as Spot Low Flow Measurement for secondary stream is deemed available for estimating irrigation water.

For planning irrigational farming in dry season, river discharge of each month in dry season is necessary. According to the available amount of discharge, crops and cropping pattern are planned.

Figure 3.1.32 shows the specific discharge observed at the Spot Low Flow Measurement in the target Dzongkhags (Observed data is shown in the Appendix-D). Trend line in the figure clearly shows that from January to April the amount of discharge gradually decreases. Discharge in January is supposed 30-40% increase more than that in April when river discharges are measured in some branches by JICA Survey Team.

In the target Dzongkhags there are only a few Spot Low Flow Measurements, especially in Samdrop Jongkhar Dzongkhag, where there are no flow measurement sites. For example in Sarpang Dzongkhag, discharge in dry season of Sisty river or Ratey river is deemed enough for irrigation but without any measurement it is difficult to estimate the possibility of irrigation in dry season.

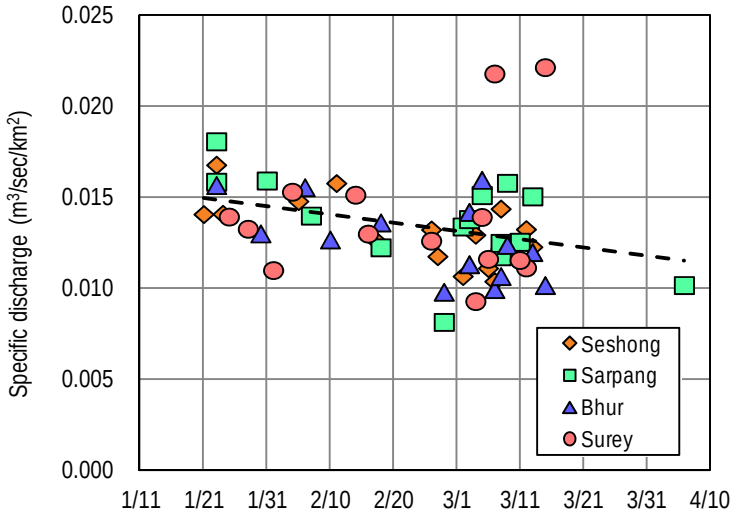


Figure 3.1.32 Specific Discharge – Observed Date

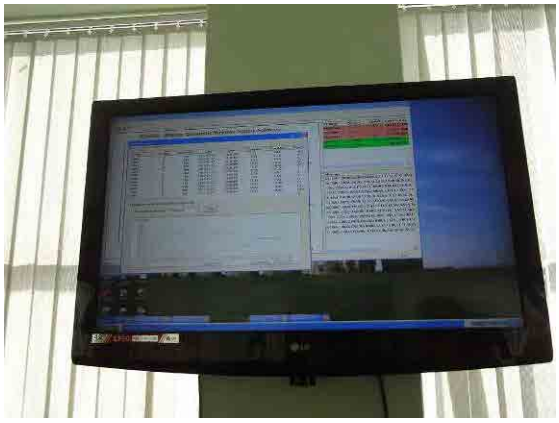
For this estimate, it is expected that the number of Spot Low Flow Measurement sites increases and frequency of measurement should be increased form once a year to once a week.

(3) Observation system of meteorological and hydrological condition

In the building of DHMS headquarter in Thimphu, there is an observation system of meteorological and hydrological condition (hereinafter referred to as the System) donated by Government of Denmark. At present, some meteorological and hydrological observation stations located in the northern part is collecting some observed data, such as rainfall, temperature and water level of rivers. Those data is automatically sent to the System every hour through radio communications. DHMS has a plan to change all the existing manual observational equipment to automatically recording one like this. DHMS also plan to manage all the stations under this System.

Designed function of the System is just collecting and storing data and showing the result on display. Through upgrading the System, it is expected to add other function using collected data, for example, to forecast flooding and provide flood warning system.

System at the head quarter of DHMS

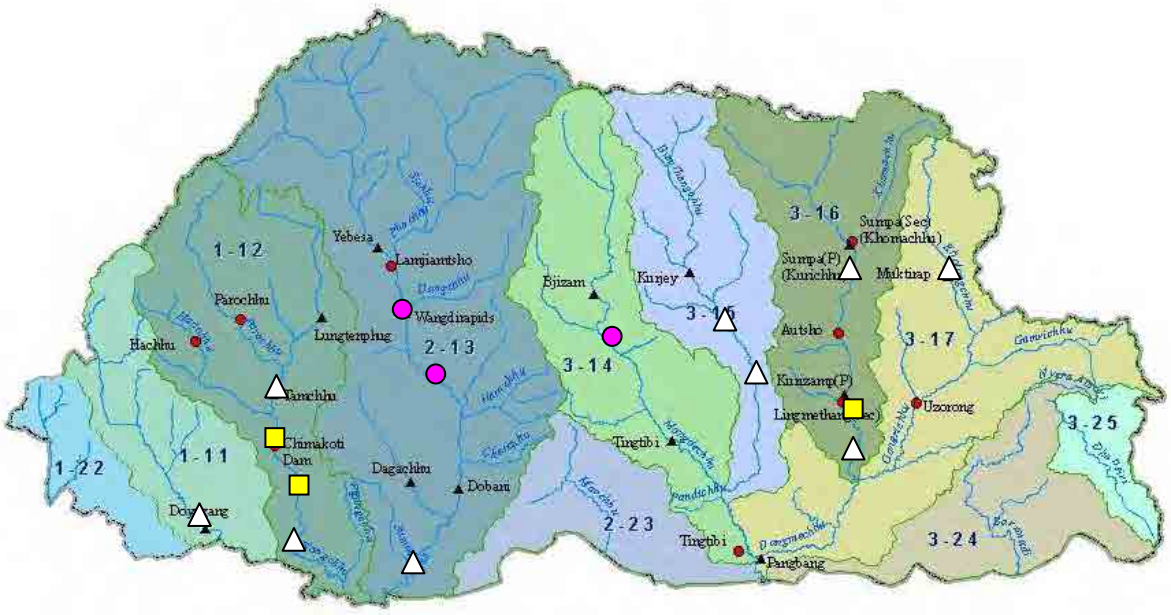


Displayed data

Figure 3.1.33 System Installed at the DHMS

(4) Hydropower station

Hydropower stations are constructed across the river in the country. So, location of the hydropower stations is shown in the figure below.



*Add location of hydropower stations on the figure quoted from "Surface hydrological data of Bhutan Year book 2009"

□ : Already constructed
○ : Under construction
△ : Planning

Figure 3.1.34 Location of Hydropower Stations

3.1.4 Environmental Protection

The map of "National Protected Areas" is provided in Bhutan (see Figure 3.1.35). The total number of the area counted is ten, occupying 16,396 km^2 corresponding to about 1/4 of the whole country. Beside these, inter-connected "Biological Corridors" is delineated as protected area. Settlements exist even in these areas but new settlements are not allowed. In the protected areas, new development of agricultural land is prohibited and any construction of water intake facilities requires NEC's permission. National Protected Areas and Biological Corridors located in the three Dzongkhags are as follows:

<u>Sarpang Dzongkhag:</u>

Phipsoo Wildlife Sanctuary

Royal Manas National Park

Jigme Singye Wangchuck National Park

Biological Corridor connecting these three parks

<u>Samdrup Jongkhar Dzongkhag:</u>

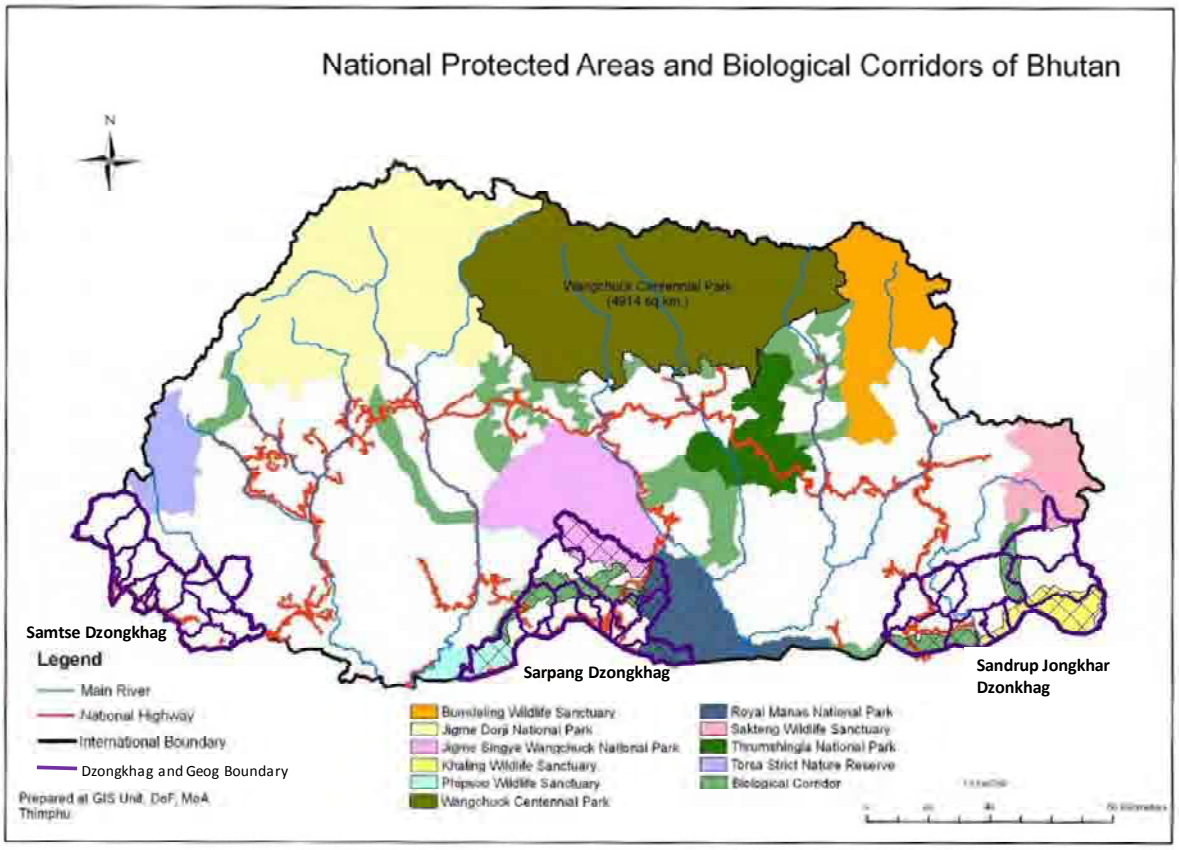
Khaling Wildlife Sanctuary

Sakteng Wildlife Sanctuary

Biological Corridors connecting these two sanctuaries and Royal Manas National Park

<u>Samtse Dzongkhag:</u>

None



Source: http://www.rspnbhutan.org/about-bhutan/protected-areas-of-bhutan. Retouched.

Figure 3.1.35 National Protected Areas and Biological Corridors of Bhutan

In case that irrigation rehabilitation plan and/ or new water resources development plan would be schemed in Sarpang and Sumdrop Jongkhar Dzongkhags, it is required to assess that no negative impact may be caused by those plans by confirming the exact location of the National Protected Areas.

3.2 SOCIETY AND ECONOMY

3.2.1 Administrative Division

There are 20 districts (Dzongkhag), which has sub-districts (Drungkhag), in Bhutan. Blocks (Gewog) are under a district/ sub-district. Blocks fall under the jurisdiction of a district (district office) and blocks which are under the jurisdiction of a sub-district (sub-district office). Each block comprises sub-blocks (Chiwog) and villages. As the average of the three targeted districts, a district has 1.7 sub-districts, a district/ sub-district has 4.8 blocks, a block has 12 sub-blocks, and a sub-block has 1.6 villages. A village comprises about 25 households.

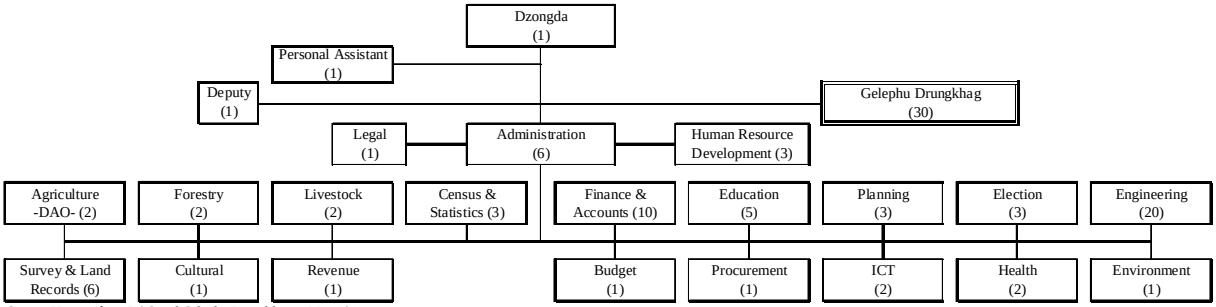
Table 3.2.1 Number of Administrative Division in the Targeted Three Districts

Dzongkhag (District)	Drungkhag (Sub-district)	Gewog (Block)	Chiwog (Sub-block)	Village
Samtse	2	15	228	323
Sarpang	1	12	90	172
Samdrup Jongkhar	2	11	136	227
Total	5	38	454	722
Average	1.7	4.8	12	1.6

Source: Annual Dzongkhag Statistics 2010

Note: The average of gewog shows number of gewogs which are covered by a dzongkhag or a drungkhag.

The centers of local administration are districts and a district office is staffed with about 80 officers under a governor (Dzongda), who is appointed by the central government. Dzongkhag officers are civil servants, who are transferred to other dzonkhags. The organization chart of the dzongkhag office in Sarpang is shown below. In the office, 75 officers work in 19 divisions under the Administration. Female staff are about 30 %, whose proportion is gradualy increasing. Three divisions of RNR, Agriculture (DAO), Forestry and Livestock are in charge of the agricultural administration. Sarpang Dzongkhag has Gelephu Drungkhag, that manages seven gewogs by 30 staff members including the Sub-governor (Dungpa), which is nominated by the central government.



Source: Hearing from DAO and Gelephu Drungkhag in May 2012

Figure 3.2.1 Organization Chart of Sarpang Dzongkhag Office (Staff number in each division)

For conducting works of the dzongkhag, related sectors and gewogs collaborate with each other. For instance, irrigation projects in the dzongkhag are planned by the gewog's Agriculture, the Engineering and the Plannig sector. Four engineers are posted in the drungkhag and six engineers are posted in gewog offices, excluding 20 engineers in the Engineering sector of the dzongkhag. A gewog-level engineer looks after two gewogs. On the other hand, there is Gelephu City in Sarpang Dzongkhag. Administrative organizations of cities are independent of the dzongkhag administration.

Each gewog has an office, basically comprising seven officers; a head of gewog and a deputy head, who are elected every five years, two gewog officers and three RNR extension officers (agriculture, forestry and livestock). In accordance with the situation of gewogs, engineers are added to the basic officers. When size of gewog is big, 1-3 supplementary extension officers are assigned. Though maintenance of irrigation facilities and farming support/ propagation in irrigation schemes are tasks of agriculture extension officers, the extension system is not enough arranged. Irrigation schemes are scattered and they have problems, such as shortage of extension officers, lack of adequate irrigation facilities, etc. Also, there is an elected head in a chiwog, which is a smallest unit of administration, comprising one or several villages. Villages are communities but not public organizations.

3.2.2 Budget for Agricultural Support in the Three Dzongkhags

In Dzongkhag Tenth Five Year Plan (2008 - 2013), planned outlays for each sector in the targeted three dzongkhags are indicated as the next table. The sector which is allocated highest outlay is the "Works and Human Settlements", that takes about 30 percent of the total outlay for residential roads, waterworks, sanitation, parks, waste treatment, flood control, etc. The second highest sector is

"Agriculture Development", which means cultivation and occupies 21 - 28 percent of the total outlay.

Table 3.2.2 Planned Outlay for Each Sector in Dzongkhag Tenth Five Year Plan

Items	Samtse		Sarpang		S/Jhongkhar		Total	
	(Mil.Nu.)	(%)	(Mil.Nu.)	(%)	(Mil.Nu.)	(%)	(Mil.Nu.)	(%)
Agriculture Development	233.332	20.8	134.682	27.6	131.940	22.8	499.954	22.9
Livestock Development	47.518	4.2	17.109	3.5	23.860	4.1	88.487	4.0
Forestry Development	43.039	3.8	19.960	4.1	12.396	2.1	75.395	3.4
Health Development	302.127	27.0	81.914	16.8	113.125	19.5	497.166	22.7
Works and Human Settlements	306.902	27.4	199.710	41.0	191.446	33.1	698.058	31.9
Administration and Management	186.573	16.7	34.000	7.0	106.391	18.4	326.964	15.0
Total	1,119.491	100.0	487.375	100.0	579.158	100.0	2,186.024	100.0

Source: Dzongkhag Tenth Five Year Plan (2008-2013)

However, about 70 percent of the outlay for the agriculture development is allocated for agricultural roads, which includes construction cost of farmers' service centers though the ratio is small. Outlay for construction/ maintenance of irrigation facilities is only 7 - 16 percent of the outlay for the agriculture development. The average of annual planned outlay for construction/ maintenance of irrigation facilities in a dzongkhag is about five million Nu. The details of the outlay for the agriculture development in the three dzongkhags are shown in the next table.

Table 3.2.3 The Details of the Planned Outlay for the Agriculture Development

Items	Samtse		Sarpang		S/Jhongkhar		Total	
	(Mil.Nu.)	(%)	(Mil.Nu.)	(%)	(Mil.Nu.)	(%)	(Mil.Nu.)	(%)
Construction/Maintenance of farm road & farmers service centres	173.551	67.1	89.580	54.4	105.529	80.0	368.660	66.4
Construction/Maintenance of irrigation channel	37.660	14.6	26.395 *	16.0	9.504	7.2	73.559	13.2
Construction/Renovation of RNR centre	28.450	11.0	30.000	18.2	11.500	8.7	69.950	12.6
Cash crop development	5.295	2.0	3.551	2.2	0.745	0.6	9.591	1.7
Extension and support services	3.500	1.4	3.243	2.0	1.100	0.8	7.843	1.4
Cereal & oil crop development	3.760	1.5	2.175	1.3	0.970	0.7	6.905	1.2
Others	6.554	2.5	9.738	5.9	2.592	2.0	18.884	3.4
Total	258.770	100.0	164.682	100.0	131.940	100.0	555.392	100.0

Source: Dzongkhag Tenth Five Year Plan (2008-2013) / Hearing from DAO in Sarpang
Note*: The budget of irrigation channel in Sarpang was estimated by the expenditure in 2011/2012.

3.2.3 Population, Industry and Employment

(1) Population in the three targeted dzongkhags

In 2010, the population of Samtse Dzongkhag was 65,000, Sarpang Dzongkhag was 41,000 and Samdrup Jongkhar was 37,000. The total of the three dzongkhags was 144,000, which makes up 21 % of the total population (696,000) of Bhutan. The total number of households in the three dzongkhags was 27,000, i.e. 19 % of the total households in Bhutan, estimated at 139,000. The average number of household members in the three dzongkhags was 5.4, which was more than the national average, 5.0 persons/household.

Table 3.2.4 Estimated Population in the Targeted Three Dzongkhags in 2010

Dzongkhag	Population	Households	Average members (persons/household)	Land area (sq. km)	Population density (persons/sq.km)
Samtse	65,387	11,634	5.6	1,309	50
Sarpang	41,300	7,346	5.6	1,946	21
Samdrup Jongkhar	37,306	7,807 *	4.8 *	1,878	20
Total / Average	143,993	26,787	5.4	5,133	28
Bhutan	695,822	139,164	5.0	38,394	18

Source: Annual Dzongkhag Statistics 2010/ Statistical Yearbook of Bhutan 2010

Note: *The "Average members" of Samdrup Jongkhar is the number in 2005 and the "Households" is caluculated backwards.

Though the total population of the three dzongkhags is 21 % of the country, the area proportion of the three dzongkhags is only 13 %. Thus, the average population density of the three dzongkhags is 28 persons/km^2, which is 50 % higher than the national average of 18 persons/km^2. Especially, the population density of Samtse Dzongkhag is very high. It is 50 persons/km^2, which is 2.8 times the national average.

(2) Industry and employment

The average proportion of persons who are engaged in agriculture in the threee dzongkhags is 52 %, which is 7 % higher than the national average. Next to the agriculture, the average of services sector is 19 %, which is 1 % lower than the national average, and the average for industry sector is 10 %, which is 6 % lower than the national average. Particularly, in Samtse Dzongkhag, nearly 70 % of the work force is engaged in the agriculture sector. The proportion of agriculture sector in Sarpang Dzongkhag remains at 38 % but the ratio of the services sector is high at 24 %. Agriculture is the most important sector that absorbs employment in the three dzongkhags though there is difference of agricultural employment ratio among the three. In order to secure continuous employment, construction of agricultural infrastructure, such as irrigation facilities, farming roads, etc., is a big problem to be solved in the local administration as well as construction of living infrastructure.

Table 3.2.5 Employment Ratio of the Key Industries in the Targeted Three Dzongkhags (%)

Dzongkhag	Agriculture	Industry	Services	Others
Samtse	67.8	10.5	11.5	10.2
Sarpang	38.2	12.9	23.5	25.3
Samdrup Jongkhar	48.7	7.8	21.6	21.9
Average	51.6	10.4	18.9	19.1
Bhutan	44.8	16.0	19.7	19.6

Source: Socio-Economic and Demographic Indicators 2005

(3) Resettlement

RGoB has supported farmers who live in the northern/ central areas and want to resettle to the southern areas since the latter half of the nineties. The Government provides land for them free. The next table shows number of resettled households in each gewog in Sarpang Dzongkhag. Eleven gewogs excluding Dovan Gewog, that is located in the north of the Dzongkhag, have resettlers. The proportion of resettled households to the whole housheols in the eleven gewogs reasches 40 percent.

However, more than half of the resettlers came to Sarpang before 2000, which means that 13 years has already passed. The gewogs in the subsequent table are arrenged from the western gewogs to the eastern gewogs in order from the up line to the bottom line. The table shows that the ratios of resettled households to the whole housholds in the three eastern gewogs exceed 70 percent.

Table 3.2.6 The State of the Resettlement in Sarpang Dzongkhag

Gewogs	Number of resettled households											%	Whole household
	1997	1998	1999	2000	2001	2002	2003	2006	2007	Others	Total		
Senge	-	-	-	-	-	-	-	114	8	-	122	54	228
Hiley	-	-	-	-	28	2	1	14	-	-	45	14	326
Shompangkhha	-	-	13	16	2	4	2	-	-	-	37	15	243
Dekiling	1	88	29	1	19	15	87	41	-	33	314	47	675
Bhur	-	-	-	-	-	34	17	-	-	-	51	20	249
Gelephu	-	62	-	-	4	8	21	-	-	1	96	23	412
Jigmechoeling	93	2	2	-	-	-	-	1	16	1	115	22	518
Sherzhong	51	4	5	1	1	2	1	-	-	-	65	21	304
Chhuzargang	237	37	23	-	-	35	2	-	4	-	338	74	458
Umiling	144	-	54	49	18	37	5	14	4	-	325	80	406
Taraythang	-	-	-	-	-	-	-	75	2	-	77	78	99
Total	526	193	126	67	72	137	136	259	34	35	1,585	40	3,918
%	33	12	8	4	5	9	9	16	2	2	100		

Source: DAO, Sarpang/ Sarpang Dzongkhag Statistics 2008

Though RGoB provided land of five acre to the all resettlers until 2008, the system was reviewed and the area of provided land was decided to be 0.5-5.0 Ac per household. The size of the land is calculated based on number of family member, number of resident, number of farmer, soil condition, distance from a town and size of the town. The support for those resettlers is conducted under the agricultural promortion policy in southern Bhutan by RGoB.

On the other hand, resettlers earn their daily bread through farming in the provided land but resettled households which are obliged to bear severe livelihood are not a few cases. Environment and farming ways in the southern area are totally different from the northern/ central area where the resettlers used to live. Therefore, in some gewogs, small scale income-generation projects for resettled households are implemented, leading by agriculture extension officers. Hence, support for agriculture in the southern area, that has high need, is also important from the view point of support for resettlers.

3.2.4 Social Infrastructure

(1) Electric power

In this section, electrification ratios as of 2012 in the targeted three dzongkhags are estimated. Of late, electricity use is expanded rapidly. Firstly, the number of electrified households in 2005 was estimated, using statistical data on main sources of lighting. The average electrification ratio of the three dzongkhags was 47 %. The ratio of Sarpang Dzongkhag was 58 %, which was the highest ratio in the three dzongkhags. (See Table 3.2.4)

Table 3.2.7 Number of Electrified Households in the Targeted Three Dzongkhags (in 2005)

Dzongkhag	Total households 2005	Main source of lighting in 2005			Electrified households 2005
		Electricity (%)	Solar (%)	Sum (%)	
Samtse	11,634	40.5	0.7	41.2	4,793
Sarpang	7,346	56.9	0.7	57.6	4,231
Samdrup Jongkhar	6,951	41.2	2.7	43.9	3,051
Total / Average	25,931	46.2	1.4	47.6	12,076

Source: Socio-Economic and Demographic Indicators 2005

Secondly, the number of electrified households during 2006-2011 was estimated, based on the actual number of electrified households during 2003-2011, and the planned number of households to be electrified in 2012 was adjusted. Then, the planned number of electrified households as of 2012 was estimated, adding the estimated number in 2006-2011 and the planned number in 2012 to the number of electrified households as of 2005. The result of the estimation shows that the average number of the electrified households in the three dzongkhags until 2012 becomes 1.7 times of the number in 2005. The increase ratio of the number in Samtse Dzongkhag seems to be 1.9, which is the highest increase ratio of the three dzongkhags.

Table 3.2.8 Electrified Households Number in the Targeted Three Dzongkhags (planned in 2012)

Dzongkhag	Electrified households 2003-2011	Electrified households 2006-2011	Households to be electrified 2012	Electrified households as of 2012	Projected households 2012	Electrified percent 2012
Samtse	2,477	1,651	2,473	8,918	12,050	74.0
Sarpang	915	610	825	5,666	7,608	74.5
Samdrup Jongkhar	1,812	1,208	1,257	5,516	8,086	68.2
Total	5,204	3,469	4,555	20,100	27,744	72.4

Source: Hearing from Bhutan Power Corporation Ltd. in April 2012
Annual Dzongkhag Statistics 2010/ Statistical Yearbook of Bhutan 2010

Finally, the electrified ratio was calculated, using the estimated number of the electrified households in the three dzongkhags as of 2012. The result of the calculation shows that the electrified ratio in Sarpang Dzongkhag is 75 %, which is the highest electrified ratio, the ratio in Samdrup Jongkhar Dzongkhag is 68 %, which is the lowest ratio, and the average ratio of the three dzongkhags is 72 %. (See Table 3.3.5) In the field survey in May 2012, irrigation zones located in flat and hill lands in Sarpang Dzongkhag were checked. All households in the survey were electrified since the electrification had been progressed in those areas rapidly in recent years. It seems that almost all households in flat lands in the targeted three dzongkhags will be electrified until the end of the fisical year 2012, considering the plan of the Bhutan Power Corporation Ltd.

(2) Drinking water

The average ratio of households which use tap/ pipe water in the three dzongkhags in 2005 was 82 %, and the average ratio of households that use stream water is 16 %. In Samtse Dzongkhag, the saturation level of tap/ pipe water is lower about 6 % than the average of the three dzongkhags, and the use level of stream water is higher, too. The ratio of households which use wells (other sources) is low

because all areas have enough surface water.

Table 3.2.9 Drinking Water Sources in the Targeted Dzongkhags in 2005 (% of households)

Dzongkhag	Tap/pipe water	Stream water	Other sources
Samtse	75.7	22.5	1.8
Sarpang	86.3	12.5	1.2
Samdrup Jongkhar	84.1	14.3	1.6
Average	82.0	16.4	1.5

Source: Annual Dzongkhag Statistics 2010

Note: Stream water includes spring, river and pond.

The quality of drinking water is managed by the each dzongkhag. In the case of Sarpang Dzongkhag, quality check of drinking water is conducted every three months. It seems that the water quality is not a serious issue though measures are taken when some problems occur, such as moving livestock away from water sources and changing places of water sources.

According to the reslt of the field survey of irrigation schemes in Sarpang Dzongkhag, residents in irrigation schemes take drinking water from same rivers/ springs that they take irrigation water, whose water volume diminishes significantly in dry season. At present, irrigation water is not taken from those rivers/ springs in dry season. If irrigation water is taken in dry season in the future, it will compete with taking drinking water. It is necessarry for avoiding the competition to survey number of drinking water users, necessary volume of drinking water, etc. in accordance with survey of irrigation development.

3.2.5 Possession of Land

According to the DAO in Sarpang Dzongkhag, about 90 percent of agricultural land is farmers' own land and 10 percent is leased land. About a half of the leased land is national land and another half is private land. Annual tax of farming dry land is Nu. 12/Ac and wet land is Nu. 24/Ac, which are paid to each gewog office. About 70 percent of leased national land is graizing land and 30 percent is orchards, whose lessees pay annual land rent of Nu. 640/Ac to the local forest office. Though the lease period is 30 years, most lease is able to be extended if the lessees apply for the extention. Traditionally, the land rent of private land used to be a half of the harvest, however, almost of all cases seem to be 25 percent of the harvest in recent years.

It is necessarry for buying and selling of land or inheritance of land to register the land. The division of Survey and Land Records in Sarpang Dzongkhag registers about 300 plots of land every month. The details of the registration are; about 70 percent is buying and selling of residential land, about 20 percent is inheritance of land, and the remaining 10 percent is buying and selling of industrial land. The contents of the land registration are i) registration number, ii) village name, iii) owner name including his/her ID number, iv) map number, v) plot number, vi) use for, vii) land name, viii) plot number, ix) land area and x) tax amount. The registration fee is Nu. 400/plot for the buying and selling, and free for the inheritance. Original registration documents are sent to the land committee in Thimphu and the copyies are kept in the Dzohgkhag. According to the division of Survey and Land

Records, 4-5 troubles of land boundary occur every year in Sarpang Dzongkhag. When a trouble of boundary arises, the division staff remeasures the land at the site and delimits the boundary.

3.3 AGRICULTURE

3.3.1 Agricultural Land Use

(1) Agricultural land use in the Agro-ecological zone

Agricultural land use is classified into Wet land, Dry land, Tseri, Kitchen Garden, Orchard, Sokzhing and Tsamdrog by agro-ecological zones, as shown in the Table 3.3.1. Area of the wet land and dry land in the humid sub-tropical zone and wet sub-tropical zone is larger than that in the other zones.

Table 3.3.1 Agricultural Land Use by Agro-ecological Zones

Agro-ecological zone	Wet land		Dry land		Tseri		Kichen Garden		Orchard		Sokzhing		Tsamdrog	
	(acre)	(ha)	(acre)	(ha)	(acre)	(ha)	(acre)	(ha)	(acre)	(ha)	(acre)	(ha)	(acre)	(ha)
Alpine	243	98	349	141	<100	<40	<100	<40	<100	<40	138	56	5,121	2,072
Cool Temperate	350	142	5,039	2,039	6,108	2,472	255	103	165	67	451	183	14,725	5,959
Warm Temperate	4,576	1,852	7,600	3,076	2,089	845	425	172	2,513	1,017	5,342	2,162	92,212	37,316
Dry Sub-tropical	18,679	7,559	37,349	15,114	19,188	7,765	1,236	500	1,009	408	10,781	4,363	281,467	113,904
Humid sub-tropical + Wet syb-tropical	29,594	11,976	68,950	27,903	47,866	19,370	953	386	17,791	7,200	2,067	836	40,126	16,238

ɹurce: RNR Sector Tenth Plan (2008-2013)

Note: The zone (Humid sub-tropical + Wet syb-tropical) covers the Dzongkhags of Samtse, Tsirang, Zhemgang, Chhukha, Pemagatshel, Samdrup Jongkhar, Sarpang and Dagana.
Tseri: shifting cultivation, Sokzhing: forest, Tsamdrog: forest land unregistered grass land for livestock fodder

(2) Land use in the southrn three dzongkhags

For the moment let us look at the situation of the land use in the southern three dzongkhags. In 2010, the proportion of forest to the total area in the three dzongkhags is 85 %, the proportion of shrubs is 5 %, cultivated land is 7 %, and the proportion of water bodies is 2 %. The proportion of the cultivated land in Samtse Dzongkhag is 13 %, which is bigger than the three dzongkhags, and the proportion of forest is 78 %, which is smaller as that much. On the other hand, Sarpang and Samdrup Jongkhar Dzongkhags show almost same tendency with the whole three dzongkhags.

Table 3.3.2 Land Use in the Targeted Three Dzongkhags

Dzongkhag		Forest	Shrubs	Meadows	Cultivated land	Built up areas	Non-built up areas	Snow cover	Bare areas	Water bodies	Marshy areas	Degraded land	Total area
Samtse	(sq.km)	1,018.3	51.4	9.9	173.7	2.9	2.1	2.9	0.9	34.9	0.0	8.2	1,305.2
	(%)	78.0	3.9	0.8	13.3	0.2	0.2	0.2	0.1	2.7	0.0	0.6	100.0
Sarpang	(sq.km)	1,466.1	83.7	0.5	66.5	3.2	0.0	0.0	2.5	38.4	0.0	5.3	1,666.2
	(%)	88.0	5.0	0.0	4.0	0.2	0.0	0.0	0.1	2.3	0.0	0.3	100.0
S/Jongkhar	(sq.km)	1,632.8	110.8	4.1	81.3	4.1	0.3	0.0	9.3	25.8	0.0	9.5	1,877.9
	(%)	86.9	5.9	0.2	4.3	0.2	0.0	0.0	0.5	1.4	0.0	0.5	100.0
Total	(sq.km)	4,117.3	245.9	14.5	321.6	10.1	2.4	2.9	12.7	99.1	0.0	22.9	4,849.3
	(%)	84.9	5.1	0.3	6.6	0.2	0.0	0.1	0.3	2.0	0.0	0.5	100.0

Source: Bhutan Land Cover Assessment 2010

Agricultural land in the three dzongkhags, which was divided into wet land (paddy field), dry land (ordinary field) and cash crop land (orchard), was added up in the next table. The proportion of paddy field in the three dzongkhags is 20 %, ordinary field is 66 %, and orchard is 14 %. The proportion of the agricultural land use in Samtse Dzongkhag is similar to the whole three dzongkhags. We can say paddy cultivation in Sarpang Dzongkhag is comparatively popular in the three dzongkhags since the proportion of paddy field is 6 % and orchard is 4 % higher than those of the whole three dzongkhags. It seems that field cropping in Samdrup Jongkhar Dzongkhag is prospering, compared to the other dzongkhags, since the proportion of ordinary field is 13 % higher than that of the whole three

dzongkhags.

Table 3.3.3 Agricultural Land Use in the Targeted Three Dzongkhags in 2009

Dzongkhag	Wet land		Dry land		Cash crop land		Total	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Samtse	3,318	21	10,318	65	2,253	14	15,889	100
Sarpang	1,903	26	4,181	56	1,350	18	7,434	100
Samdrup Jongkhar	863	14	5,067	79	451	7	6,381	100
Total	6,084	20	19,566	66	4,053	14	29,704	100

Source: Statistical Yearbook of Bhutan 2010

3.3.2 Agricultural Production

(1) Dzongkhag wise agricultural production

Cereals

Various crops are cultivated depending on the local climatic and topographic conditions. Cereal crops of paddy, corn and wheat are cultivated as major food security crops over the country. Above all, paddy and corn are the major crops, constituting 90% of the total cereal production. Next crops are the wheat/ barely, millets and buckwheat. Production of the paddy and corn in 2009 and 2010 of the three Dzongkhags and whole country is summarized as shown in the Table 3.3.4 and Table 3.3.5.

Table 3.3.4 Production of Paddy and Corn (2009)

Dzongkhag	Paddy			Maize		
	Harvested area (ha)	Production (MT)	Yield (ton/ha)	Harvested area (ha)	Production (MT)	Yield (ton/ha)
Samdrup Jongkhar	1,689	4,024	2.38	2,272	4,346	1.91
Samtse	3,054	6,266	2.05	4,393	8,624	1.96
Sarpang	2,067	4,157	2.01	2,237	3,403	1.52
Total	6,810	14,447	2.12	8,901	16,373	1.84
Bhutan	23,718	65,766	2.17	28,573	61,161	2.14
Share (%)	29	22		31	27	

Source: Agricultural Statistic 2009

Table 3.3.5 Production of Paddy and Corn (2010)

Dzongkhag	Paddy			Maize		
	Harvested area (ha)	Production (MT)	Yield (ton/ha)	Harvested area (ha)	Production (MT)	Yield (ton/ha)
Samdrup Jongkhar	953	3,032	3.18	1,879	5,251	2.80
Samtse	3,421	7,216	2.11	2,879	5,588	1.94
Sarpang	2,098	4,512	2.15	1,716	2,612	1.52
Total	6,473	14,760	2.28	6,474	13,451	2.08
Bhutan	22,815	71,726	3.14	24,881	57,663	2.32
Share (%)	28	21		26	23	

Source: Agricultural Statistic 2010

Production of paddy and corn in the three Dzongkhags occupies 22% in 2009(21% in 2010) and 27% (23%) of the whole country. However, the yield of around 2.0 ton/ha is lower than the average of whole country. In general, agricultural production activity in the country is significantly constrained

by small size of terrace farming. Small terrace prevents expansion of farm mechanization. In addition, self-sufficient farmer have little incentive to increase yields and maximize cropping intensity or invest in land improvements for commercial agriculture. Especially for the southern zones, other constraining factors that have encumbered improvement of agricultural productivity are poor soil fertility, non-functional irrigation system or lack of irrigation facilities, associated low level of nitrogen and lack of access to high quality seeds. In addition, paddy production is limited due largely to a shortage of arable land and farm labor, low cropping intensity, and crop loss to pest and wild animals. (To promote paddy cropping, "Field Manual for RICE PRODUCTION IN LOW ALTITUDE ZONE" (DoA, February 2011) was prepared. Concrete promotion activities are not taken at present.)

Table 3.3.6 Cereals Crops Production in 2009 (1/2)

Dzongkhag	Paddy				Maize				Wheat			
	Harvested Area		Production	Yield	Harvested Area		Production	Yield	Harvested Area		Production	Yield
	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)
Bumthang	28	11	27	2.38	17	7	12	1.74	760	308	338	1.10
Chukha	1,752	709	1,581	2.23	4,314	1,746	3,163	1.81	410	166	215	1.30
Dagana	3,967	1,605	3,163	1.97	7,515	3,041	4,738	1.56	90	36	40	1.10
Gasa	166	67	197	2.93	3	1	3	2.47	107	43	54	1.25
Haa	97	39	92	2.34	254	103	182	1.77	725	293	325	1.11
Lhuentse	2,216	897	3,287	3.67	2,563	1,037	2,873	2.77	19	8	9	1.17
Mongar	1,420	575	1,649	2.87	8,855	3,584	11,625	3.24	79	32	31	0.97
Punakha	4,686	1,896	9,027	4.76	72	29	123	4.22	804	325	512	1.57
Paro	125	51	96	1.90	3,482	1,409	3,283	2.33	37	15	10	0.67
Pemagatshel	8,518	3,447	12,981	3.77	492	199	441	2.21	1,309	530	577	1.09
Samdrup Jongkhar	4,173	1,689	4,024	2.38	5,613	2,272	4,346	1.91	106	43	27	0.63
Samtse	7,547	3,054	6,266	2.05	10,854	4,393	8,624	1.96	354	143	167	1.17
Sarpang	5,108	2,067	4,157	2.01	5,527	2,237	3,403	1.52	22	9	4	0.45
Thimphu	650	263	1,054	4.01	5	2	4	1.98	176	71	112	1.57
Trashigang	2,198	890	3,124	3.51	6,630	2,683	7,065	2.63	79	32	76	2.38
Trashiyangtse	1,477	598	1,656	2.77	1,930	781	2,236	2.86	39	16	21	1.33
Trongsa	2,135	864	2,176	2.52	2,169	878	1,860	2.12	635	257	361	1.40
Tsirang	5,640	2,283	4,255	1.86	6,630	2,683	3,829	1.43	104	42	40	0.95
Wangdue	5,437	2,200	5,837	2.65	452	183	323	1.77	1,676	678	666	0.98
Zhemgang	1,267	513	1,117	2.18	3,226	1,306	3,028	2.32	177	72	93	1.30
(1) Bhutan	58,607	23,718	65,766	2.77	70,603	28,573	61,161	2.14	7,708	3,119	3,678	1.18
(2) Total of three Dzongkhags	16,828	6,810	14,447	2.12	21,994	8,901	16,373	1.84	482	195	198	1.02
Share (2)/(1) (%)	29	29	22		31	31	27		6	6	5	

Dzongkhag	Barly				Finger Millet				Foxtail Millet			
	Harvested Area		Production	Yield	Harvested Area		Production	Yield	Harvested Area		Production	Yield
	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)
Bumthang	450	182	162	0.89								
Chukha	71	29	28	0.97	1,046	423	395	0.93	90	36	41	1.13
Dagana	38	15	11	0.72	1,042	422	318	0.75	73	30	25	0.85
Gasa	88	36	44	1.24								
Haa	48	19	28	1.44	164	66	64	0.96	6	2	2	0.82
Lhuentse	15	6	5	0.82	91	37	64	1.74	10	4	6	1.48
Mongar	2,073	839	945	1.13	78	32	26	0.82	57	23	17	0.74
Punakha	128	52	150	2.90	4	2	3	1.85				
Paro	46	19	27	1.45	14	6	9	1.59	29	12	40	3.41
Pemagatshel	33	13	13	0.97	161	65	71	1.09	463	187	222	1.18
Samdrup Jongkhar	228	92	89	0.96	241	98	78	0.80	137	55	58	1.05
Samtse	76	31	36	1.17	2,514	1,017	974	0.96	358	145	120	0.83
Sarpang	7	3	5	1.76	1,624	657	779	1.19	42	17	24	1.41
Thimphu	29	12	7	0.60								
Trashigang	735	297	411	1.38	88	36	39	1.10	22	9	8	0.90
Trashiyangtse	32	13	17	1.31	389	157	337	2.14	65	26	56	2.13
Trongsa	324	131	172	1.31	45	18	9	0.49	2	1	0	0.00
Tsirang	16	6	7	1.08	882	357	266	0.75	13	5	3	0.57
Wangdue	422	171	193	1.13	71	29	29	1.01				
Zhemgang	97	39	47	1.20	135	55	75	1.37	168	68	73	1.07
(1) Bhutan	4,956	2,006	2,397	1.20	8,589	3,476	3,536	1.02	1,535	621	695	1.12
(2) Total of three Dzongkhags	311	126	130	1.03	4,379	1,772	1,831	1.03	537	217	202	0.93
Share (2)/(1) (%)	6	6	5		51	51	52		35	35	29	

Source : Agriculture Statistics 2009

Table 3.3.7 Cereals Crops Production in 2009 (2/2)

Dzongkhag	Sweet buckheat				Bitter Buckwheat			
	Harvested Area		Production	Yield	Harvested Area		Production	Yield
	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)
Bumthang	446	180	150	0.83	457	185	156	0.84
Chukha	616	249	354	1.42	247	100	120	1.20
Dagana	352	142	158	1.11	217	88	69	0.79
Gasa	0	0	0	0.00				
Haa	280	113	97	0.86	356	144	145	1.01
Lhuentse	5	2	0	0.00	3	1	1	0.82
Mongar	399	161	125	0.77	192	78	62	0.80
Punakha	22	9	15	1.68	131	53	57	1.08
Paro	268	108	90	0.83	104	42	171	4.06
Pemagatshel	29	12	15	1.28	306	124	94	0.76
Samdrup Jongkhar	1,047	424	388	0.92	114	46	50	1.08
Samtse	622	252	223	0.89	181	73	65	0.89
Sarpang	277	112	73	0.65	33	13	9	0.67
Thimphu								
Trashigang	443	179	141	0.79	169	68	98	1.43
Trashiyangtse	21	8	14	1.65	16	6	7	1.08
Trongsa	428	173	251	1.45	436	176	171	0.97
Tsirang	148	60	37	0.62	48	19	8	0.41
Wangdue	71	29	27	0.94	749	303	250	0.82
Zhemgang	129	52	82	1.57	162	66	85	1.30
(1) Bhutan	5,603	2,268	2,240	0.99	3,921	1,587	1,618	1.02
(2) Total of three Dzongkhags	1,946	788	684	0.87	328	133	124	0.93
Share (2)/(1) (%)	35	35	31		8	8	8	

Source: Agriculture Statistics 2009

Table 3.3.8 Cereals Crops Production in 2010

Dzongkhag	Paddy				Maize				Wheat			
	Harvested Area		Production	Yield	Harvested Area		Production	Yield	Harvested Area		Production	Yield
	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)
Bumthang	175	71	236	3.33	2	1	1	1.24	872	353	455	1.29
Chukha	2,934	1,187	2,760	2.32	4,917	1,990	3,247	1.63	212	86	156	1.82
Dagana	4,465	1,807	4,085	2.26	5,600	2,266	3,208	1.42	29	12	25	2.13
Gasa	267	108	308	2.85					69	28	56	2.01
Haa	123	50	163	3.27	337	136	236	1.73	1,016	411	1,414	3.44
Lhuentse	1,917	776	2,861	3.69	2,195	888	2,852	3.21	16	6	20	3.09
Mongar	779	315	868	2.75	8,793	3,559	10,751	3.02	48	19	33	1.70
Punakha	6,522	2,639	12,425	4.71	187	76	205	2.71	705	285	622	2.18
Paro	6,784	2,745	12,403	4.52	6	2	9	3.71	630	255	394	1.55
Pemagatshel	50	20	68	3.36	4,377	1,771	4,024	2.27	18	7	10	1.37
Samdrup Jongkhar	2,356	953	3,032	3.18	4,642	1,879	5,251	2.80	35	14	45	3.18
Samtse	8,454	3,421	7,216	2.11	7,115	2,879	5,588	1.94	153	62	108	1.74
Sarpang	5,185	2,098	4,512	2.15	4,239	1,716	2,612	1.52	8	3	3	0.93
Thimphu	879	356	1,499	4.21	13	5	8	1.52	235	95	121	1.27
Trashigang	1,435	581	2,410	4.15	5,721	2,315	8,299	3.58	160	65	210	3.24
Trashiyangtse	931	377	1,443	3.83	1,441	583	2,049	3.51				
Trongsa	1,577	638	1,807	2.83	1,381	559	1,291	2.31	420	170	330	1.94
Tsirang	4,347	1,759	4,218	2.40	5,031	2,036	2,994	1.47	53	21	25	1.17
Wangdue	5,237	2,119	7,645	3.61	212	86	294	3.43	764	309	756	2.45
Zhemgang	1,957	792	1,767	2.23	5,272	2,134	4,744	2.22	121	49	89	1.82
(1) Bhutan	56,374	22,815	71,726	3.14	61,481	24,881	57,663	2.32	5,564	2,252	4,872	2.16
(2) Total of three Dzongkhags	15,995	6,473	14,760	2.28	15,996	6,474	13,451	2.08	196	79	156	1.97
Share (2)/(1) (%)	28	28	21		26	26	23		4	4	3	

Dzongkhag	Barly				Millet				Backwheat			
	Harvested Area		Production	Yield	Harvested Area		Production	Yield	Harvested Area		Production	Yield
	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)
Bumthang	419	170	211	1.24					1,098	444	522	1.17
Chukha	202	82	56	0.69	2,093	847	793	0.94	1,310	530	584	1.10
Dagana	45	18	20	1.10	926	375	442	1.18	427	173	174	1.01
Gasa	27	11	29	2.65								
Haa	9	4	12	3.29	109	44	66	1.50	440	178	255	1.43
Lhuentse	8	3	7	2.16	102	41	79	1.91				
Mongar	1,285	520	606	1.17	81	33	26	0.79	220	89	114	1.28
Punakha	27	11	19	1.74	11	4	2	0.45	24	10	26	2.68
Paro	68	28	70	2.54	3	1	1	0.82	106	43	59	1.38
Pemagatshel	26	11	20	1.90	333	135	130	0.96	506	205	137	0.67
Samdrup Jongkhar	108	44	96	2.20	324	131	199	1.52	968	392	691	1.76
Samtse	31	13	20	1.59	2,375	961	1,161	1.21	271	110	135	1.23
Sarpang	7	3	2	0.71	898	363	595	1.64	51	21	27	1.31
Thimphu	6	2	5	2.06								
Trashigang	132	53	111	2.08	108	44	48	1.10	654	265	337	1.27
Trashiyangtse					210	85	109	1.28				
Trongsa	102	41	46	1.11	78	32	16	0.51	888	359	386	1.07
Tsirang	6	2	2	0.82	458	185	222	1.20	16	6	14	2.16
Wangdue	124	50	95	1.89	81	33	22	0.67	302	122	311	2.54
Zhemgang	21	8	20	2.35	264	107	153	1.43	225	91	179	1.97
(1) Bhutan	2,653	1,074	1,447	1.35	8,454	3,421	4,064	1.19	7,506	3,038	3,951	1.30
(2) Total of three Dzongkhags	146	59	118	2.00	3,597	1,456	1,955	1.34	1,290	522	853	1.63
Share (2)/(1) (%)	6	6	8		43	43	48		17	17	22	

Source: Agriculture Statistics 2010

Vegetable and Cash Crops

A variety of vegetables are cultivated in the country. Most crops are produced for home consumption on a subsistence basis. Major cultivated crops are the potato, chili, radish, beans, tomato, carrot, cabbage, ginger and garlic. Some of them are sold in a market. Potato and chili are the major cash crops. Especially, potato is the most important cash crop in the country. Production area is located mostly at mid and higher altitude zones. Most of them are sold through the Food Corporation of Bhutan (FCB) auction yard and exported to Bangladesh and India. (Export of potatoes, fresh or chili is ranked tenth of the top ten commodities (source: Statistical Yearbook of Bhutan 2010.) Potato is one of the major crops with higher export level than import. The other positive products are apple, orange, cardamom, and lemon grass oil.

In the southern zone, Ginger and Cardamom are the most cash crops. Ginger production was 68% (2009) and 80% (2010) of the country's total production, cardamom by 79% (2009) and 48% (2010).

Table 3.3.9 Major Vegetable Production (2009)

Dzongkhag	Bean				Potato				Chilli			
	Harvested Area		Production	Yield	Harvested Area		Production	Yield	Harvested Area		Production	Yield
	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)
Bumthang	24	10	11	1.13	998	404	4,042	10.01	32	13	79	6.10
Chukha	130	53	142	2.70	528	214	3,125	14.62	126	51	265	5.20
Dagana	174	70	63	0.89	213	86	292	3.39	235	95	84	0.88
Gasa	4	2	2	1.24	53	21	73	3.40	22	9	24	2.70
Haa	21	8	21	2.47	552	223	3,347	14.98	31	13	35	2.79
Lhuentse	73	30	94	3.18	229	93	557	6.01	251	102	553	5.44
Mongar	386	156	417	2.67	1,618	655	3,781	5.77	842	341	1,252	3.67
Punakha	99	40	85	2.12	1,284	520	3,496	6.73	972	393	2,131	5.42
Paro	115	47	58	1.25	352	142	1,398	9.81	139	56	93	1.65
Pemagatshel	245	99	328	3.31	123	50	284	5.71	481	195	1,217	6.25
Samdrup Jongkhar	119	48	90	1.87	537	217	827	3.81	269	109	175	1.61
Samtse	154	62	74	1.19	188	76	154	2.02	91	37	40	1.09
Sarpang	107	43	53	1.22	89	36	101	2.80	60	24	35	1.44
Thimphu	13	5	20	3.80	537	217	1,735	7.98	117	47	276	5.83
Trashigang	143	58	85	1.47	1,420	575	3,687	6.42	535	217	884	4.08
Trashiyangtse	136	55	50	0.91	519	210	1,260	6.00	443	179	494	2.76
Trongsa	49	20	32	1.61	118	48	254	5.32	290	117	393	3.35
Tsirang	123	50	50	1.00	273	110	312	2.82	175	71	107	1.51
Wangdue	94	38	90	2.37	2,322	940	17,117	18.22	435	176	608	3.45
Zhemgang	63	25	56	2.20	201	81	319	3.92	138	56	141	2.52
(1) Bhutan	2,272	919	1,821	1.98	12,154	4,919	46,161	9.38	5,684	2,300	8,886	3.86
(2) Total of three Dzongkhags	380	154	217	1.41	814	329	1,082	3.28	420	170	250	1.47
Share (2)/(1) (%)	17	17	12		7	7	2		7	7	3	

Dzongkhag	Cabbage				Ginger				Cardamon			
	Harvested Area		Production	Yield	Harvested Area		Production	Yield	Harvested Area		Production	Yield
	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)
Bumthang	51	21	59	2.86								
Chukha	42	17	124	7.30	343	139	749	5.40	443	179	27	0.15
Dagana	27	11	27	2.47	129	52	39	0.75	673	272	25	0.09
Gasa	14	6	8	1.41								
Haa	18	7	46	6.31					431	174	29	0.17
Lhuentse	62	25	89	3.55	6	2	4	1.65				
Mongar	187	76	316	4.18	53	21	21	0.98				
Punakha	146	59	352	5.96					3	1	1	0.82
Paro	38	15	29	1.89								
Pemagatshel	3	1	4	3.29	45	18	25	1.37				
Samdrup Jongkhar	47	19	44	2.31	280	113	563	4.97	11	4	3	0.67
Samtse	35	14	18	1.27	930	376	1,718	4.56	3,523	1,426	342	0.24
Sarpang	21	8	19	2.24	523	212	513	2.42	21	8	2	0.24
Thimphu	27	11	27	2.47								
Trashigang	148	60	100	1.67	38	15	13	0.85	4	2	1	0.62
Trashiyangtse	59	24	104	4.36	15	6	8	1.32				
Trongsa	80	32	90	2.78	3	1	1	0.82	15	6	2	0.33
Tsirang	58	23	52	2.22	127	51	72	1.40	5	2	1	0.49
Wangdue	86	35	231	6.64	25	10	14	1.38				
Zhemgang	40	16	36	2.22	27	11	23	2.10				
(1) Bhutan	1,189	481	1,775	3.69	2,544	1,030	3,763	3.65	5,129	2,076	433	0.21
(2) Total of three Dzongkhags	103	42	81	1.94	1,733	701	2,794	3.98	3,555	1,439	347	0.24
Share (2)/(1) (%)	9	9	5		68	68	74		69	69	80	

Source : Agriculture Statistics 2009

Table 3.3.10 Major Vegetable Production (2010)

Dzongkhag	Bean				Potato				Chilli			
	Harvested Area		Production	Yield	Harvested Area		Production	Yield	Harvested Area		Production	Yield
	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)
Bumthang	10	4	20	4.94	1,239	501	5,808	11.58	33	13	65	4.87
Chukha	101	41	116	2.84	1,208	489	6,349	12.99	237	96	200	2.09
Dagana	132	53	39	0.73	76	31	181	5.88	262	106	231	2.18
Gasa	5	2	4	1.98	48	19	108	5.56	30	12	28	2.31
Haa	49	20	24	1.21	489	198	2,277	11.51	90	36	65	1.78
Lhuentse	41	17	64	3.86	35	14	146	10.31	362	147	357	2.44
Mongar	266	108	138	1.28	668	270	2,502	9.26	980	397	721	1.82
Punakha	152	62	281	4.57	29	12	117	9.97	642	260	771	2.97
Paro	47	19	75	3.94	1,078	436	5,233	11.99	923	374	875	2.34
Pemagatshel	242	98	100	1.02	188	76	1,002	13.17	167	68	170	2.52
Samdrup Jongkhar	111	45	78	1.74	159	64	498	7.74	336	136	354	2.60
Samtse	98	40	60	1.51	23	9	98	10.53	114	46	109	2.36
Sarpang	83	34	45	1.34	7	3	21	7.41	62	25	51	2.03
Thimphu	9	4	17	4.67	690	279	5,481	19.63	233	94	197	2.09
Trashigang	359	145	103	0.71	1,079	437	4,192	9.60	895	362	919	2.54
Trashiyangtse	95	38	41	1.07	133	54	591	10.98	430	174	422	2.42
Trongsa	34	14	25	1.82	378	153	1,954	12.77	304	123	283	2.30
Tsirang	197	80	106	1.33	45	18	73	4.01	275	111	169	1.52
Wangdue	48	19	75	3.86	1,671	676	9,285	13.73	524	212	594	2.80
Zhemgang	43	17	32	1.84	23	9	98	10.53	85	34	117	3.40
(1) Bhutan	2,122	859	1,443	1.68	9,266	3,750	46,014	12.27	6,984	2,826	6,698	2.37
(2) Total of three Dzongkhags	292	118	183	1.55	189	76	617	8.07	512	207	514	2.48
Share (2)/(1) (%)	14	14	13		2	2	1		7	7	8	

Dzongkhag	Cabbage				Ginger				Cardamon			
	Harvested Area		Production	Yield	Harvested Area		Production	Yield	Harvested Area		Production	Yield
	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)	(Acre)	(ha)	(MT)	(ton/ha)
Bumthang	19	8	53	6.89								
Chukha	29	12	30	2.56	322	130	637	4.89	1,814	734	439	0.60
Dagana	38	15	18	1.17	54	22	24	1.10	499	202	122	0.60
Gasa	3	1	3	2.47								
Haa	18	7	31	4.26	1	0	1	2.47	142	57	34	0.59
Lhuentse	35	14	54	3.81	4	2	5	3.09				
Mongar	86	35	70	2.01	35	14	23	1.62				
Punakha	13	5	36	6.84	1	0	1	2.47				
Paro	140	57	360	6.35								
Pemagatshel	35	14	40	2.82	114	46	24	0.52				
Samdrup Jongkhar	30	12	39	3.21	218	88	370	4.19	5	2	1	0.49
Samtse	22	9	19	2.13	937	379	2,458	6.48	2,211	895	551	0.62
Sarpang	28	11	29	2.56	300	121	390	3.21	70	28	9	0.32
Thimphu	15	6	31	5.11								
Trashigang	113	46	130	2.84	25	10	13	1.28				
Trashiyangtse	81	33	119	3.63	19	8	8	1.04				
Trongsa	49	20	107	5.40	13	5	8	1.52	30	12	7	0.58
Tsirang	52	21	36	1.71	101	41	93	2.28				
Wangdue	37	15	77	5.14	6	2	7	2.88				
Zhemgang	20	8	18	2.22	18	7	13	1.78				
(1) Bhutan	863	349	1,300	3.72	2,168	877	4,075	4.64	4,771	1,931	1,163	0.60
(2) Total of three Dzongkhangs	80	32	87	2.69	1,455	589	3,218	5.46	2,286	925	561	0.61
Share (2)/(1) (%)	9	9	7		67	67	79		48	48	48	

Source : Agriculture Statistics 2010

Fruits and Industrial Crops

Mandarin/ oranges and apples exported to India and Bangladesh are the major cash fruits in the country. Apple fruit, however, is produced in the higher altitude zone. For lower altitude zone, mandarin is the major fruits in the southern zone, occupied 33% (2009), 27% (2010) of the country's production. Mango and banana are also produced under the southern sub-tropical climatic condition. Areca nut in the southern zone is ranked as the top industrial crop, occupied 82 % (2009) and 79% (2010) of the country's production.

Table 3.3.11 Cash Crops and Fruits Production (2009)

Dzongkhag	Areca nut				Banana			
	Number of Trees	Bearing Tress	Production (MT)	Yield (kg/tree)	Number of Trees	Bearing Tress	Production (MT)	Yield (kg/tree)
Samdrup Jongkhar	144,764	82,686	1,097	13	27,842	12,225	162	13
Samtse	521,978	176,728	2,420	14	135,678	36,399	460	15
Sarpang	750,610	183,624	1,708	9	130,038	38,761	588	15
(1) Bhutan	1,703,168	585,649	6,375	11	594,775	165,756	2,183	13
(2) Total of three Dzongkhangs	1,417,352	443,038	5,225		293,558	87,385	1,210	
Share (2)/(1) (%)	83	76	82		49	53	55	

Dzongkhag	Mandarin				Mango			
	Number of Trees	Bearing Tress	Production (MT)	Yield (kg/tree)	Number of Trees	Bearing Tress	Production (MT)	Yield (kg/tree)
Samdrup Jongkhar	272,601	123,852	3,371	27	3,302	625	14	22
Samtse	166,453	109,731	2,679	24	2,173	557	25	45
Sarpang	326,431	193,100	8,430	44	8,002	1,105	31	28
(1) Bhutan	2,804,287	1,570,380	44,177	28	44,101	13,279	315	24
(2) Total of three Dzongkhangs	765,485	426,683	14,480		13,477	2,287	70	
Share (2)/(1) (%)	27	27	33		31	17	22	

Source : Agriculture Statistics 2009

Table 3.3.12 Cash Crops and Fruits Production (2010)

Dzongkhag	Areca nut				Banana			
	Number of Trees	Bearing Tress	Production (MT)	Yield (kg/tree)	Number of Trees	Bearing Tress	Production (MT)	Yield (kg/tree)
Samdrup Jongkhar	98,815	59,685	527	9	36,989	10,258	120	12
Samtse	677,442	231,289	3,129	14	107,117	32,542	439	13
Sarpang	683,440	256,064	2,103	8	91,732	33,540	511	15
(1) Bhutan	1,796,999	718,770	7,280	10	558,370	162,850	2,208	14
(2) Total of three Dzongkhangs	1,459,697	547,038	5,759		235,838	76,340	1,070	
Share (2)/(1) (%)	81	76	79		42	47	48	

Dzongkhag	Mandarin				Mango			
	Number of Trees	Bearing Tress	Production (MT)	Yield (kg/tree)	Number of Trees	Bearing Tress	Production (MT)	Yield (kg/tree)
Samdrup Jongkhar	243,404	108,250	3,747	35	5,475	1,286	36	28
Samtse	202,265	128,373	3,214	25	3,234	1,011	32	32
Sarpang	294,804	169,332	7,173	42	4,865	1,452	58	40
(1) Bhutan	2,968,370	1,575,133	52,621	33	46,036	13,460	398	30
(2) Total of three Dzongkhangs	740,473	405,955	14,134		13,574	3,749	126	
Share (2)/(1) (%)	25	26	27		29	28	32	

Source : Agriculture Statistics 2010

(2) Gewog wise agriculture production

Agricultural crops cultivated in three Dzongkhags are listed as follows.

Table 3.3.13 Major Agriculture Produce in the Targeted Three Dzongkhags

Cereals	Paddy, Maize, Wheat, Barely, Buckwheat, Millets
Vegetables and Spices	Mustard, Carrot, Radish, Potato, Cardamom, Garlic, Ginger, Onion, Beans, Cabbage, Cauliflower, Chili, Egg plant, Green leaves, Peas, Tomato, Cucumber, Gourds, Pumpkin
Fruits/ Industrial crops	Areca nut, Banana, Guava, Jack fruit, Mandarin, Mango, Papaya, Peach, Pear, Plum, Walnut,

Based on the Agriculture Statistic 2010, agricultural production of each Gewog is compiled as shown in Tables from 3.3.14 to 3.3.16. Paddy and maize are cultivated in every Gewogs. For Sarpang Dzongkhag, related data which indicates agricultural land use and production is collected as shown in Table 3.1.17. According to those data, in Sarpang Dzongkhag, cardamom which is a representative crop of the southern zone is exclusively produced in both Gewogs of Dovan and Jigmecholing.

Table 3.3.14 Gewog Wise Agriculture Production (Samdrup Jongkhar) (1/2)

Geog	Paddy				Maize				Wheat				Barley				Buckwheat			
	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild
	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)
Deothang	36	15	69,530	4,773	474	192	533,910	2,783												
Gomdar	29	12	46,330	3,948	454	184	579,520	3,154					63	25	71,680	2,812	99	40	117,320	2,928
Jangchubling	16	6	9,330	1,441	469	190	439,970	2,318	8	3	3,650	1,127					8	3	6,190	1,912
Langchenphu	291	118	336,190	2,855	333	135	232,490	1,725									4	2	2,750	1,699
Lauri	72	29	103,740	3,560	950	384	1,546,450	4,023	15	6	30,230	4,980					408	165	325,510	1,971
Martshala	129	52	157,470	3,016	639	259	360,650	1,395	2	1	3,990	4,930	35	14	12,430	878	164	66	39,400	594
Pemethang	560	227	757,110	3,341	57	23	60,540	2,625									5	2	4,870	2,407
Phuntshothang	1,120	453	1,447,590	3,194	175	71	196,130	2,769												
Samrang	41	17	37,120	2,237	3	1	3,080	2,537												
Serthig	44	18	55,930	3,141	682	276	884,410	3,204	9	4	7,090	1,947					175	71	134,030	1,893
Wangphu	19	8	11,570	1,505	406	164	413,910	2,519					11	4	12,260	2,754	105	42	61,390	1,445
Total	2,357	954	3,031,910	3,179	4,642	1,879	5,251,060	2,795	34	14	44,960	3,268	109	44	96,370	2,185	968	392	691,460	1,765

Geog	Millets				Potato				Chilli				Onion				Cabbage			
	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild
	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)
Deothang									10	4	12,360	3,054					2	1	2,880	3,558
Gomdar	56	23	52,430	2,314	10	4	34,300	8,476	31	13	18,750	1,495	5	2	1,774	877	2	1	3,540	4,374
Jangchubling	3	1	650	535													1	0	1,150	2,842
Langchenphu	80	32	33,520	1,035	22	9	62,880	7,063	15	6	16,420	2,705	5	2	3,576	1,767	3	1	3,410	2,809
Lauri	18	7	24,230	3,326	49		125,120		111	45	174,770	3,891	2	1	1,429	1,766	5	2	12,150	6,005
Martshala					42	17	174,370	10,259	119	48	85,770	1,781	2	1	1,105	1,365	2	1	2,220	2,743
Pemethang	17	7	3,790	551					9	4	5,180	1,422	2	1	754	932	7	3	6,220	2,196
Phuntshothang	13	5	17,040	3,239					10	4	11,820	2,921					2	1	3,070	3,793
Samrang									4	2	6,150	3,799								
Serthig	69	28	50,190	1,797	6	2	21,730	8,949	23	9	16,960	1,822	6	2	2,794	1,151	5	2	3,120	1,542
Wangphu									3	1	5,620	4,629					1	0	690	1,705
Total	256	104	181,850	1,755	129	32	418,400	12,924	335	136	353,800	2,610	22	9	11,432	1,284	30	12	38,450	3,167

Geog	Cauliflower				Tomato				Carrot				Egg plant				Raddish			
	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild
	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)
Deothang	1	0	1,560	3,855	1	0	490	1,211												
Gomdar	1	0	280	692	1	0	2,400	5,931	1	0	276	682	1	0	662	1,636	15	6	21,630	3,563
Jangchubling													1	0	757	1,871	8	3	10,310	3,185
Langchenphu	1	0	730	1,804	3	1	3,000		3	1	2,245	1,849	4	2	2,711	1,675	12	5	11,480	2,364
Lauri	7	3	21,660	7,646	1	0	2,260	5,585	1	0	2,201	5,439	3	1	7,803	6,427	15	6	56,450	9,300
Martshala	1	0	810	2,002													10	4	17,320	4,280
Pemethang	1	0	1,500	3,707	1	0	950	2,348					1	0	485	1,198	7	3	6,360	2,245
Phuntshothang	2	1	2,150	2,656	1	0	270	667					1	0	154	381	7	3	9,620	3,396
Samrang																				
Serthig	1	0	930	2,298	1	0	390	964					2	1	1,198	1,480	45	18	33,380	1,833
Wangphu					1	0	870	2,150					1	0	1,184		7	3	13,240	4,674
Total	15	6	29,620	4,880	10	4	10,630	2,627	5	2	4,722	2,334	14	6	14,954	2,639	126	51	179,790	3,526

Source:Agricultural Statistic 2010

Table 3.3.15 Gewog Wise Agriculture Production (Samdrup Jongkhar) (2/2)

Geog	Ginger				Cardamom				Garlic				Beans				Mustard			
	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild
	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)
Deothang	7	3	6,380	2,252					3	1	2,160	1,779	4	2	4,354	2,690	11	4	17,940	4,030
Gomdar	6	2	13,630	5,613					4	2	1,230	760	15	6	13,163	2,168	5	2	4,020	1,987
Jangchubling	11	4	32,930	7,398					2	1	1,560	1,927	7	3	6,379	2,252	3	1	3,310	2,726
Langchenphu	68	28	98,670	3,586					1	0	630	1,557	14	6	8,949	1,580	55	22	20,450	919
Lauri									19	8	12,200	1,587	11	4	7,553	1,697	10	4	16,410	4,055
Martshala	46	19	88,260	4,741					4	2	1,930	1,192	8	3	7,730	2,388	187	76	41,050	542
Pemethang	33	13	49,870	3,734					4	2	2,190	1,353	4	2	2,557	1,580	2	1	2,140	2,644
Phuntshothang	35	14	69,180	4,884					1	0	1,450	3,583	7	3	8,118	2,866				
Samrang	1	0	1,830	4,522																
Serthig	6	2	5,060	2,084					6	2	5,060	2,084	14	6	7,000	1,236	9	4	11,040	3,031
Wangphu	3	1	3,300	2,718	5	2	1,340	662	1	0	580	1,433	27	11	12,412	1,136	13	5	4,070	774
Total	216	87	369,110	4,223	5	2	1,340	662	45	18	28,990	1,592	111	45	78,215	1,741	295	119	120,430	1,009

Geog	Mandarin				Banana				Areca Nut				Mango			
	Total trees	Bearing trees	Production (kg)	Yield (kg/tree)	Total trees	Bearing trees	Production (kg)	Yield (kg/tree)	Total trees	Bearing trees	Production (kg)	Yield (kg/tree)	Total trees	Bearing trees	Production (kg)	Yield (kg/tree)
Deothang	30,408	15,575	105,230	7	1,835	1,708	24,242	14	2,228	585	6,530	11	890	334	4,346	13
Gomdar	67,150	35,810	1,556,320	43	1,954	414	4,191	10					1,477	188	1,009	5
Jangchubling	36,947	13,987	557,330	40	4,589	1,178	7,350	6					433	86	1,661	19
Langchenphu	6,889	2,439	50,710	21	3,011	382	3,312	9	23,780	17,453	122,380	7	102	63	1,091	17
Lauri	640	395	19,320	49	4,015	1,935	24,316	13								
Martshala	28,304	13,065	842,680	64	599	330	6,214	19	55	25	230	9	57	22	951	43
Pemethang	2,692	838	35,220	42	8,015	1,392	9,081	7	21,080	11,465	114,550	10	1,341	124	2,970	24
Phuntshothang	9,853	2,200	146,450	67	3,342	1,165	16,478	14	51,056	29,843	280,980	9	1,022	432	23,126	54
Samrang	4,451	7	370	50	289	37	395	11	688	361	1,840	5	5	4	140	35
Serthig	29,390	10,523	246,810	23	8,779	1,205	8,873	7					7	4	118	27
Wangphu	26,679	13,411	186,470	14	561	511	16,031	31					135	28	723	26
Total	243,403	108,250	3,746,910		36,989	10,257	120,483		98,887	59,732	526,510		5,469	1,285	36,135	

Source:Agricultural Statistic 2010

Table 3.3.16 Gewog Wise Agriculture Production (Samtse) (1/2)

Geog	Paddy				Maize				Wheat				Barley				Buckwheat			
	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild
	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)
Bangra	309	125	230,430	1,843	325	132	339,280	2,580	64	26	27,790	1,073	2	1	2,520	3,114	50	20	33,010	1,631
Biru	723	293	609,040	2,082	233	94	293,010	3,108	4	2	8,660	5,350	2	1	970	1,198	10	4	270	67
Chargharay	659	267	547,040	2,051	55	22	91,700	4,120												
Chengmari	1,149	465	1,191,440	2,562	841	340	714,130	2,098	31	13	30,840	2,458					19	8	9,500	1,236
Denchhukha	555	225	380,450	1,694	478	193	332,480	1,719	2	1	1,080	1,334					2	1	1,820	2,249
Dorokha	570	231	450,870	1,955	841	340	679,920	1,998									7	3	2,470	872
Dungtoe	57	23	50,400	2,185	437	177	271,970	1,538									70	28	20,620	728
Namgay Chholing	458	185	397,880	2,147	137	55	58,300	1,052	3	1	6,370	5,247					8	3	1,960	605
Pagli	244	99	194,960	1,974	1,232	499	880,390	1,766	8	3	4,270	1,319	4	2	2,630	1,625	15	6	19,750	3,254
Samtse	769	311	751,190	2,414	662	268	572,620	2,137	15	6	7,800	1,285	6	2	2,500	1,030	37	15	10,500	701
Sipsu	940	380	700,030	1,840	128	52	84,740	1,636									5	2	3,990	1,972
Tading	134	54	129,820	2,394	1,167	472	851,670	1,803												
Tenduk	497	201	388,480	1,932	345	140	316,160	2,265	28	11	21,620	1,908	17	7	10,980	1,596	48	19	31,490	1,621
Ugyentse	428	173	374,600	2,163	9	4	20,370	5,593												
Yoeseltse	963	390	729,790	1,873	224	91	81,220	896												
Total	8,455	3,422	7,126,420	2,083	7,114	2,879	5,587,960	1,941	155	63	108,430	1,729	31	13	19,600	1,562	271	110	135,380	1,234

Geog	Millets				Potato				Chilli				Onion				Cabbage			
	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild
	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)
Bangra	35		32,230						8	3	4,980	1,538	11	4	3,855	866	5	2	2,740	1,354
Biru	38	15	37,100	2,413					4	2	2,440	1,507	1	0	379	937	3	1	820	675
Chargharay	33	13	24,600	1,842					2	1	2,810	3,472					2	1	1,480	1,829
Chengmari	419	170	144,730	854					4	2	2,140	1,322	6	2	2,950	1,215	4	2	4,230	2,613
Denchhukha	44	18	35,550	1,997	2	1	6,190	7,648	2	1	2,510	3,101	2	1	29	36				
Dorokha	86	35	71,060	2,042					14	6	11,900	2,100								
Dungtoe	23	9	17,140	1,841																
Namgay Chholing	68	28	51,680	1,878					16	6	21,330	3,294					1	0	1,550	3,830
Pagli	435	176	183,860	1,044					3	1	1,810	1,491	2	1	888	1,097	1	0	540	1,334
Samtse	312	126	90,160	714	2	1	11,950	14,765	2	1	3,500	4,324	1	0	327	808	2	1	1,660	2,051
Sipsu	30	12	33,640	2,771					8	3	11,800	3,645	11	4	99	22	1	0	710	1,754
Tading	495	200	214,590	1,071	12	5	48,890	10,068	3	1	3,370	2,776	2	1	1,486	1,836	1	0	1,940	4,794
Tenduk	100	40	63,790	1,576					11	4	5,910	1,328	11	4	1,859	418	1	0	1,550	3,830
Ugyentse	34	14	25,780	1,874					32	13	32,270	2,492					1	0	840	2,076
Yoeseltse	224	91	135,190	1,491					4	2	1,760	1,087	2	1	131	162	1	0	310	766
Total	2,376	947	1,161,100	1,226	16	6	67,030	10,352	113	46	108,530	2,373	49	20	12,003	605	23	9	18,370	1,974

Source:Agricultural Statistic 2010

Table 3.3.17 Gewog Wise Agriculture Production (Samtse) (2/2)

Geog	Cauliflower				Tomato				Carrot				Egg plant				Raddish			
	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild
	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)
Bangra	3	1	1,240	1,021	3	1	1,260	1,038	1	0	263	650	1	0	627	254				
Biru					3	1	440	362					1	0	531	215	7	3	5,770	2,037
Chargharay					2	1	1,730	2,137					1	0	481	1,189	5	2	5,170	2,555
Chengmari	3	1	2,240	1,845	8	3	4,920	1,520					7	3	2,432	859	11	4	7,500	1,685
Denchhukha																	5	2	5,810	2,871
Dorokha																	4	2	3,690	2,280
Dungtoe																	1	0	440	1,087
Namgay Chholing	1	0	1,050	2,595													3	1	5,570	4,588
Pagli	1	0	590	1,458	1	0	290	717					1	0	253	625	4	2	2,620	1,619
Samtse	1	0	640	1,581	3	1	1,360	1,120					1	0	322	796				
Sipsu					3	1	1,440	1,186					2	1	870	1,075	4	2	6,930	4,281
Tading	1	0	620	1,532													3	1	5,910	4,868
Tenduk	1	0	1,910	4,720													8	3	14,000	4,324
Ugyentse					1	0	710	1,754									4	2	4,020	2,483
Yoeseltse					8	3	1,170	361					4	2	737	455	55	22	17,520	787
Total	11	4	8,290	1,862	32	13	13,320	1,029	1	0	263	650	18	7	6,253	858	114	46	84,950	1,841

Geog	Ginger				Cardamom				Garlic				Beans				Mustard			
	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild
	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)
Bangra	62	25	126,340	5,035	868	351	187,300	533	4	2	2,070	1,279	11	4	6,335	1,423	2	1	2,460	3,039
Biru	290	117	880,090	7,499	117	47	61,150	1,292	4	2	3,410	2,107	6	2	5,800	2,389	4	2	6,270	3,873
Chargharay	32	13	75,180	5,806	3	1	1,250	1,030		0	1,560	#DIV/0!	3	1	1,932	1,591				
Chengmari	1	0	320	791	3	1	1,330	1,096	1	0	320	791	7	3	2,648	935	108	44	28,590	654
Denchhukha	14	6	6,380	1,126	64	26	11,460	442					8	3	3,405	1,052	3	1	3,270	2,693
Dorokha	5	2	3,710	1,834	225	91	50,320	553					5	2	3,208	1,585	7	3	4,690	1,656
Dungtoe	2	1	1,750	2,162	139	56	31,430	559					4	2	3,243	2,003				
Namgay Chholing	45	18	117,380	6,446	266	108	69,120	642					4	2	3,662	2,262	2	1	2,400	2,965
Pagli					15	6	6,560	1,081					12	5	5,345	1,101	19	8	8,140	1,059
Samtse	182	74	712,520	9,674	13	5	7,040	1,338					3	1	1,691	1,393	95	38	16,990	442
Sipsu	70	28	122,530	4,325					10	4	6,650	1,643	3	1	1,435	1,182				
Tading	45	18	167,110	9,177	77	31	31,330	1,005	2	1	640	791	6	2	3,929	1,618	6	2	5,650	2,327
Tenduk	23	9	25,380	2,727	421	170	92,690	544	2	1	370	457	15	6	14,458	2,382	24	10	13,050	1,344
Ugyentse	38	15	69,800	4,539									3	1	1,827	1,505				
Yoeseltse	44	18	33,430	1,877					5	2	5,180	2,560	9	4	1,182	325				
Total	853	345	2,341,920	6,784	2,211	895	550,980	616	28	11	20,200	1,783	99	40	60,100	1,500	270	109	91,510	838

Geog	Mandarin				Banana				Areca Nut				Mango			
	Total trees	Bearing trees	Production (kg)	Yield (kg/tree)	Total trees	Bearing trees	Production (kg)	Yield (kg/tree)	Total trees	Bearing trees	Production (kg)	Yield (kg/tree)	Total trees	Bearing trees	Production (kg)	Yield (kg/tree)
Bangra	4,282	2,952	69,640	24	16,732	5,344	61,532	12					32	15	390	26
Biru	15,803	10,721	272,730	25	5,206	3,811	63,513	17	6,042	2,407	41,050	17	41	22	527	24
Chargharay	8,400	3,970	220,080	55	13,202	1,905	31,588	17	49,419	13,789	113,810	8	242	60	4,346	72
Chengmari	22,760	12,161	124,780	10	5,484	3,948	56,272	14	113,915	44,140	583,030	13	246	122	4,440	36
Denchhukha	11,056	8,284	263,830	32	6,999	3,394	52,709	16					29	7	1,024	150
Dorokha	29,522	22,268	464,260	21	10,165	1,788	16,015	9					25	4	175	45
Dungtoe	14,507	10,512	202,560	19	4,874	596	3,867	6					4	3	66	25
Namgay Chholing	16,937	13,173	317,140	24	6,027	1,935	15,891	8	20,260	5,896	73,640	12	448	19	427	23
Pagli	13,284	8,495	174,680	21	3,979	1,730	34,897	20	61,145	27,074	300,120	11	840	359	9,263	26
Samtse	6,490	4,204	99,940	24	4,770	1,476	17,825	12	92,923	55,442	938,460	17	332	184	5,533	30
Sipsu	2,885	1,957	45,310	23	3,280	1,037	17,435	17	62,455	19,154	265,290	14	558	88	2,351	27
Tading	44,678	21,734	795,430	37	11,600	1,592	18,636	12	102,411	34,095	490,640	14	81	25	731	30
Tenduk	4,485	3,933	76,950	20	6,222	1,663	21,525	13					6	2	19	10
Ugyentse	5,942	3,437	79,840	23	2,892	806	12,135	15	58,894	10,840	131,140	12	168	62	1,665	27
Yoeseltse	1,235	572	7,250	13	5,707	1,516	14,644	10	109,978	18,451	167,000	9	183	41	932	23
Total	202,266	128,373	3,214,420		107,139	32,541	438,484		677,442	231,288	3,104,180		3,235	1,013	31,889	

Source:Agricultural Statistic 2010

Table 3.3.18 Gewog Wise Agriculture Production (Sarpang) (1/2)

Gewog	Paddy				Maize				Wheat				Barley				Buckwheat			
	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild
	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)
Bhur	194	79	207,940	2,649	23	9	33,870	3,639									2	1	320	395
Chhuzargang	970	393	897,500	2,286	303	123	165,480	1,350												
Dekiling	208	84	214,490	2,548	205	83	240,030	2,893												
Dovan	321	130	250,090	1,925	1,043	422	654,710	1,551					6	2	1,930	795	30	12	14,760	1,216
Gelephu	915	370	997,170	2,693	328	133	192,550	1,451												
Hiley	385	156	318,310	2,043	323	131	213,970	1,637									4	2	3,250	2,008
Jigmechoeling	1,257	509	725,950	1,427	858	347	427,080	1,230									13	5	7,020	1,334
Senge	16	6	10,170	1,571	58	23	28,190	1,201									2	1	530	655
Serzhong	347	140	336,840	2,399	388	157	169,070	1,077												
Shompangkhha	103	42	84,240	2,021	128	52	41,600	803	3	1	1,340	1,104	1	0	190	470	1	0	710	1,754
Taraythang	18	7	13,410	1,841	66	27	49,960	1,871												
Umiling	451	183	456,080	2,499	515	208	395,780	1,899	5	2	1,890	934								
Total	5,185	2,098	4,512,190	2,150	4,238	1,715	2,612,290	1,523	8	3	3,230	998	7	3	2,120	748	52	21	26,590	1,264

Gewog	Millets				Potato				Chilli				Onion				Cabbage			
	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild
	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)
Bhur	18	7	6,690	918					4	2	2,380	1,470					2	1	440	544
Chhuzargang	48	19	30,760	1,584					5	2	3,220	1,591	2	1	2,437	3,011	1	0	760	1,878
Dekiling	123	50	120,620	2,423					4	2	2,390	1,476	1	0	254	628	1	0	900	2,224
Dovan	34	14	23,550	1,712	2	1	6,390	7,895	4	2	2,690	1,662	2	1	844	1,043	2	1	1,860	2,298
Gelephu	97	39	95,500	2,433					6	2	2,840	1,170	1	0	891	2,202	3	1	1,480	1,219
Hiley	185	75	86,650	1,157	4	2	11,630	7,185	7	3	3,770	1,331	2	1	1,420	1,754	8	3	13,800	4,263
Jigmechoeling	66	27	39,460	1,477					12	5	13,330	2,745					6	2	2,370	976
Senge	39	16	24,990	1,583					7	3	3,030	1,070	3	1	1,663	1,370	2	1	3,790	4,683
Serzhong	80	32	39,200	1,211																
Shompangkhha	76	31	38,990	1,268	1	0	2,960	7,314	4	2	3,620	2,236					2	1	2,680	3,311
Taraythang	31	13	7,060	563					2	1	1,890	2,335	1	0	1,074	2,654				
Umiling	101	41	81,650	1,998					8	3	11,800	3,645					1	0	250	618
Total	898	363	595,120	1,638	7	3	20,980	7,406	63	25	50,960	1,999	12	5	8,583	1,767	28	11	28,330	2,500

Gewog	Cauliflower				Tomato				Carrot				Egg plant				Raddish			
	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild
	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)
Bhur					1	0	1,110	2,743	1	0	1,110	2,743	1	0	686	1,695	3	1	3,740	3,081
Chhuzargang					1	0	880	2,175	1	0	331	818	1	0	920	2,273	9	4	7,110	1,952
Dekiling	1	0	370	914	2	1	1,350	1,668									4	2	3,050	1,884
Dovan									2	1	946	1,169	3	1	1,192	982	13	5	11,480	2,182
Gelephu	1	0	410	1,013	10	4	5,550	1,371	1	0	1,418	3,504	1	0	1,144	2,827	8	3	10,830	3,345
Hiley	5	2	6,090	3,010	4	2	4,040	2,496									9	4	13,750	3,775
Jigmechoeling	1	0	1,050	2,595	3	1	610	502									12	5	14,040	2,891
Senge	1	0	1,140	2,817	3	1	2,490	2,051					2	1	1,316	1,626	9	4	6,280	1,724
Serzhong																	4	2	4,220	2,607
Shompangkhha	1	0	630	1,557	3	1	3,820	3,147	1	0	1,071	2,647	2	1	1,870	2,310	4	2	6,530	4,034
Taraythang																	2	1	880	1,087
Umiling					1	0	360	890									6	2	2,860	1,178
Total	10	4	9,690	2,394	28	11	20,210	1,784	6	2	4,876	2,008	10	4	7,128	1,761	83	34	84,770	2,524

Source:Agricultural Statistic 2010

Table 3.3.19 Gewog Wise Agriculture Production (Sarpang) (2/2)

Gewog	Ginger				Cardamom				Garlic				Beans				Mustard			
	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild	Area		Production	Yeild
	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)	(Acre)	(ha)	(kg)	(Kg/ha)
Bhur	11	4	15,800	3,549	11	4	11,850	2,662	0	0	60	927	16	6	2,296	355	7	3	3,170	1,119
Chhuzargang	86	35	175,980	5,057									2	1	4,137	5,111				
Dekiling	9	4	12,170	3,341	2	1	810	1,001					5	2	2,491	1,231	10	4	5,500	1,359
Dovan	1	0	630	1,557	46	19	5,050	271					26	11	9,231	877	76	31	25,450	827
Gelephu	9	4	14,740	4,047					1	0	880	2,175	18	7	3,115	428	24	10	10,420	1,073
Hiley	6	2	6,370	2,623					1	0	440	1,087	12	5	7,817	1,610	15	6	8,390	1,382
Jigmechoeling	3	1	2,170	1,787	22	9	3,260	366	8	3	1,560	482	10	4	5,470	1,352	13	5	18,210	3,461
Senge	14	6	22,840	4,031									6	2	1,835	756	12	5	5,010	1,032
Serzhong	8	3	8,450	2,610									3	1	2,103	1,732	20	8	3,070	379
Shompangkhha	25	10	25,260	2,497									4	2	3,304	2,041	17	7	7,540	1,096
Taraythang	23	9	19,310	2,075									2	1	844	1,043				
Umiling	106	43	86,020	2,005									3	1	730	601	5	2	3,850	1,903
Total	301	122	389,740	3,200	81	33	20,970	640	10	4	2,940	715	107	43	43,373	1,002	199	81	90,610	1,125

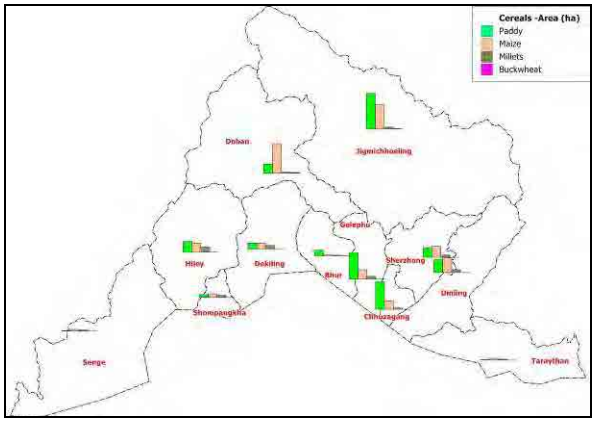
Gewog	Mandarin				Banana				Areca Nut				Mango			
	Total trees	Bearing trees	Production (kg)	Yield (kg/tree)	Total trees	Bearing trees	Production (kg)	Yield (kg/tree)	Total trees	Bearing trees	Production (kg)	Yield (kg/tree)	Total trees	Bearing trees	Production (kg)	Yield (kg/tree)
Bhur	26,231	18,446	1,494,020	81	4,982	1,709	21,371	13	24,416	11,472	226,560	20	426	58	1,407	24
Chhuzargang					2,051	1,527	17,264	11	232,730	93,849	593,390	6	864	340	10,978	32
Dekiling	72,400	28,227	1,354,090	48	8,264	3,928	46,914	12	71,289	28,120	233,310	8	692	229	14,243	62
Dovan	1,323	634	17,150	27	4,139	1,208	14,643	12								
Gelephu	7,246	3,927	165,650	42	3,109	2,526	40,739	16	54,207	36,126	458,000	13	549	194	11,323	58
Hiley	73,161	55,393	2,516,400	45	15,122	4,297	47,405	11	14,415	7,799	87,210	11	311	93	3,501	37
Jigmechoeling	34,859	23,888	529,910	22	2,871	1,287	17,234	13					46	3	5	2
Senge	9,776	7,119	324,730	46	13,669	4,040	66,422	16	14,146	7,817	89,290	11	187	93	6,182	67
Serzhong	57,397	24,888	556,070	22	4,917	932	11,659	13	49,911	13,462	106,660	8	441	139	4,284	31
Shompangkhha	12,338	6,773	214,050	32	30,889	11,102	214,190	19	60,766	25,768	188,830	7	629	142	4,613	32
Taraythang	73	36	480	13	329	147	3,030	21	10,300	1	30	24	225	8	181	22
Umiling					1,390	838	10,048	12	151,242	31,648	119,740	4	494	153	1,301	9
Total	294,804	169,331	7,172,550		91,732	33,541	510,919		683,422	256,062	2,103,020		4,864	1,452	58,018	

Source:Agricultural Statistic 2010

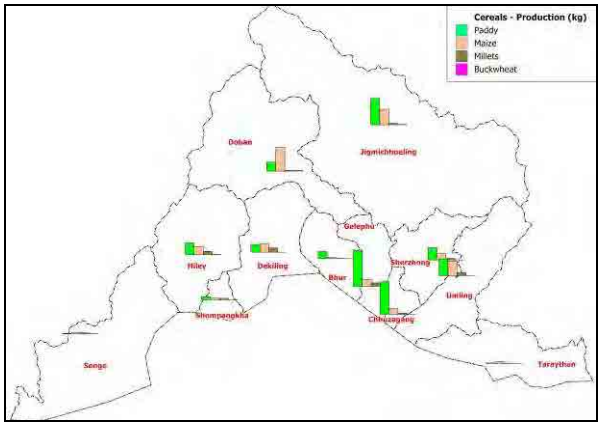
Table 3.3.20 Gewog Wise Land Use and Agricultural Production in Sarpang Dzongkhag

Geog	Unit	Senge	Hilley	Shompangkha	Doban	Ligmecholing	Dekiling	Bhur	Gelephu	Serzhong	Chuzagang	Umiling	Taraythang
Land coverage													
Area	Km2	215	141	22	251	472	115	55	54	42	57	122	399
Forest coverage	%	80	80	38	80	90	88	89	80	80	80	82	85
Land use													
Dry Land	*acres*	*315*	*1,002*	*647*	*947*	*1,009*	*2,145*	*1,552*	*1,928*	*1,091*	*1,322*	*1,054*	*91*
	ha	127	406	262	383	408	868	628	780	441	535	427	37
Wet Land	*acres*	*124*	*323*	*239*	*250*	*931*	*569*	*316*	*1,035*	*399*	*1,021*	*617*	*41*
	ha	50	131	97	101	377	230	128	419	162	413	250	16
Tsheri	*acres*	*64*	*550*	*1,750*	*462*	*308*	*1*	*66*	*22*			*6*	*7*
	ha	26	223	708	187	125	1	27	9			3	3
Shokshing	*acres*				*65*	*40*							
	ha				26	16							
Pangshing	*acres*	*7*	*51*			*308*	*72*						
	ha	3	21			125	29						
Orange Orchard	*acres*	*65*	*197*	*30*	*7*	*240*	*218*	*27*	*5*	*764*	*35*	*92*	*19*
	ha	26	80	12	3	97	88	11	2	309	14	37	8
Cardamom	*acres*	*3*	*874*	*1*	*473*	*1,427*	*54*	*0*		*36*		*21*	
	ha	1	354	0	191	578	22	0		15		9	
Agricultural Production													
Paddy													
Area	*acres*	*410*	*460*	*522*	*527*	*1,262*	*832*	*295*	*851*	*213*	*962*	*546*	*n.a.*
	ha	166	186	211	213	511	337	119	344	86	389	221	
Production	kg	433,150	744,909	541,480	603,224	1,135,015	742,437	317,578	845,763	282,475	1,205,411	672,926	
Yield	kg/ha	2,611	4,002	2,563	2,829	2,222	2,205	2,660	2,456	3,277	3,096	3,046	
Maize													
Area	*acres*	*504*	*685*	*415*	*1,335*	*1,530*	*841*	*273*	*667*	*210*	*461*	*523*	
	ha	204	277	168	540	619	340	110	270	85	187	212	
Production	kg	594,311	840,642	455,044	2,003,137	1,646,289	1,051,358	334,401	776,034	272,678	193,553	696,766	
Yield	kg/ha	2,914	3,033	2,710	3,708	2,659	3,089	3,027	2,875	3,209	1,037	3,292	
Wheat													
Area	*acres*	*235*										*1,104*	
	ha	95										447	
Production	kg	117,500										552,000	
Yield	kg/ha	1,236											
Buchwheat													
Area	*acres*		*38*		*202*	*292*							
	ha		15		82	118							
Production	kg		10,643		97,743	123,761							
Yield	kg/ha		692		1,196	1,047							
Millet													
Area	*acres*	*94*	*226*	*135*		*288*	*244*	*229*	*134*	*85*	*259*	*166*	
	ha	38	91	55		117	99	93	54	34	105	67	
Production	kg	51,447	114,226	38,464		77,785	278,183	99,196	50,374	38,473	167,079	291,180	
Yield	kg/ha	1,352	1,249	704		667	2,817	1,070	929	1,118	1,594	4,335	

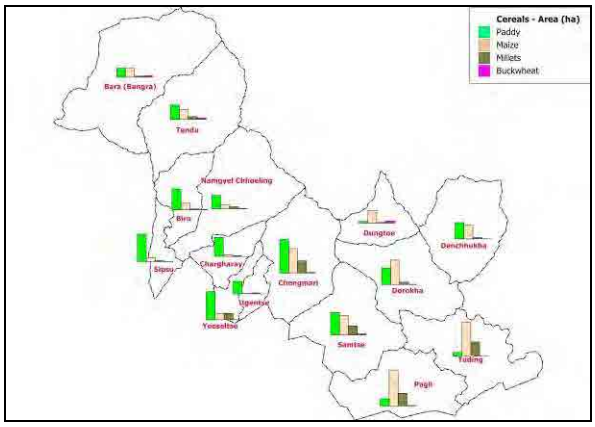
Source: Prepared by JICA Survey Team based on the Gewog Fact Shhet



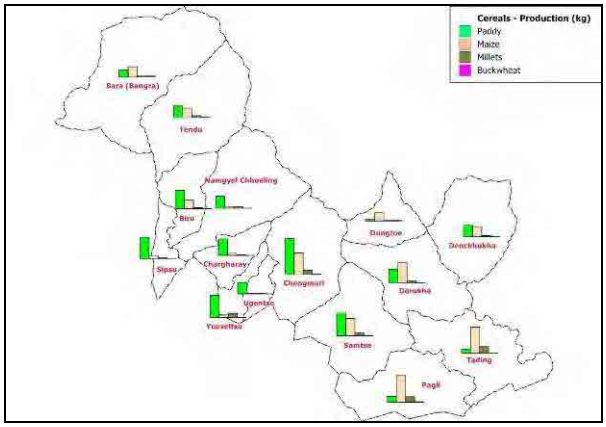
Cropping Area (Sarpang)



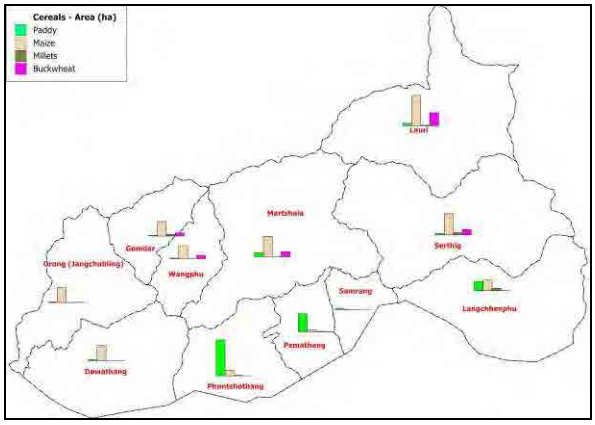
Production (Sarpang)



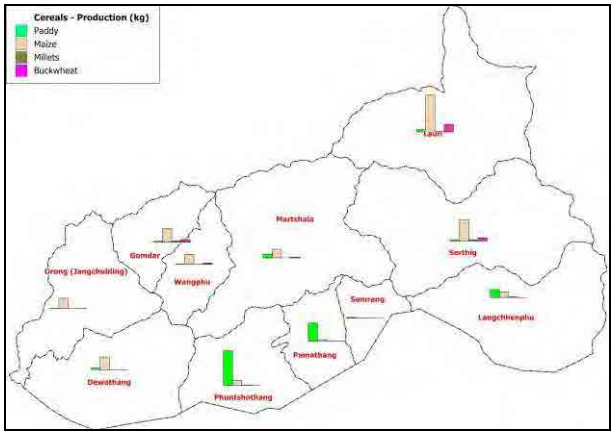
Cropping Area (Samtse)



Production (Samtse)



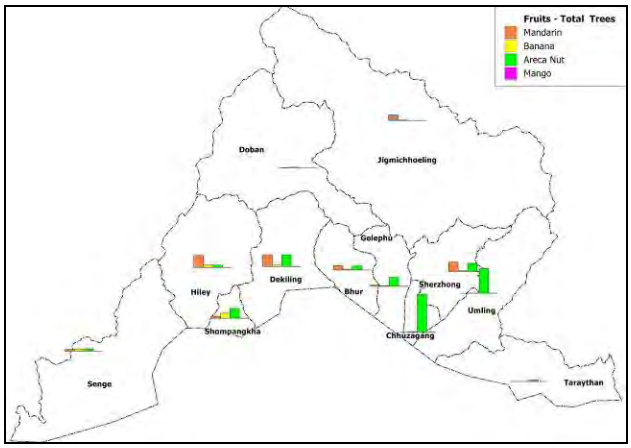
Cropping Area(Sumdrop Jongkhar)



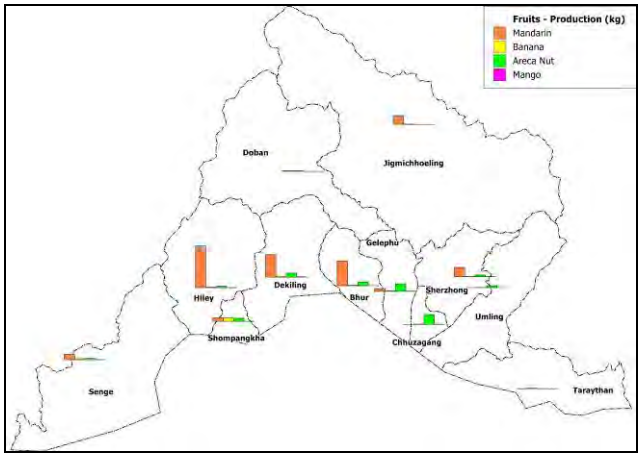
Production (Sumdrop Jongkhar)

Source; Mapped by JICA Survey Team based on the Agriculture Statistic 2010

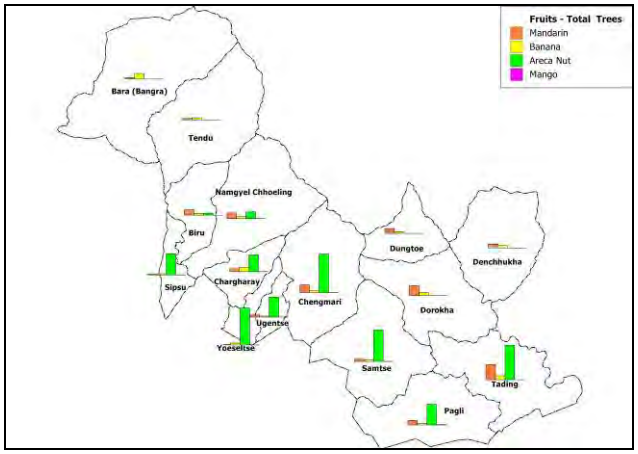
Figure 3.3.1 Comparison of Cereals Production by Gewogs (2010)



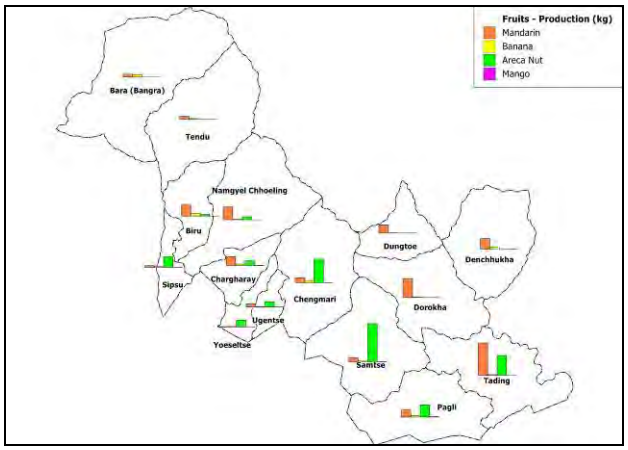
Number of Fruits Trees (Sarpang)



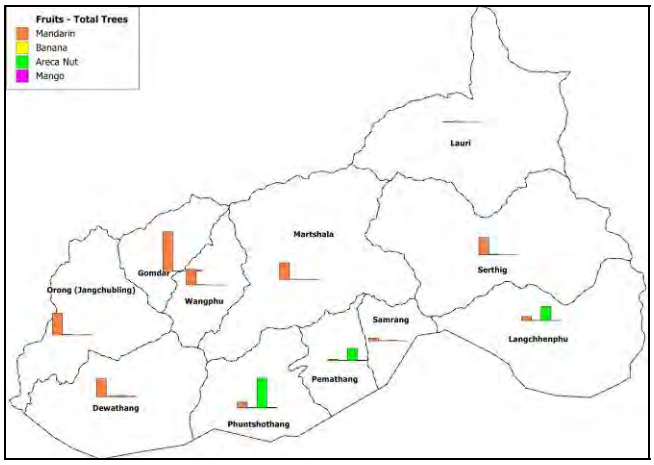
Production (Kg) (Sarpang)



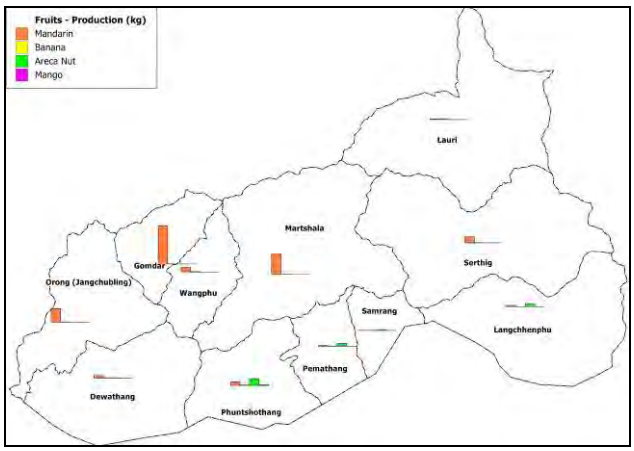
Number of Fruits Trees (Samtse)



Production (Kg) (Samtse)



Number of Fruits Trees (Samdrop Jongkhar)



Production (Kg) (Samdrop Jongkhar)

Source ; Mapped by JICA Survey Team based on the Agriculture Statistic 2010

Figure 3.3.2 Comparison of Fruits Production (2010)

3.3.3 Irrigation Scheme

(1) Dzongkhag wise irrigation scheme

According to the Dzongkhag wise irrigation scheme information, total number of registered irrigation system in the country is counted 1,496. From the information, as for three Dzongkhags, Samdrup Jongkhar has 42, Samtse by 19 and Sarpang by 282. Sarpang Dzongkhag has the largest number in the country. Average size of command area per irrigation scheme varies from 6 ha to 52 ha. Size of irrigation scheme of Sarpang is comparatively small. It can be said that there exist many smaller size irrigation scheme in Sarpang.

Table 3.3.21 Dzongkhag wise Irrigation Scheme Information

Dzongkhag	Number of Irrigation Schemes	Total Canal Length (km)	Total Beneficiary Households	Total Command Area		Length per Irri. Scheme	Command Area per Irri. Scheme
				(acres)	(ha)	(km/scheme)	(ha/scheme)
Bumthang	29	54.03	510	2,385.74	965.5	1.9	33
Chukha	60	140.53	1,423	1,549.15	626.9	2.3	10
Dagana	59	130.27	1,112	3,137.00	1,269.5	2.2	22
Gasa	16	41.50	108	234.00	94.7	2.6	6
Haa	13	27.93	165	383.98	155.4	2.1	12
Lhuentse	67	245.65	1,892	2,466.07	998.0	3.7	15
Mongar	67	161.28	1,937	1,601.19	648.0	2.4	10
Punakha	105	341.08	235	6,839.00	2,767.6	3.2	26
Paro	131	374.07	6,419	10,603.00	4,290.8	2.9	33
Pemagatshel	12	25.35	265	340.00	137.6	2.1	11
Samdrup Jongkhar	42	102.54	957	1,610.00	651.5	2.4	16
Samtse	19	53.11	1,074	2,413.00	976.5	2.8	51
Sarpang	282	380.70	3,005	6,844.16	2,769.7	1.4	10
Thimphu	40	132.30	1,064	1,944.43	786.9	3.3	20
Trashigang	46	117.25	2,387	5,880.00	2,379.5	2.5	52
Trashiyangtse	41	107.47	2,400	4,412.00	1,785.4	2.6	44
Trongsa	88	283.60		4,575.00	1,851.4	3.2	21
Tsirang	220	452.73	1,721	4,368.21	1,767.7	2.1	8
Wangdue	115	499.27	2,548	6,146.28	2,487.3	4.3	22
Zhemgang	44	91.82	3,670	1,173.00	474.7	2.1	11
Bhutan	1,496	3,762.48	32,892	68,905.21	27,884.6	2.5	19

Source : Agriculture Statistics 2010 (Orginal source: Dzongkhag Agriculture Sector, January 2011)

(2) Irrigation scheme inventory of Sarpang Dzongkhag

Gewog wise irrigation scheme information of Sarpang Dzongkhag was collected from the DAO. Collected data/ information items are:

> Number, Geog, Name of Channel, Name of Source, Location, Canal Length (approximate km), Command Area (acres), Beneficiary (HH), Year of Construction, WUA *(present status: existing or not)*, Funding source *(in the construction or renovation stage)*, Present Status *(Functional or not functional, any damaged)*.

Collected data/ information are compiled as an inventory of irrigation system, as shown in the Appendix A. Average data of each Gewog is compiled as follows.

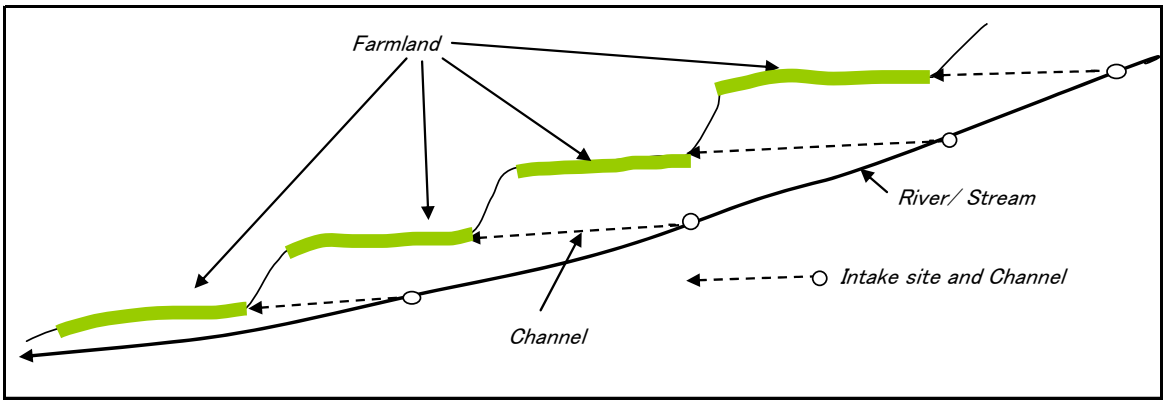
Table 3.3.22 Summary of Gewog Wise Irrigation Scheme Inventory of Sarpang

Gewog	Number	Canal Length	Command area		Beneficiary
		(km)	(acre)	(ha)	(HH)
Bhur	15	48.50	706.50	285.91	240
Chuzapang	5	16.28	1,400.00	566.55	605
Dekiling	15	38.50	1,016.08	411.19	407
Dovan	30	44.80	191.50	77.50	155
Gelephu	8	11.50	478.69	193.72	182
Hilley	74	56.86	321.11	129.95	235
Jimecholing	79	103.15	1,190.16	481.63	425
Sengye	18	22.85	245.23	99.24	135
Sershong	19	33.45	788.95	319.27	358
Shmpangkha	22	19.81	529.44	214.25	211
Taraythang	n.a	n.a	n.a	n.a	n.a
Umling	15	33.50	704.00	284.89	302
Total	300	429.20	7,571.66	3,064.10	3,255

Source: Prepared by JICA Survey Team, based on the collected data/ information form Sarpang DAO.

Irrigation system and irrigation area

Irrigation system is provided to supply irrigation water to the farmland ranged in the mountain slope. All irrigation system is formed as gravity irrigation. Irrigation water is taken from neighboring river/ stream along the peripheral terrace farmland. Irrigation system is constructed as communal irrigation unit of farmland. Irrigation facilities such as irrigation canal and intake facility are operated and managed by related community/ villagers on their farmland.



Size of the irrigation area varies from smaller size of 1.0 ha to larger one of around 100 ha. Average size is estimated around 10 ha. Channel length is depending on the altitude difference between the farm land and the river/ stream required as water source. It is also affected by the distance between them. Longer one extends from 5 km to 7 km. Canal structure is influenced by the topographic and geologic features such as gradient of slope and existence of fault along its route. Channels are often stratified in a river system.

Preparation of irrigation system rehabilitation site list

List of irrigation system rehabilitation sites was prepared as a long-list. It shows the irrigation system rehabilitation candidate site. It was made from the irrigation system inventory by screening related data in the inventory. To screen the sites, technical criteria which has been prepared by the Irrigation Division of DoA was applied.

= Applied criteria for screening =

> ***Irrigation Engineering Manual Revised Version 1-1-1998***
>
> ***(Research, Extension and Irrigation Division, Irrigation Section)***
>
> *1. Introduction*
>
> *1.4 Selection Craiteria of Irrigation Schemes*
>
> *Economic/ Financial feasibility*
>
> *2. The Command area should be no less tha 5 ha.*
>
> *3. No schemes should have less than 10 househilds.*
>
> . . .

= Preparation of the long list =

As mentioned above, present irrigation system inventory was screened by applying two numerical criteria: the number of beneficial household and the size of command area. As the result of screening, the long list was prepared (an example of the prepared one is shown in Table 3.3.24. Gewog wise long list is shown in Appendix A). Basic data/ information after the screening such as the site number, canal length and command area, is shown in Table 3.3.23. Based on the list, the total site number of irrigation system is counted 79 sites, command area 2,324 ha and beneficiary 2,449 households.

Table 3.3.23 Basic Information of Irrigation System Site after Screening by Gewog

Gewog	Number of irrigation system sites	Length of Canal (km)	Area of command area		Number of house hold
			(acre)	(ha)	
Bhur	9	39	627	254	218
Chuzagang	5	16	1,400	567	605
Dekiling	12	34	968	392	388
Dovan	2	4	44	18	28
Gelephu	5	10	461	187	173
Hilley	2	4	59	24	25
Jigmecholing	11	18	441	179	153
Sengye	5	17	200	81	101
Sershong	11	27	634	257	309
Shompangkha	4	8	289	117	141
Tarithang	1	2	26	11	14
Umling	12	30	594	240	294
Total	79	206	5,743	2,324	2,449

Source: Prepared by JICA Survey Team. Totalled based on the inventory data collected from DAO, by screening the size of command area and number of beneficiary.

The average scale per one irrigation system is calculated canal length 2.6 km, command area 29 ha, number of beneficiary 31 households, as shown in Table 3.3.25.

Table 3.3.24 Example of Registered Irrigation Site (Gewog: Sengye)

Gewog: Sengye

No.	No.[1] (in the original list)	Gewog[1]	Name of the Channel[1]	Water Source		Location[1]	Length Approx[1] (Km)	Command Area[1]		Beneficiary[1] (HH)	Year of Construction[1]	WUA[1]	Funding Source[1]	Present Status		Accessibility[2]		
				Name[1]	Water availability[2] P: Permanent S:Seasonal			(Ac)	(ha)					Status[1][3]	Reason of non-functional[2][3]	Distance from beneficiary area to road (km)	Time to get to road (min)	Transportation way (Local bus, on foot etc)
Sen-1	240	Sengye	Baral kulo	Sisty khola	P	Sisty A	4.00	59.05	23.90	24	1940	No	Community	Functional		0.0	0	-
Sen-2	239	Sengye	Mazan kulo	Sisty khola	P	Sisty A	6.00	46.95	19.00	25	1946	No	Community	Functional (Non functional)	(Under reparing)	0.0	0	-
Sen-3	234	Sengye	Upper Senghe Kulo	Senghe khola	P	Hatikhuar	1.00	36.10	14.61	20		No	Community	Functional		0.5	20	On foot
Sen-4	236	Sengye	Koigaon kulo	Tungkhola	P	Koigaon	2.50	35.50	14.37	18		No	Community	Functional		0.0	0	-
Sen-5	238	Sengye	Rumdali kulo	Sisty khola	P	Sisty B	3.00	22.05	8.92	14	1973	No	Community	Functional		0.3	10	On foot
Sen-6	235	Sengye	Lower Senghe kulo	Senghe kola	P	Hatikhuar	1.00	15.12	6.12	9		No	Community	Functional		0.5	20	On foot
Sen-7	250	Sengye	Mirgay kulo	Mirgay Kholsi	S	Thoemba	0.30	7.10	2.87	6		No	Community	Functional		0.3	10	On foot
Sen-8	243	Sengye	Ringalung kulo	Sisty khola	P	Khopan	1.00	4.58	1.85	4	1971	No	Community	Functional		0.5	30	On foot
Sen-9	244	Sengye	Bhalu Khola kulo	Bhalu Kholsi	S	Khopan	0.50	4.20	1.70	3	1971	No	Community	Functional		1.0	60	On foot
Sen-10	246	Sengye	Sahajbotay Channel	Karbari river	S	Labarbotey	1.00	3.69	1.49	2	1945	No	Community	Functional		0.5	30	On foot
Sen-11	248	Sengye	Simsarey kulo	Karbari khola	S	Labarbotey	0.50	2.12	0.86	1	1945	No	Community	Functional		0.5	30	On foot
Sen-12	251	Sengye	Panthak kulo	Kuapani kholsi	S	Balatung	0.50	2.00	0.81	2	1976	No	Community	Functional		0.5	30	On foot
Sen-13	242	Sengye	Prasadey kulo	D.B.Kholsi	S	Sisty B	0.20	1.50	0.61	1	1970	No	Community	Functional		0.6	40	On foot
Sen-14	247	Sengye	Lungali kulo	Sisty khola	P	Khopan	0.30	1.50	0.61	1	1960	No	Community	Functional		0.8	50	On foot
Sen-15	237	Sengye	Dhara Kholsi kulo	Dhara Kholsi	S	Koigaon	0.30	1.45	0.59	1	1970	No	Community	Functional		0.3	10	On foot
Sen-16	249	Sengye	Kabra Botey kulo	Kabra Botey kholsi	S	Kopchey	0.30	1.00	0.40	1	1958	No	Community	Functional		0.1	5	On foot
Sen-17	241	Sengye	Debithaney kulo	Debithaney Kholsi	S	Sisty A	0.15	0.74	0.30	1	1970	No	Community	Functional		0.0	0	-
Sen-18	245	Sengye	Deosali kulo	Sisty khola	P	Deosali Khopan	0.30	0.58	0.23	2	1975	No	Community	Functional		0.2	5	On foot

1) Posted from the table obtained from DAO Sarpang. 2) Identified through field survey and interview 3) Status in () is Identified through field survey. : Target for field survey

Table 3.3.25 Average Size of Irrigation System by Gewog

Gewog	Number of irrigation system sites	Length of Canal (km)	Area of command area		Number of house hold
			(acre)	(ha)	
Bhur	9	4	70	28	24
Chuzagang	5	3	280	113	121
Dekiling	12	3	81	33	32
Dovan	2	2	22	9	14
Gelephu	5	2	92	37	35
Hilley	2	2	30	12	13
Jigmecholing	11	2	40	16	14
Sengye	5	3	40	16	20
Sershong	11	2	58	23	28
Shompangkha	4	2	72	29	35
Tarithang	1	2	26	11	14
Umling	12	2	50	20	25
Total	79	3	73	29	31

Source: Prepared by JICA Survey Team.

Survey in the long list sites

Long list sites were surveyed to check their existence and condition, and collect related information through the interview survey with Gewog office. Joint survey with JICA survey team and Gewog extension staff was also conducted. By this survey, location and present status of water source such as intake point/ facility and irrigation canal were surveyed. Surveyed information was put on the long list. Interview survey with beneficial farmers was conducted in the course of the survey. Paddy fields of the command area were observed to grasp soil condition and cultivating crops. An example of survey results is shown in Table 3.3.26. Survey results of all the sites are shown in Appendix B. (In the course of the interview survey, it was found that some doubtful data was included in the original inventory prepared by DAO. But, these data were not updated in this survey, since no one could show exact data. To make the long list reliable, basic information such as command area and number of beneficiary should be updated by DAO and Gewog office.

As the results of the survey, following points are summarized from the viewpoints of future irrigation agricultural development.

- Paddy field plot are distributed in the terrace on the slope topography. Surface soil of the paddy fields consisted of sandy or silty soil containing gravel, so that, infiltration rate is high, according to the interview survey, it is assumed from 20 mm to 50 mm/day. Irrigation water supply is indispensable for paddy cropping, especially in no rainfall period.
- Plot-to-plot irrigation is conducted among small plots. Water loss and soil erosion are prone to occur in the fields. Small and random row of paddy plots prevents form mechanizing farming activities.
- Two WUA in Chuzagang Gewog and one in Sershong Gewog are registered as the WUA. However, beneficial farmers organize water users groups to operate and maintain their irrigation facilities, although intensity of group's unity differs from each other. Water charge collection system is

introduced in a WUA. In this WUA, collected charge is appropriated to repair and .maintenance works for the facilities. In an advanced group, water guard who operates and manages irrigation water supply and distribution is hired from beneficial farmers.

- Repair and cleaning of irrigation facilities is the critical work. The repair work is conducted in the working processes; i) request the repair of damaged facilities for beneficial farmers to related gewog and dzongkhag, ii) survey and make budget for repair by gewog/ dzongkhag, iii) supply of civil work materials like cement from gewog/ dzongkhag, iv) repair works through labor contribution by beneficial farmers labor. In the case that no budget is made and labor contribution exceeds in damage, repairing can not be conducted. In that case, as the result, damaged facilities would be left, and no irrigation agriculture could be brought until the facilities are repaired and functioned.
- According to the interview survey with farmers, home made paddy seed is normally utilized and no chemical fertilizer and pesticide are applied. As for applying fertilizer, in some plots, excreta are applied through free cattle grazing.
- Dry season irrigation is not executed, although there is some irrigable area. According to the interview survey, farmers mentioned that; crop damage occurs in dry season by intrusion of wild animal, harvest loss sometimes occur at the time when harvesting of dry paddy overlaps with the beginning stage of wet paddy.
- Small scale inland fishery ponds in which fishing water can be supplied from irrigation canal and seepage loss can be prevented by clayey and low permeability soils exist in a few irrigation areas.
- It is surveyed that market oriented agriculture such as chicken house raising in which breeding water is supplied from home domestic water is conducted in some areas along the main traffic road easy access to market. Most farmers, however, operate farming in which major crop is the wet paddy for home consumption purpose.

(3) Irrigation system inventory of Samdrup Jongkhar Dzongkhag

Present data/ information on the irrigation scheme of Samdrup Jongkhar Dzongkhag were collected from DAO. According to this, total 42 irrigation sites exist in the 10 Gewogs. Total is the canal length 109 km, beneficiary 956 households and command area 652 ha (see Table 3.3.27). The inventory was screened by applying the same criteria of 10 households and command area 5 ha as mentioned above. After the screening, the long list is prepared by 25 sites, total 79 km, 847 households and 608 ha.

(4) Irrigation system inventory of Samtse Dzongkhag

There was no compiled data showing present irrigation scheme in the Dzongkhag office. Accordingly, in this survey, inventory was prepared through the discussion with dzongkhag agriculture office. (see Table 3.3.28).

Table 3.3.26 Survey Items and Survey Results in Irrigation Site Long List (Sen-2, Sengye Gewog)

No.	Sen-2	(No. in the original list)	239

Date of survey: 2010/4/2

Intake system	Name		Mazan kulo
	Dzongkhag		Sarpang
	Gewog		Sengye
	Latitude		26 ° 52 ' 0.4 " N
	Longitude		90 ° 12 ' 37.5 " E
	Type of intake facility		Concrete Gabion (Rock) (Earth) Wood
	Constructed year*		-
	Construction cost*	Material	Covered by Government (Beneficiaries) Donor
		Workforce	Covered by Government (Beneficiaries) Donor
	Latest rehabilitated year		Under rehabilitation
	Length of Canal		6.0 km
	Structure of Canal		(Concrete (Wet masonry)) (Earth) Pipe
	Function*		(Functional) Non Functional
	Problems		Canal is under rehabilitation.
Water source	Name		Sisty khola
	Water source		(River) Spring Well
	Water discharge	Rainy season	Nil (Available) (m^3/s)
		Dry season	Nil (Available) (0.468m^3/s)
	Water taken by intake	Rainy season	(Enough) Not enough
		Dry season	(Enough) Not enough
	Quality in dry season	pH	8.2
		EC	44.10 ms/m
		Temperature	23.5 ℃

Beneficiary Area	Name		Sisty A
	Command area		46.95 acre (19.00 ha)
	Number of house holds		25
	Distance to road		0.0 km
	Time to get to road		0 min
	Transportation way to road		-
Operation and Management*	Organization		Private organization
	Activity		Annual maintenance, Employing water guard
	Budget		Covered by Government (Beneficiaries)
	Water use fee		150BTN/HH or crop
Cropping	Variety	Rainy season	Paddy, Maize, Millet
		Dry season	Wheat, Vegetable
	Fertilizer		Nil
	Manure		Cow dung
Soil Condition	Thickness of surface soil		18cm
	Structure of surface soil		Gravel Sandy (Silt) (Clay)
	pH		5.5
	Days of drying up water with 15cm depth in paddy field		2-5days
Remarks	-Water amount is enough even in dry season and once farmers tried paddy cropping in dry season. But harvesting season was just the beginning of rainy season and damage of paddy was so serious. Therefore farmers gave up to make paddy in dry season. -Instead of paddy, farmers farms fish in dry season. -Farmers say that if they can obtain another type of paddy which can be harvested before rainy season, they will make paddy in dry season.		

*If present condition identified through field survey is different from that in the irrigation system list, present condition is mentioned.

Picture-1: Situation of intake facility
Date:2010/4/2

Picture-2: Situation of Canal
Date:2010/4/2

Picture-3: Situation of beneficiary area
Date:2010/4/2

Table 3.3.27 Irrigation Sites of Sumdrup Jongkhar Dzongkhag

Gewog	No.	Name of the Channel	Water Source	Location	Length Approx (Km)	Command Area		Beneficiary (HH)	Year of Construction	WUA	Funding Source	Present Status	Remarks
						(Ac)	(ha)						
Deothang	1	Rekhey	Degran	Rekhey	1.50	35	14.16	50		Yes	RGoB	Functional	
Gomdar	2	Khoyar	Toka rayri	Khoyar	1.56	25	10.12	40	1985-86	No	RGoB	Functional	Cemented
	3	Mokhoma	Sangsingri	Mokhama	9.00	9	3.64	23		No	RGoB	Functional	Cemented
	4	Geriwoong			0.85	3	1.21	14		No	RGoB	Non functional	Cemented
Langchenphu	5	Golanti/Borla Kulo	Borla Khola	Golanti	3.00	40	16.19	18		No	RGoB	Non functional	
	6	Angrakhola	Angra khola	Lanchenphug	3.00	219	88.63	54		No	RGoB	Non functional	
	7	Khawrong	Lebayoli	Kawrong	3.00	21	8.50	18		No	RGoB	Non functional	
Lauri	8	Gonoong	Sershong ri	Zangthi	10.00	16	6.48	30		No	RGoB	Non functional	Earthern/ lined canal
	9	Sershong	Sershong ri	Zangthi	3.00	34	13.76	35		No	RGoB	Functional	Earthern/ lined canal
	10	Tashiphu	Sershong ri	Zangthi	6.00	20	8.09	13		No	RGoB	Non functional	Earthern/ lined canal
Martshala	11	Kakpadung	Tekree	Kakpadung	2.00	70	28.33	20	2009-2010	No	RGoB	Functional	Newly constructed
	12	Chortenwoong	Rechanglu	Martshala	1.00	15	6.07	16		No	RGoB	Functional	Cemented
	13	Galingkhar	Wangphuri	Wangphu	9.00	10	4.05	12		No	RGoB	Functional	Cemented
	14	Kakpadung	Brangsari	Kakpadung	1.62	35	14.16	15	2001-02	No	RGoB	Functional	Pipe
	15	Kangkharwoong	Zalamuri	Martshala	3.00	10	4.05	8		No	RGoB	Functional	Cemented
Orong	16	Yongdor	Dogonaree	Tershari	0.15	2	0.81	1		No	RGoB	Non functional	Private Channel,
	17	Brongshingko	Dogonaree	Tershari	0.14	2	0.81	1		No	RGoB	Non functional	Private Channel,
	18	Namthapha	Namthapharee	Suzung Melum	0.20	5	2.02	3		No	RGoB	Non functional	Private Channel,
	19	Mencheri	Dongsoree/ Bodori	Mencheri	0.67	3	1.21	1		No	RGoB	Non functional	Private Channel,
	20	Mencheri	Jatshoree	Mencheri	0.26	8	3.24	7		No	RGoB	Non functional	
	21	Malang	Remungsing- dangshingre	Malang	0.35	8	3.24	7		No	RGoB	Functional	
	22	Orong	Ngadonaree	Mentshang /Durtsher	3.14	110	44.52	47	2000-01	No	RGoB	Non functional	
	23	Liphu	Liphuree	Liphu/Remung	0.62	2	0.81	4		No	RGoB	Non functional	
Pemathang	24	Tarulay	Wangphuri	Nainital	3.96	98	39.66	70		No	RGoB	Functional	Earthern/ lined canal
	25	Warong Khola	Warong ri	Dalim	1.38	140	56.66	49		No	RGoB	Functional	Earthern/ lined canal
	26	Dumpha Shilingay	Diglai Chu	Shillingey	3.28	130	52.61	65		No	RGoB	Functional	Earthern/ lined canal
Phuntshothang	27	Prasai Khola	Baranadhi Khola	Prasai	1.44	66	26.71	18		No	RGoB	Non functional	Earthern/ lined canal
	28	Khateythang	Baranadhi Khola	Khateythang	1.72	32	12.95	16		No	RGoB	Non functional	Earthern/ lined canal
	29	Khateythang	Masaney khola	Khateythang	0.30	8	3.24	3		No	RGoB	Functional	Earthern/ lined canal
	30	Thapa holi	Thapa holi	Khateythang	1.00	7	2.83	7		No	RGoB	Functional	Earthern/ lined canal
	31	Woongdaza	Masaney khola	Woongdaza	1.00	10	4.05	8		No	RGoB	Functional	Earthern/ lined canal
	32	Khameythang	Baranadhi Khola	Khameythang	4.50	131	53.01	70		No	RGoB	Functional	Earthern/ lined canal
	33	Khameythang	Baranadhi Khola	Khameythang	4.00	35	14.16	23		No	RGoB	Functional	Earthern/ lined canal
	34	Khameythang	Sukhey khola	Khameythang	0.60	7	2.83	3		No	RGoB	Functional	Earthern/ lined canal
	35	Khameythang	Sukhey khola	Khameythang	0.30	4	1.62	4		No	RGoB	Functional	Earthern/ lined canal
	36	Gairitar	Warong Khola	Gairitar	4.00	60	24.28	30		No	RGoB	Non functional	Earthern/ lined canal
	37	Tshangchutham	Baranadhi Khola	Tshangchutham	1.00	30	12.14	21		No	RGoB	Non functional	Earthern/ lined canal
	38	Tekree	Tekree khola	Jagkartala	3.00	10	4.05	3		No	RGoB	Non functional	Earthern/ lined canal
	39	SamdrupChoeling	Daap khola	SamdrupChoeling	1.00	60	24.28	30		No	RGoB	Functional	Earthern/ lined canal
	40	Belamcherang		Belamcherang	1.50	30	12.14	27		No	RGoB	Functional	Earthern/ lined canal
Wangphu	41	Yorong ri	Yorong ri	Pangthang	1.50	15	6.07	20		No	RGoB	Non functional	Earthern/ lined canal
Serthi	42	Barkalanang	Tashi ri	Barkhalangna	4.00	35	14.16	52		No	RGoB	Non functional	Earthern/ lined canal

*All contents are posted from irrigation list obtained from DAO Samdrug Jongkhar

:Listed one after screaning by JICA Survey Team

Table 3.3.28 Irrigation Sites of Samtse Dzongkhag

Gewog	No.	Name of the irrigation channel	Location	Length (Km)	Beneficiary (HH)	Command area		WUA	Year of construction	Funding source	Present status
						(Acre)	(ha)				
Bangra	1	Khopi	Khopi	1.50	20	31.00	12.55	Yes	2005-2006	RGoB	Functional
Biru	2	Katarey Channel	Katarey	0.90	76	210.00	84.98	No	2005-2006	RGoB	Functional
	3	Hatikharka A	Hatikharka	0.60	40	46.17	18.68	No	2009-2010	RGoB	Functional
	4	Khopi irrigation	Biru	0.70	20	29.13	11.79	No	2009-2010	RGoB	Functional
	5	Kharasay Khola	Biru	3.00	55	90.00	36.42	No	2008-2009	RGoB	Functional
	6	Chisopani	Chisopani	1.50	25	30.00	12.14	No	2010-2011	RGoB	Functional
	7	Hatikharka B	Hatikharka B	1.70	38	46.17	18.68	No	2010-2011	RGoB	Functional
Chargharay	8	Lengthey	Lengthey	2.00	30	89.00	36.02	No	2006-2007	RGoB	Non functional
Chengmari	9	Dipojora A	Dipujora A	0.99	32	45.00	18.21	No	2003-2004	RGoB	Functional
	10	Dipujora B	Dipujora B	0.91	33	65.00	26.30	No	2005-2006	RGoB	Functional
Dorokha	11	Dogap	Dogap	5.00	47	80.00	32.37	No	2004-2005	RGoB	Functional
Dungtoe	12	Thulu	Thulu Dungtoe	1.00	18	23.00	9.31	No	2004-2005	RGoB	Functional
Namgaye Chholing	13	Namgaye Chholing	Namgaye Chholing	5.00	68	60.00	24.28	No	2006-2007	RGoB	Functional
Samtse	14	Kalikhola	Gombadara	3.00	39	85.00	34.40	No	2003-2004	RGoB	Functional
	15	Mechitar	Mechitar	0.81	91	300.00	121.40	Yes*	2005-2006	RGoB	Functional
	16	Lamitar	Lamitar	1.20	23	150.00	60.70	Yes*	2009-2010	FAO	Functional
	17	Sangla	Sangla	3.00	24	13.75	5.56	Yes*	2008-2009	RGoB	Functional
	18	Cholicop	Cholicop	2.20	28	100.00	40.47	Yes*	2009-2010	FAO	Functional
Sipsu	19	Penjorling	Sipsu Khola	4.00	66	140.00	56.66	Yes	2003-2004	KRII Plan III	Functional
	20	Sanyanasi	Lower Balbotey	0.50	92	200.00	80.94	Yes	2004-2005	RGoB	Functional
	21	Gangatey-hangay	Hangay	7.00	150	352.00	142.45	Yes	2009-10	RGoB	Functional
	22	Lapchey -Kothigoan	Kotigoan	4.50	69	40.05	16.21	Yes	2009-10	RGoB	Functional
	23	Bayasi Irrigation channel	Sipsu Khola	3.00	61	45.00	18.21	Yes	2010-2011	RGoB	Functional
Tading	24	Jenchu	Jenchu	2.50	6	32.00	12.95	No	2003-2004	RGoB	Functional
Tendru	25	Pakpay	Pakpay	1.50	56	60.50	24.48	Yes	2008-2009	RGoB	Functional
	26	Kuchintar	Kuchintar	2.50	38	104.00	42.09	No	2005-2006	RGoB	Functional
	27	Tendrutar channel	Tendrutar	2.00	25	65.00	26.30	No	2006-2007	RGoB	Functional
Ugyentse	28	Thakuri Dara	Thakuri Kholsi	1.00	20	50.00	20.23	No	2004-2005	RGoB	Functional
Yoeseltse	29	Lamitar	Lamitar	2.00	32	136.00	55.04	No	2003-2004	RGoB	Functional
	30	Kuchidiana	Kuchudiana	15.00	256	659.00	266.68	No	2004-2005	RGoB	Functional
	31	Kuchidina irrigation channel	Kuchidina	3.74	52	206.73	83.66	No	2009-2010	ASSP	Functional
	32	Kuchidina Irrigation channel	Lower Kuchidiana	3.70	52	206.73	83.66	No	2010-2011	RGoB	Functional

Screened

* Formed but not registered

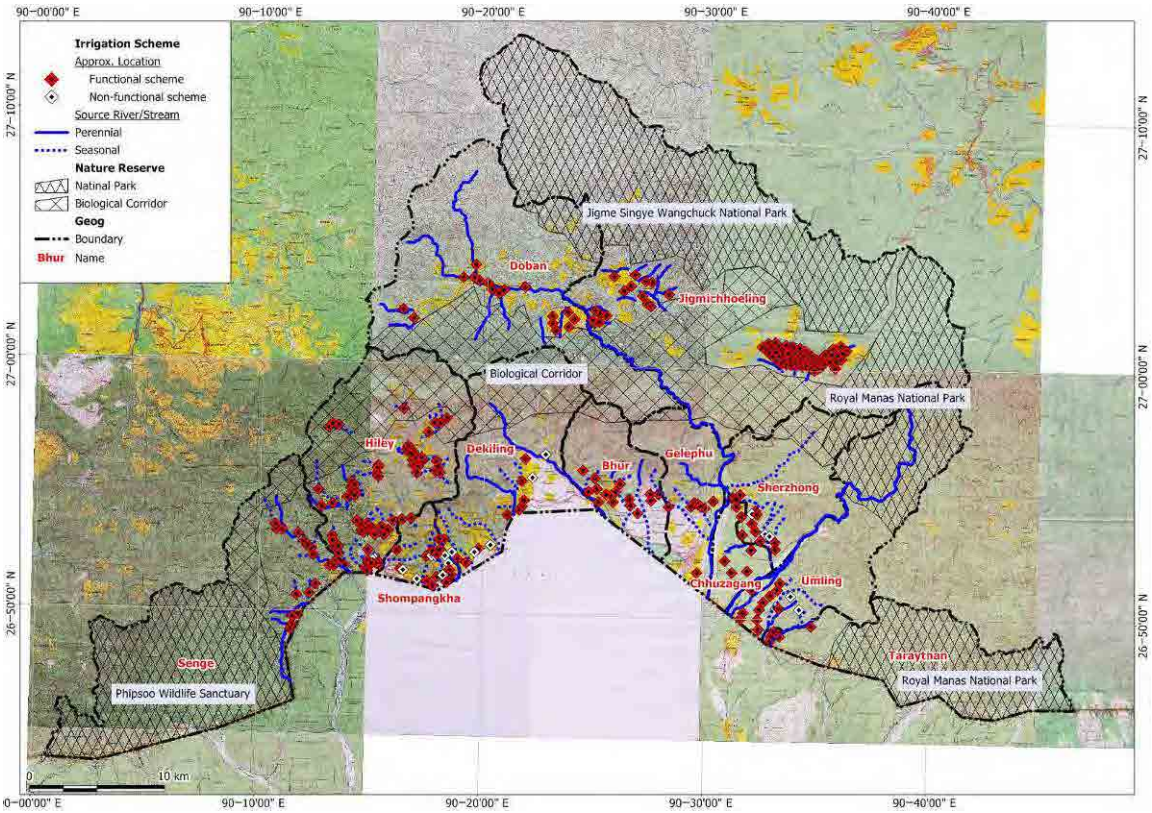


Figure 3.3.3 Location Map of Irrigation Areas (Sarpang)

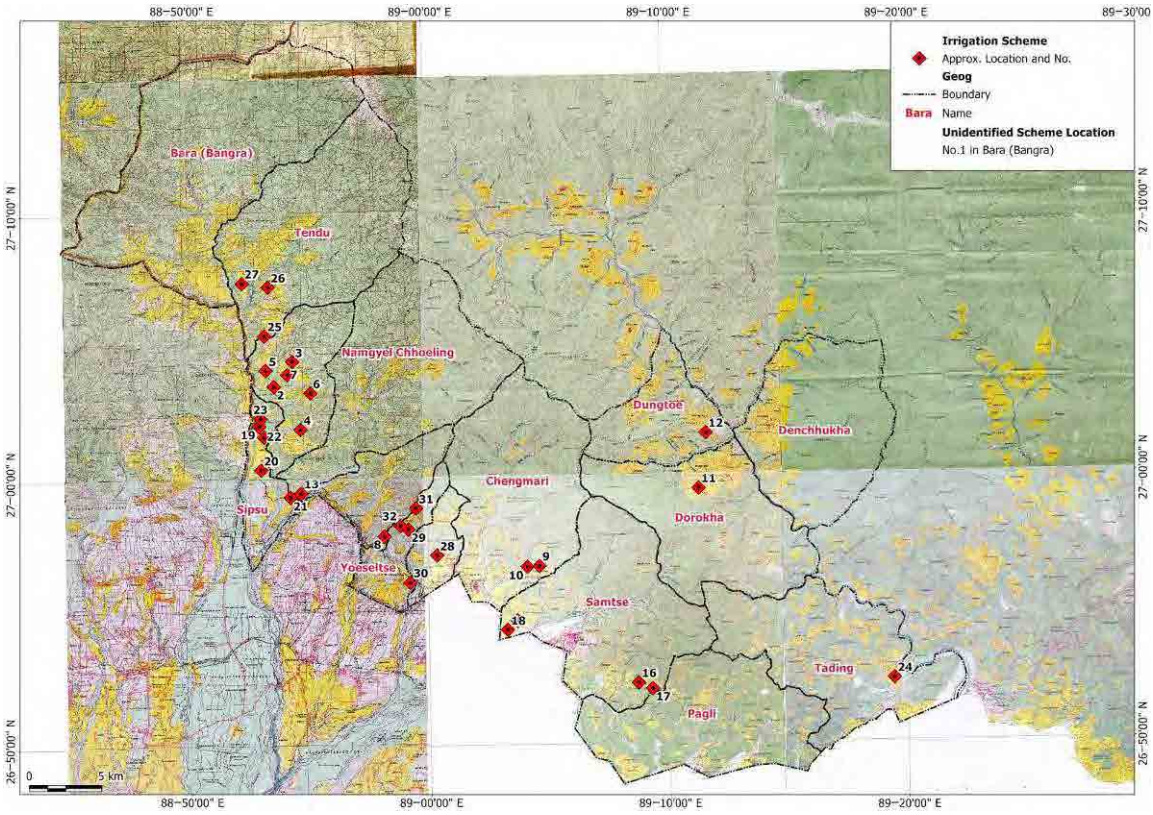


Figure 3.3.4 Location Map of Irrigation Areas (Samtse)

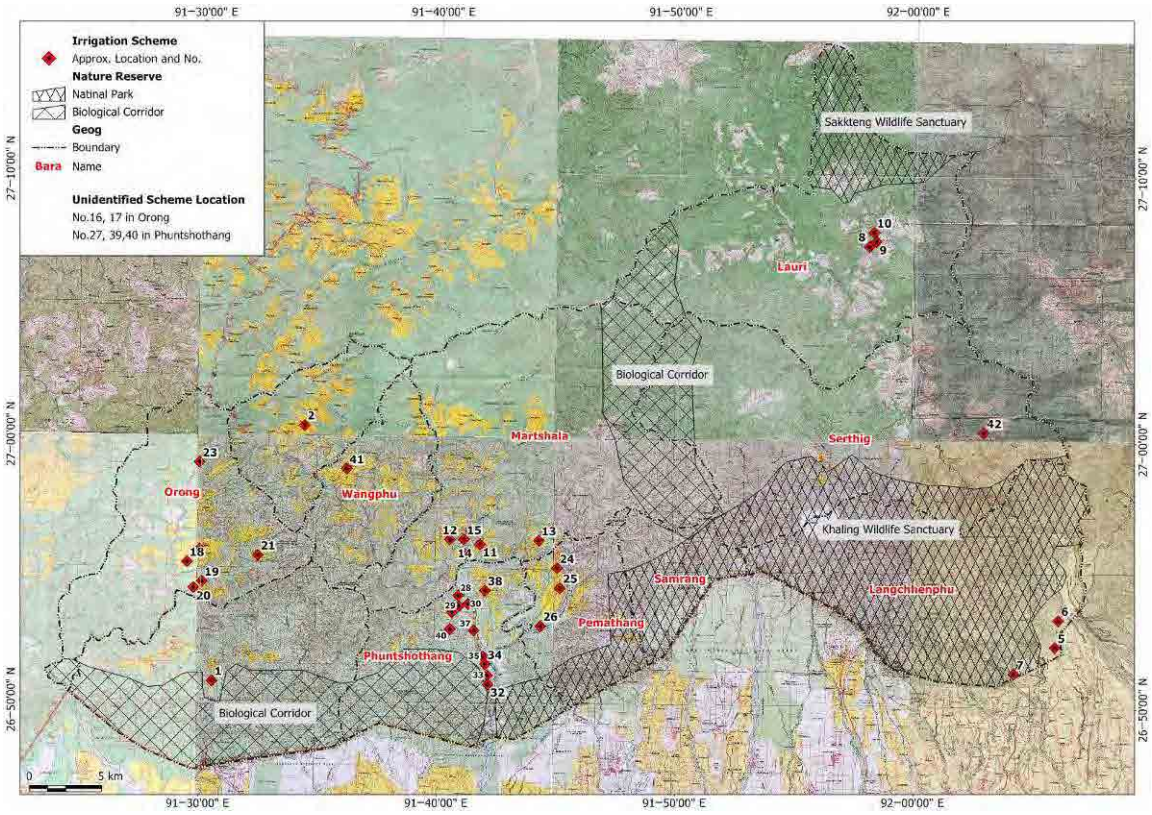


Figure 3.3.5 Location Map of Irrigation Areas (Samdrop Jongkhar)

Inventory was prepared based on the past related data/ information with on-going canal construction and rehabilitation works. The inventory was screened by applying the same criteria as mentioned above. After the screening, the long list is prepared by 31 sites, total 85 km, 1,676 households and 1,520 ha.

GIS mapping was made on the Figures from 3.3.3 to 3.3.5.

(5) On-going irrigation system rehabilitation project

DoA is executing three projects for irrigation system rehabilitation in two areas in Sarpang Dzongkhag and one area in Samtse Dzongkhag. (Bidding process for construction was taken from June to July in 2012.) Contents of the projects are designed as shown in Table 3.3.29).

Table 3.3.29 On-going Irrigation Rehabilitation Projects by DoA

No.	Name	Dzongkhag	Gewog	Length of Channel (km)	Existing Scheme Number Involved*
1	Biru-Sipsu Irrigation Canal	Samtse	Sipsu	7.84	20, 22, 23
2	Maogaon Irrigation Scheme	Sarpang	Dovan	7.36	90, 99,100, 101, 102, 104
3	Paanch Khola Irrigation Scheme	Sarpang	Umling	9.46	278, 279, 280

Data source; DoA, Engineering Section, Note *; surveyed by JICA Survey Team

Out of the three, Maogan Irrigation Scheme is located in almost center in the Dovan Gewog. Irrigation water is provided from new water source by integrating existing small intake facilities. As for Pasnch Khola Irrigation Scheme, the project site is located in Umiling Gewog in Sarpang Dzongkhag. In this

project, water source is planned to change from the existing seasonal river to the permanent river Paanch khola. Intake way is the natural intake method same as in the present method.

(6) Irrigation planning area by FAO

FAO recommended 26 irrigation planning areas in the reconnaissance survey report (2010). Relationship between the recommended areas and the inventory's areas was checked from the name of water source and beneficial villages. As the result, it is clarified that FAO's recommended areas correspond to the inventory's areas except three areas; Dewankulo, Lower Gatia and Shiv Kholalamata in Samtse (see Table 3.3.30).

Table 3.3.30 FAO's Recommended Irrigation Planning Areas and Inventory's Area

Description in FAO's List								Description by JICA Survey Team	
No.	Name of Irrigation Scheme	Geog	Source Name	Area (acres)	Intake type	Sufficiency of Source	Canal Condition	Scheme NO. by the Present Survey	Remarks
Sarpang Dzongkhag									
A	Kalikhola-Khopitar	Hilley	Kali Khola	22	T	S	P	H-2	
B	Sarpang	Shompangkha	Sarpang Chu	2434	Proposed	I	Proposed	-	FAO's proposal；Canal Length 15 km. No plan in DOA
C	Pemacholing	Taraythang	Pemacholing	82	NF	J	VP	-	This area is abandoned because of security problem, though 6 to 7 irrigation scenes are once constructed before 1996. Located in Royal Manasu National Park.
D	Dangling	Umling	Panch Khola / Taklai	136	Proposed	S	Proposed	U-2,U-12, U-14	Under planning by DOA as Paanch Khola Irrigation Scheme; Canal Length 9.5km; To replace the source from seasonal to permanent. The new source, Paanch Khlola is a tributary of Takulai Chu.
E	Samdrup Chuyor(L)	Chuzagnag	Taklai	600	P	J	G	C-2	Taklai low level Scheme
F	Phunsum Chuyor(U)	Chuzagang	Taklai	1137	P	I	G	C-1	Taklai high levee Scheme
G	Barshong Chu (Kheor khola)	Sershong	Kheor Khola	259	NF	S	F	Ser-12, Ser-13	
H	Karbithang	Chuzagang	Karibithang	148	T	S	F	C-3	
I	Chasikhar / Serupcholing	Chuzagang	Chasikar	49	Proposed	S	Proposed	C-4	Included in Taklai high level Scheme
J	Aipowali	Bhur	Aipowali	297	NF	J	P	B-1,B-2, B-6	
K	Seran Kulo	Bhur	Dechenpelri	35	T	S	P	B-7, B-8, B-11	
L	Tarulay	Gelephu	Dzomlingthang	84	T	S	F	G-5	
M	Sonamgatshe / Raptenling	Gelephu	Sarpang Chu	148	T	S	G	G-1	
Samdrup Jongkhar Dzongkhag									
N	Khateythang	Phuntsothang	Baranadhi	32	NF	S	F	28	
O	Masane Khola	Phuntsothang	Masanekhola	7	T	I	P	29	
P	Samdrup Choeling	Phuntsothang	Daap & Kapre	59	T	S	P	39	
Q	Drumpha Shilingay	Pemathang	Digai Chu	133	T	S	P	26	

Description in FAO's List								Description by JICA Survey Team	
No.	Name of Irrigation Scheme	Geog	Source Name	Area (acres)	Intake type	Sufficiency of Source	Canal Condition	Scheme NO. by the Present Survey	Remarks
R	Gaitar	Pemathang	Warong Khola	2471	T	I	Proposed	36	
Samtse Dzongkhag									
S	Jumsa	Tendru	Kuchin Khola	89	Proposed	S	F	26	
T	Sipsu-Biru	Sipau & Biru	Biru Khola	1001	Proposed	I	F	19,22,23	Under planning by DOA as Biru-Sipsu Irrigation Canal; Canal Length 7.8 km
U	Penjoring	Sipsu	Sipsu Khola	141	T	S	G	19	
V	Dewankulo	Sipsu	Sipsu Khola	395	T	I	F	-	
W	Lower Gatia	Chargary	Gatia Khola	499	T	S	P	-	
X	Lengthey	Chargary	Gatia Khola u/s	89	NF	S	P	8	
Y	Lower kuchidiana	Yoselts	Kuchidiana Khola	222	P	S	G	22	
Z	Shiv Khola lamatar		Shiv Khola	1201	Proposed	I	Proposed	-	No plan in DOA.

Abbreviations

P: Permanent
T: Temporary
NF: Not functional

S: Sufficient
J: Just sufficient
I: Insufficient

G: Good
F: Fair
P: Poor
VP: Very poor

3.3.4 Resources of Agricultural Activities

(1) Rural roads

The situation of constructing roads in the targeted three dzongkhags in 2009 was arranged in the next table. The total length of highways/ dzongkhag roads, farm roads and feeder roads in the three dzongkhags is 660 km, which is equivalent to 129 meter per km^2. Samtse Dzongkhag, whose total road length is 146 m/km^2, is comparatively better situation of road preparation than other Dzongkhags since the length of highways/ dzongkhag roads and feeder roads is longer than other two dzongkhags. On the other hand, the situation of road preparation in Samdrup Jongkhar Dzongkhag is the most behaind in the three dzongkhags. Especially, the length of constructed highways/ dzongkhag roads is short.

Table 3.3.31 Situation of Road Preparation in the Targeted Three Dzongkhags in 2009

Dzongkhag	Land area	Highways/ Dzongkhag roads		Farm roads		Feeder roads		Total roads	
	(sq. km)	(km)	(m/sq.km)	(km)	(m/sq.km)	(km)	(m/sq.km)	(km)	(m/sq.km)
Samtse	1,309	88	67	52	40	52	39	191	146
Sarpang	1,946	123	63	80	41	39	20	242	124
Samdrup Jongkhar	1,878	73	39	88	47	67	36	227	121
Total	5,133	284	55	219	43	157	31	660	129

Source: Annual Dzongkhag Statistics 2010

(2) Rice mills and farming machines

The numbers of rice mills and hand-tractors in each dzongkhag in 2008 were arranged in the next table. The total number of rice mills in the three dsongkhags is 117. Half the number of the rice mills is in Sarpang Dzongkhag. The average number of users of a rice mill in the three dzongkhags was calculated at 240 persons per mill. The number of labour in agriculture sector in 2005 was devided by the number of the rice mills. The average number of the users in Sarpang Dzongkhag was 89 persons/mill, however, the average users in Samtse Dzongkhag was 839 persons/mill, which is more than nine times of the average users in Sarpang.

Table 3.3.32 Numbers of Rice Mills and Hand-tractors in the Targeted Dzongkhags in 2008

Dzongkhag	Labour force a (persons)	Employed in agriculture b (%)	Labour in agriculture c=a*b (persons)	Agriculture mills d (places)	Agriculture mills e=c/d (persons/place)	Power tillers f (units)	Power tillers e=c/f (persons/unit)
Samtse	24,760	67.8	16,787	20	839	7	2,398
Sarpang	13,993	38.2	5,345	60	89	54	99
Samdrup Jongkhar	12,288	48.7	5,984	37	162	6	997
Total / Average	51,041	55.1	28,117	117	240	67	420

Source: Socio-Economic and Demographic Indicators 2005/ Annual Dzongkhag Statistics 2010

Note: Labour force (a) and Employed in agriculture (b) are data in 2005.
The place number of Agriculture mills in Samtse is datum in 2009.

In recent years, farming machines are introduced into some areas, such as riding-tractors, combine harvesters and rice-transplanters. However, utilizing farming machines is still not popular and farmers do not buy those machines directly from dealers. Even hand-tractors, farmers buy them through

Regional Agriculture Machinery Center (RAMC), MoAF, receiving subsidies. More than 80 % of the total hand-tractors are working in Sarpang Dzongkhag since Sarpang has a regional office of RAMC and a national agriculture project.

(3) Market places

In each dzongkhags, there are 2-4 towns, which manage a small-scale market place of food. In Gelephu City in Sarpang Dzongkhag manages a market place of 20 permanent retail shops, which sell vegetables, fruits, dried groceries, fresh fish, chicken meat and eggs, mainly in weekdays. In weekends, about 60-70 merchants/ farmers come to the market place and open temporaly shops. For the cash crops, such as ginger, citrus and areka nut, Department of Agriculture Marketing and Cooperatives (DAMC), MoAF opens auction yards in the harvesting seasons.

The targeted three dzongkhags are located in the border area with India, where a lot of Indian products flow in. Especially in the market place in Gelephu, most of the products are coming from India excluding a part of commodities, such as dried groceries, chicken eggs and cash crops in Bhutan, since the distance from a checkpoint of the border to Gelephu town is only one kilometer, which is connected by a main road.

(4) CAFCO (Chuzagang Agriculture Farmers Cooperative)

CAFCO is a farmers' cooperative in Chuzagang Gewog, which was established in 2010. The number of the member is 209 of 159 households, whose activities are rice cultivation, pig/ poultry/ fish farming, saving, bamboo management and building a community house. In the activity of the rice cultivation, a large milling system is introduced, supported by EU. Brand rice of CAFCO is sold not only in the local areas but also in Thimphu. Through RAMC, tractors, transplanters, harvesters, pedal threshers, etc. are also introduced in CAFCO, which lends those farming machines to farmers. The organization is an advanced cooperative, foreseeing the irrigated agriculture development in Takali irrigation scheme. Though their activities have just been started, it is necessary for seeing through the development direction of irrigation farming in the southern area to monitor the activities and the results in the future.