

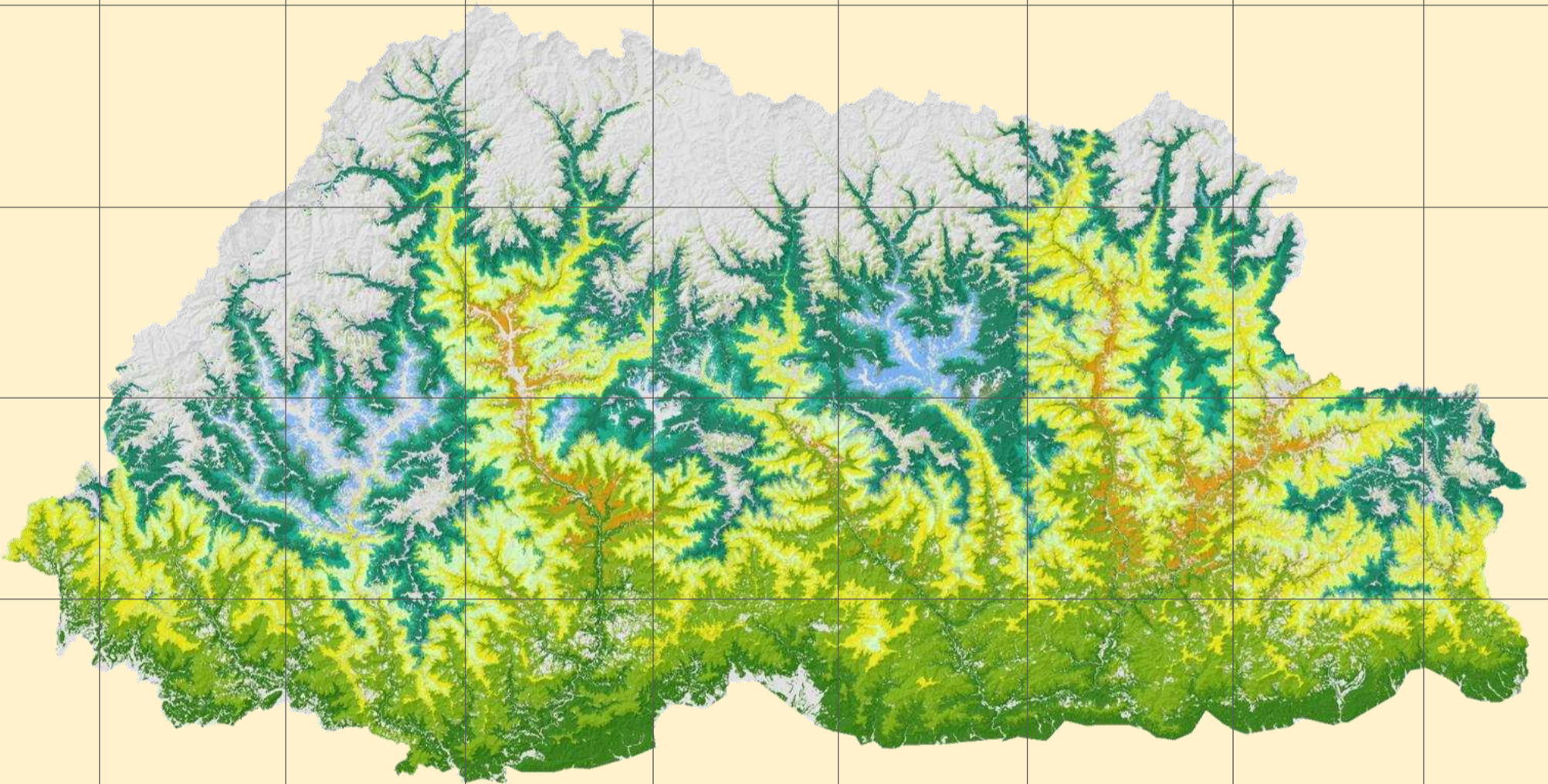


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Royal Government of Bhutan
Ministry of Agriculture and Forests
Department of Forests and Park Services



FOREST TYPES OF BHUTAN



MAPS AND STATISTICS

Forest Resources Management Division

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Department of Forests & Park Services
Ministry of Agriculture and Forests
Thimphu, Bhutan

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- 1. This map shows forest types as generated from remote sensing materials of the Landsat 8 satellite instruments—the Operational Land Imager (OLI), NASA and National Forest Inventory ground information.*
- 2. It is not legal document and has no legal connection to the laws, rules and regulations affecting the ownership or registration of the land.*
- 3. The administrative boundary, road network and place names are based on the information of respective responsible agency and cannot be taken as authoritative.*



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Royal Government of Bhutan
Ministry of Agriculture and Forests
Department of Forests and Park Services
Thimphu: Bhutan



FOREWORD



Bhutan is a small country with over 71 percent forest cover and a strong conservation history. The Department of Forest and Park Services (DoFPS) is committed to ensuring that 60 percent of its geographical land is covered with forest cover in perpetuity, as required by the Constitution. Forests of Bhutan display wide range of altitudinal variation, ranging from sub-tropical forests in the Southern foothill to alpine scrub in the North. Despite forest serving as an important reservoir of different forest resources for more than 7 million people of Bhutan, it also provides refuge to more than 200 mammals and more than 700 bird species.

It is critical to create a spatial map of different types of forest in Bhutan in order to understand the spatial extent of different forest types inside the country and to monitor forest dynamics in the context of climate change. Although A.J.C Grierson and D.G. Long conducted an extensive study on Bhutan’s vegetation zone classification in 1983, DoFPS has not been able to develop a map utilizing the same data. However, with the advent of remote sensing technology and availability of more comprehensive ground information through the National Forest Inventory, DoFPS is now able to produce the spatial extent of the different forest types in Bhutan.

I am really pleased to see our department’s forest type map of Bhutan, which is the first of its kind. This information will be important not just for determining the extent of various forest types in Bhutan, but also for monitoring forest the extent and forest types changes over the period. I would like to express my gratitude to the Department’s GIS and remote sensing team for their exceptional work in achieving this milestone.

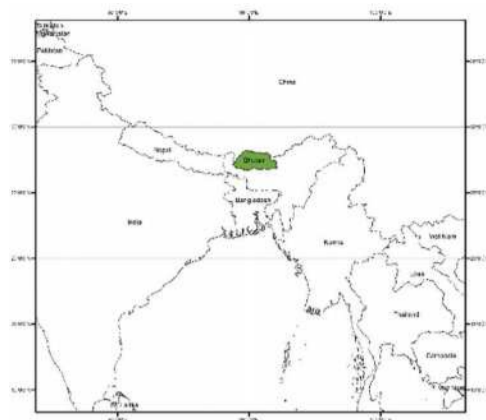
I hope that the various government agencies, academic institutions, researchers, and other users will find this document to be a valuable source of information.

Lobzang Dorji
Director

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INTRODUCTION



THE KINGDOM OF BHUTAN is in the Eastern Himalaya and situated between longitude 88° 54' and 92° 10' East and latitude 26° 40' and 28° 15' North. Bhutan is bordered by China in the North and India in the East, West, and South. The entire 38,394 km² of geographical area of Bhutan is mountainous with little flat plain limited to Southern parts of the country. The elevation varies from 100m asl in the Southern foothills to more than 7,700m asl in the northern mountains. Bhutan has a wide variety of climatic conditions influenced by the topography, elevation, and rainfall patterns. Bhutan is divided into six agro-ecological zones namely alpine, cool temperate, warm temperate, dry sub-tropical, humid subtropical and wet subtropical.

According to the Land Use and Land Cover report of 2016 (LULC 2016), around 71% of the total geographical land is covered with forest. The detailed information on the forest type was not available until A.J.C Grierson and D.G. Long carried out the detailed study on vegetation zone classification of Bhutan. They classified the major recognizable vegetation zone of Bhutan with reference to flora and vegetation type of neighboring countries. Thereafter, the vegetation zone is considered as the major forest types of Bhutan. The same forest type information was also collected during the first comprehensive National Forest Inventory (NFI) between 2012-2015. The major vegetation zones/forest types according to A.J.C Grierson and D.G. Long are;

- 1. Subtropical Forest:** True tropical rain forest is doesn't exist in Bhutan. The tropical genera and species found in Bhutan lies outside the tropics and is considered as subtropical forest. Subtropical forest is present between an altitude of 200-1000m asl (-1200m asl) and precipitation of 2500-5000mm. Such forests dominate the foothills forming dense jungle on the steep slopes and river banks. Some of the characteristic species found in the subtropical forests are; *Gmelina arborea*, *Chukrasia tabularis*, *Acrocarpus fraxinifolius*, *Ailanthus grandis*, *Bombax ceiba*, *Duabanga grandiflora*, *Shorea robusta*, *Pterospermum acerifolium*, *Aquilaria agallocha*, etc.
- 2. Warm broad-leaved Forest:** This is essentially a type of subtropical forest, but occurs at a higher altitude with a lower rainfall and contains a mixture of evergreen and deciduous broad-leaved tree species. Warm broad-leaved forest is present between an altitude of 1000 to 2000m asl (-2300m asl) and precipitation of 2300-4000mm. Many tropical genera, e.g. *Daubanga*, *Pterospermum* and *Tetramles*, are absent and more temperate genera appear. Some of the characteristics species found in the this forest type are; *Alangium chinense*, *Alnus nepalensis*, *Altingia excelsa*, *Betula alnoides*, *Bischofia javanica*, *Callicarpa arborea*, *Castanopsis indica*, *Cordia obliqua*, *Dendrocalamus hookeri*, *Dichroa febrifuga*, *Engelhardia spicata*, *Entada pursaetha*, *Euodia fraxinifolia*, *Firmiana colorata*, *Helicia nilagirica*, *Lithocarpus elegans*, *L. pachyphyllus*, *L. fenestratus*, *L. dealbatus*, *L. listeri*, *Macaranga pustulata*, *Maclura cochinchinensis*, *Maesa spp.*, *Mussaenda roxburghii*, *Ostodes paniculata*, *Pouzolzia sanguinea*, *Rhaphidophora eximea*, *Schima wallichii*, *Stereospermum personatum*, *Trevesia palmata*, *Wendlandia puberula*, etc.
- 3. Chir pine Forest:** This is a low altitude xerophytic forest occurring in the deeper dry valleys of Bhutan. These valleys have a very long dry season during which burning is common, and heavy rain occurs only in the monsoon season when abundant herbs, especially grasses, appear. Chirpines are resistant to burning but the shrub layer is more susceptible and therefore poorly developed. Chir pine forest mostly occurs as pure stand with little or no other tree species. Chirpine forest is present in the drier valleys between an altitude of 900-1800m asl (-2000m asl) and precipitation of 1000-1300mm. Some of the characteristic species found along this forest type are: *Pinus roxburghii*, *Buddleja asiatica*, *B. bhutanica*, *Cycas pectinata*, *Cymbopogon flexuosus*, *Euphorbia royleana*, *Ficus oligodon*, *Grewia sapida*, *Indigofera dosua*, *Osyris lanceolata*, *Rhus paniculata*, *Securinega suffruticosa*, *Solanum erianthum*, *Woodfordia fruticosa*, *Ziziphus incurva*, etc.
- 4. Cool broad-leaved Forest:** This forest type is usually found above the warm broad-leaved forest on the wetter slope. This forest type is dominated with mixed broad-leaved species of both deciduous and evergreen in nature with oak being less common. Cool broad-leaved forest is found between an altitude of 2000-2900m asl and precipitation of 2000-3000mm. This forest type is closely integrated with Oak Forest. Some of the characteristic species found are; *Acer campbellii*, *A. sterculiaceum*, *Betula alnoides*, *Beilschmiedia sikkimensis*, *Brassaiopsis alpina*, *Chirita lachenensis*, *Corylopsis himalayana*, *Daphniphyllum himalense*, *Elatostema monandrum*, *E. obtusum*, *Exbucklandia populnea*, *Helwingia himlaica*, *Ilex fragilis*, *Lecanthus peduncularis*, *Lindera neesiana*, *L. pulcherrima*, *Michelia doltsopa*, *M. kisopa*, *Persea clarkeana*, *Persea fructifera*, *Pilea bracteosa*, *Rosa moschhata*, *Rubus lineatus*, *R. pentagonus*, *R. treutleri*, *Schisandra grandiflora*, *Symplocos dryophila*, etc.
- 5. Evergreen Oak Forest:** This forest type is present above warm broad-leaved forests, together with cool broad-leaved forest but on the drier slope. It is mostly present between an altitude of 1800-2000m asl (2600m asl) and precipitation of 2000-3000mm. At a lower levels *Castanopsis hystrix* and *C. tribuloides* are often dominant with *Quercus lamellosa* becomes common at higher altitude. Some of the characteristic species in this forest type are; *Quercus lamellosa*, *Q. lanata*, *Q. glauca*, *Q. semecarpifolia*, *Acer campbellii*, *Castanopsis hystrix*, *C. tribuloides*, *Elatostema hookerianum*, *E. sessile*, *Galeola lindleyana*, *Juglans regia*, *Pilea symmeria*, *Skimmia arborescens*, *Symplocos lucida*, etc.
- 6. Blue pine Forest:** Blue pine forest occupies the inner dry valleys of Bhutan where rainfall is very low except during the monsoon season. This forest type is found between an altitude of 2100-3000m asl (-3100m asl) and precipitation of 700-1200mm. It is best developed in Haa, Paro and Thimphu valleys in the West and in Bumthang valley in the East. In these valleys it is often dominant and act as pioneer colonist of burnt or disturbed ground. There is a gradual transition between this forest type and evergreen oak forest, and on the moisture slopes above

the main valley, with Spruce, Hemlock, and Fir forests. Some of the characteristic species found in this forest type are; *Pinus wallichiana*, *P. bhutanica*, *Arisaema consanguineum*, *Berberis asiatica*, *Berchemia edgeworthii*, *Ceratostigma griffithii*, *Cotoneaster griffithii*, *Elaeagnus parviflora*, *Euonymus grandiflorus*, *Indigofera heterantha*, *Jasminum humilie*, *Leptodermis scabrada*, *Lonicera quinquelocularis*, *Lyonia ovalifolia*, *Ophiopogon intermedius*, *Philadelphus tomentosus*, *Polygala sibirica*, *Prinsepia utilis*, *Quercus griffithii*, *Q. semecarpifolia*, *Rhododendron arboreum*, *Rosa sericea*, *Spiraea canescens*, *Zanthoxylum armatum*, etc.

7. **Spruce Forest:** Spruce Forest, together with Hemlock and Fir Forest, occupy the montane cloud-forest zone of Bhutan between the temperate broad-leaved forest and tree line. Spruce is found at lower altitude and occupies drier valleys. Such forest is often seen between an altitude of 2500-3100m asl (-3200m asl) and precipitation of 500-1000mm. Often spruce is found in mixed with other species like pine, larch, oak, maple, and birch but pure stand of spruce can be frequently recognized. Some of the characteristic species found in the zone are; *Picea spinulosa*, *Picea brachytyla*, *Acer cappadocicum*, *A. pectinatum*, *Berberis praecipua*, *Enkianthus deflexus*, *Larix griffithiana*, *Lindera heterophylla*, *Osmanthus suavis*, *Pyrola sikkimensis*, *Ribes takare*, *Rosa macrophylla*, *Salix daltonia*, *Salvia campanulata*, *Taxus baccata*, etc.
8. **Hemlock Forest:** This forest is found in the similar zone with spruce forest but appear on the wetter slope due to higher precipitation requirement. Hemlock is present between an altitude of 2800-3100m asl (-3300m asl) and precipitation of 1300-2000mm. Shrubby and arborescent Rhododendrons are often found mixed in this forest. It is more on the mountain ridges below Fir forests, through the central and Northern part of the country. Some the characteristic species found here are; *Tsuga dumosa*, *Arundinaria griffithiana*, *Betula utilis*, *Buddleja colvilei*, *Daphne bholua*, *Gaultheria fragrantissima*, *Larix griffithiana*, *Litsea sericea*, *Maddenia himalaica*, *Magnolia globosa*, *Panax pseudo-ginseng*, *Rhododendron falconeri*, *R. hodgsonii*, *R. keysii*, *Rubus calophyllus*, *R. pentagonous*, *Sorbus thibetica*, *Viburnum mullaha*, etc.
9. **Fir Forest:** Fir Forest is the characteristic of highest forested ridges throughout Bhutan. This forest is found between an altitude of 3100-3300m asl (3800m asl) and precipitation of 1300-2000mm. The dense canopy provides a humid environment for a luxuriant understory of Rhododendron and other shrubs, and the mossy ground layer supports many small herbs, e.g. *Primula* species and *Bryocarpum himalaicum*. Characteristic species found in this zone are; *Abies densa*, *Arundinaria maling*, *Betula utilis*, *Bryocarpum himalaicum*, *Daphne bholua*, *Juniperus pseudosabina*, *Maddenia himalaica*, *Primula denticulata*, *Prunus rufa*, *Rheum acuminatum*, *Rhododendron cinnabarinum*, *R. hodgsonii*, *Ribes takare*, *Rubus fragariodes*, *Skimmia laureola*, *Sorbus foliolosa*, *Viburnum nervosum*, etc.
10. **Juniper/Rhododendron Scrub:** This is a moist scrub vegetation occurring above the tree line through Northern and Central Bhutan. Such vegetation is found between an altitude of 3700-4200m asl. Typically, it consists of scattered shrubs of *Juniperus*, *Rhododendron* and *Potentilla arbuscula* but with rich herb layer appearing during the monsoon season. Some of the characteristic species found in this zone are; *Juniperus recurva*, *J. squamata*, *Rhododendron lepidotum*, *Morina nepalensis*, *Pedicularis megalantha*, *Phlomis tibetica*, *Potentilla arbuscula*, *Primula sikkimensis*, *Thalictrum chelidonii*, *Trollius pumilus*, *Gaultheria trichophylla*, etc.
11. **Dry alpine scrub:** This is a more xerophytic vegetation found at higher altitude than Juniper/Rhododendron scrub. It is found between an altitude of 4000-4600m asl. Some of the characteristic species found in this zone are; *Aconitum orochryseum*, *Astragalus acaulis*, *Chesneya nubigena*, *Cremanthodium thomsonii*, *Ephedra gerardiana*, *Meconopsis simplicifolia*, *Picrorhiza scrophulariifolia*, *Primula calderiana*, *Rheum nobile*, *Rhododendron anthopogon*, *Salix lindleyana*, *Saussurea gossypiphora*, *S. obvallata*, *Saxifraga moorcroftiana*, *Tenacetum gossypinum*, *Thermopsis barbata*, etc.

The Forest Type Map was developed using ground data from the National Forest Inventory (NFI) and Landsat 8 satellite imagery. The ground data for NFI were collected between 2012 and 2015. Cloud-free Landsat 8 images from 2015 were chosen in order to align the period of ground data collection with the satellite image. Map was generated using random forest classifier in eCognition 9.3. Random Forest is a new non-parametric ensemble machine-learning algorithm. Random forest classifier algorithms are widely used for generating land use and land cover maps based on satellite imageries. After the generation of draft map, intensive field validation was conducted, which was followed by model calibration and accuracy assessment.

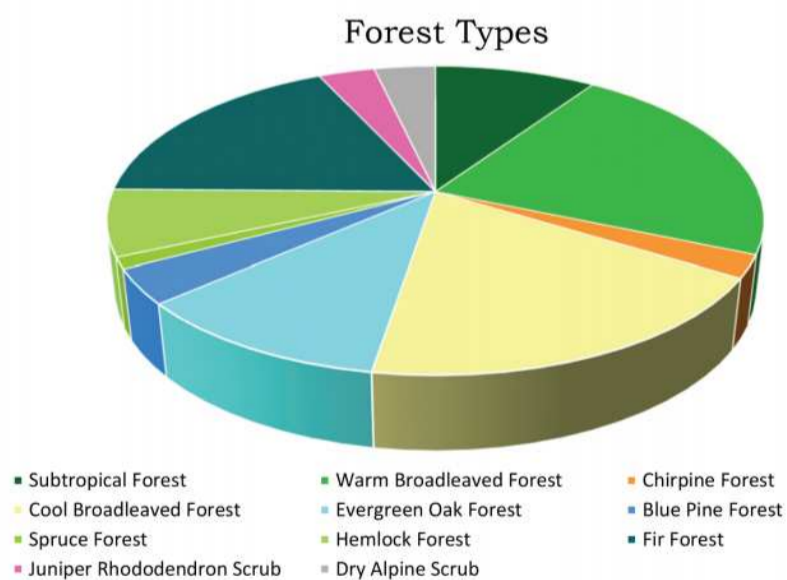
Forest Type	Area (Ha)	Percentage
Subtropical Forest	269209.21	7.01%
Warm Broadleaved Forest	623593.89	16.24%
Chir pine Forest	66852.55	1.74%
Cool Broadleaved Forest	533961.33	13.91%
Evergreen Oak Forest	310756.99	8.09%
Blue pine Forest	103131.74	2.69%
Spruce Forest	32944.99	0.86%
Hemlock Forest	197033.57	5.13%
Fir Forest	506834.07	13.21%
Juniper Rhododendron Scrub	94097.46	2.45%
Dry Alpine Scrub	102255.60	2.66%
Non-Forest	998728.60	26.01%

** Non-forest includes any land use category other than forest types (agriculture, water, built up, snow, glaciers, rocky outcrops, barren area, etc.)*

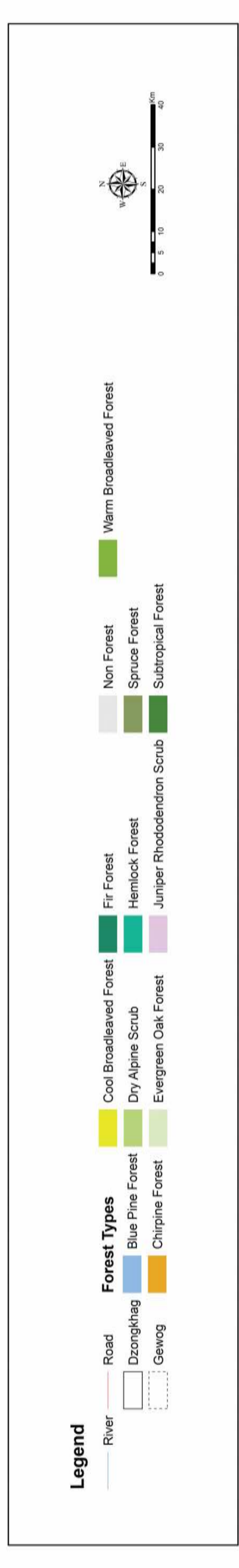
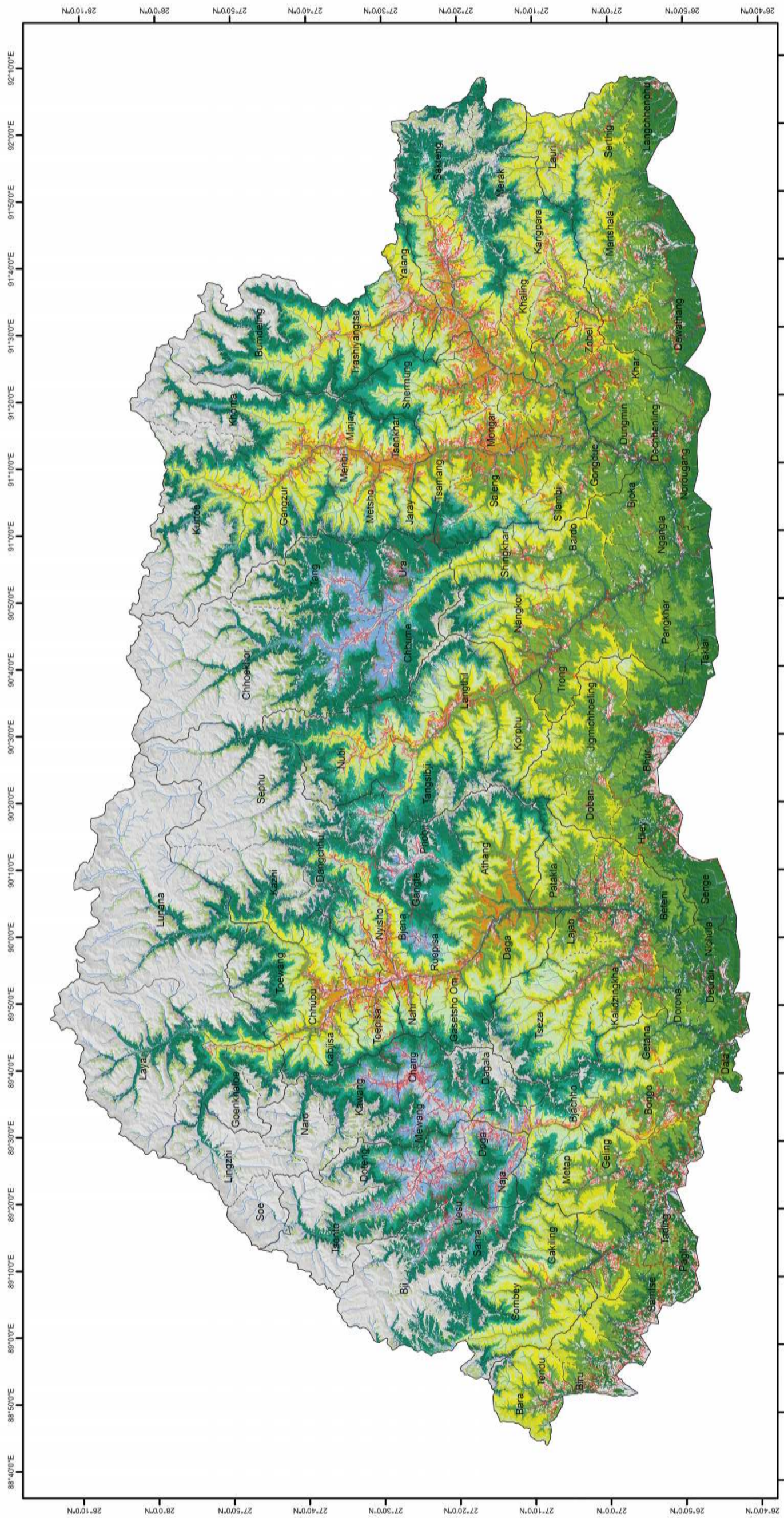
Bhutan’s diverse forest types, which ranges from Subtropical Forests in the South to Dry Alpine Scrub in the North, cover around 74 percent of its total geographical land. However, owing to the technical definition of the forest as per the National Forest Policy of Bhutan, 2011, where forest is defined as “Forests means land with tree spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent. It does not include land that is predominantly under agriculture or urban land use”, Dry Alpine Scrub may not be classified as forest stand due to its height lower than the set criteria. Therefore, by excluding the Dry Alpine Scrub, around 71% of the total geographical land is occupied by the forest stand.

Different forest types cover around 2840671.40 hectares of Bhutan’s total geographical land area. Broad-leaved forest covers around 61 percent of the forest types. Only about 32% of the forest is made up of conifer forests. Juniper Rhododendron Scrub accounts for around 3% of the forest, while Dry Alpine Scrub accounts for the remaining 4%. Warm broad-leaved forests comprise most of the forest landscape, accounting for approximately 22 percent. This is followed by Cool broad-leaved Forest and Evergreen Oak Forest, which account for around 19% and 11%, respectively. Subtropical Forests, which constitute around 9% of forest types, are found throughout the country’s southern foothills.

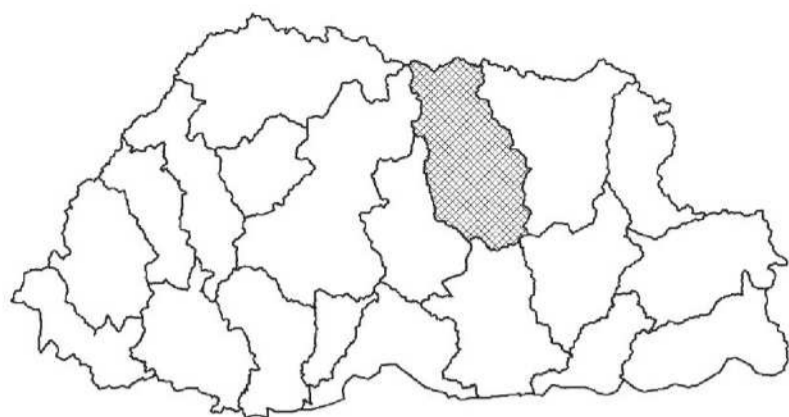
Blue pine Forest is mostly concentrated in the valleys of Bumthang, Thimphu, Paro, and Haa Dzongkhags, contributing for about 4% of total forest types. Similarly, Chir pine Forest, which accounts for approximately 2%



of all forest types, is predominantly located in the hot and arid valleys of Wangduephodrang, Punakha, Mongar, Lhuentse, Trashigang, and Trashiyangtse Dzongkhags. Bhutan has a significant proportion of Fir Forest. Fir Forest, which accounts for around 18% of forest types, is mostly distributed on high-altitude mountain ridges. In high-altitude areas, Hemlock Forest is frequently seen just below the Fir Forest. Hemlock Forest accounts for around 7% of all forest types. Bhutan’s Spruce Forest represents for only about 1% of the country’s total land area.



BUMTHANG

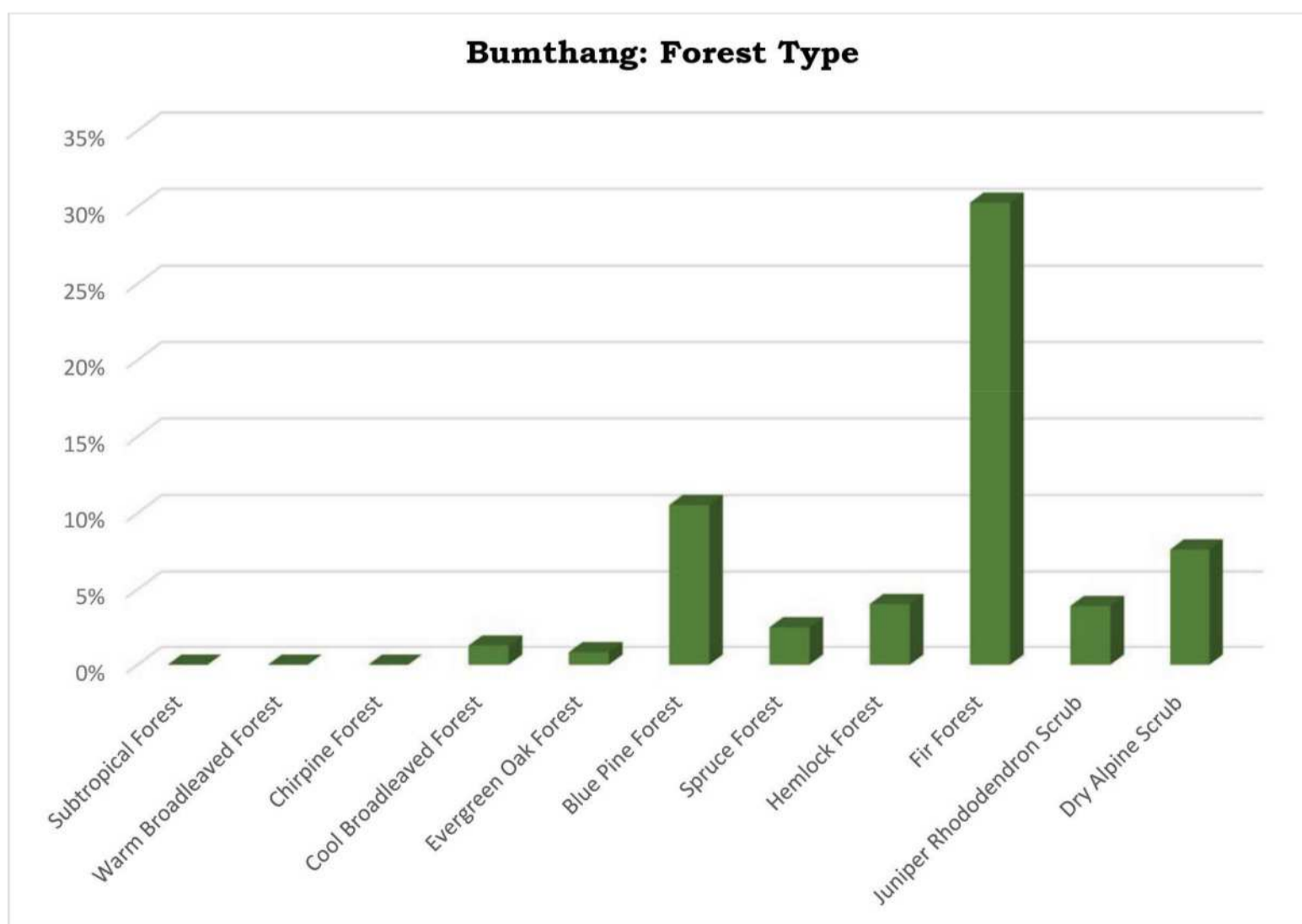


BUMTHANG DZONGKHAG is situated between Trongsa and Lhuentse Dzongkhags. (27°19' to 28°04' latitude and 90°28' to 91°00' longitude) and shares its borders with China in the North.

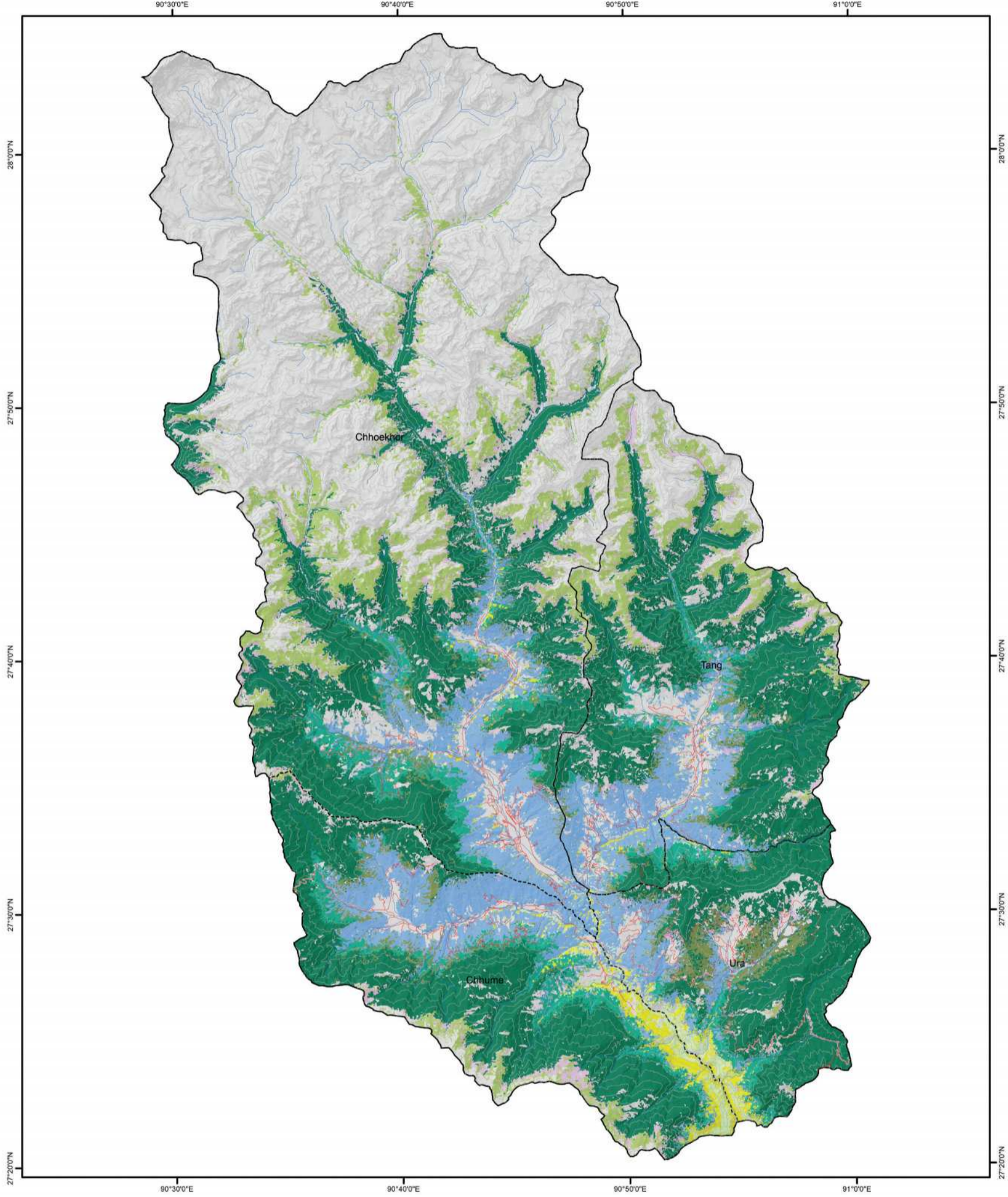
The elevation ranges from 2000 m to 6800 m above sea level. Bumthang remains cold for the major part of the year so the summer period is rather short. The climate is mainly temperate with an annual rainfall between 1000 mm and 1500 mm. The Dzongkhag partly covers the Wangchuck Centennial National Park and Phrumsengla National Park.

Bumthang forests are dominated by conifer species, with Fir Forest accounting for 30.27 %, followed by Bluepine Forest which is around 10.53%. The majority of Bhutan’s Blue pine Forest is situated in Bumthang. Bumthang lacks Subtropical Forest, Warm Broad-leaved Forest, and Chir pine Forest. Dry Alpine Scrub covers around 7.63 % of the geographical region in Bumthang. Other forest types present in Bumthang are Hemlock Forest, Spruce Forest, Cool Broadleaved Forest, and Juniper Rhododendron Scrub.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	0.00	0.00%
Warm Broadleaved Forest	0.00	0.00%
Chir pine Forest	0.00	0.00%
Cool Broadleaved Forest	3431.32	1.28%
Evergreen Oak Forest	2240.91	0.83%
Blue Pine Forest	28327.17	10.53%
Spruce Forest	6688.01	2.49%
Hemlock Forest	10843.23	4.03%
Fir Forest	81446.81	30.27%
Juniper Rhododendron Scrub	10496.38	3.90%
Dry Alpine Scrub	20519.42	7.63%



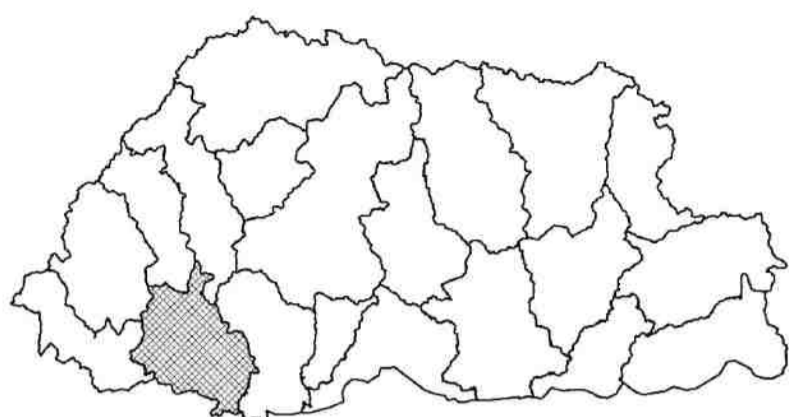
Dzongkhag: Bumthang



Legend

Dzongkhag	Forest Types	Evergreen Oak Forest	Non Forest
Gewog	Blue Pine Forest	Fir Forest	Spruce Forest
Road	Chirpine Forest	Hemlock Forest	Subtropical Forest
River	Cool Broadleaved Forest	Juniper Rhododendron Scrub	Warm Broadleaved Forest
	Dry Alpine Scrub		

CHHUKHA



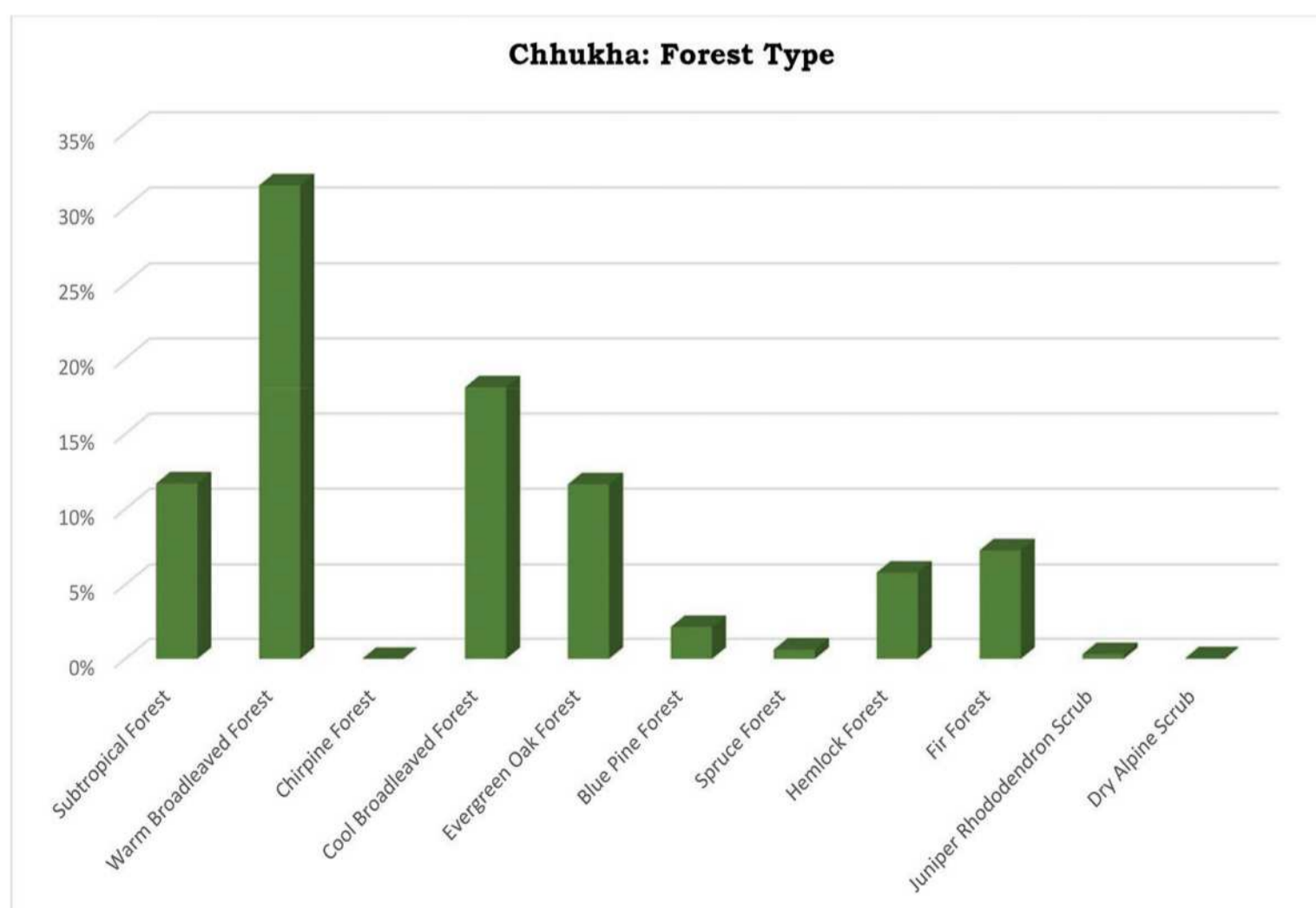
CHHUKHA DZONGKHAG lies within the 26°43’ to 27°18’ latitude and 89°15 to 89°49’ longitude. It borders with Samtse to the West, Ha to the North-West, Paro and Thimphu to the North and Dagana to the East. Towards the South, it borders with India.

The Chhukha Dzongkhag has an altitudinal range between 200m to 4400m asl and the summer is hot and winter is cold. Annual precipitation ranges from 750 mm in the North to 4000mm in the South.

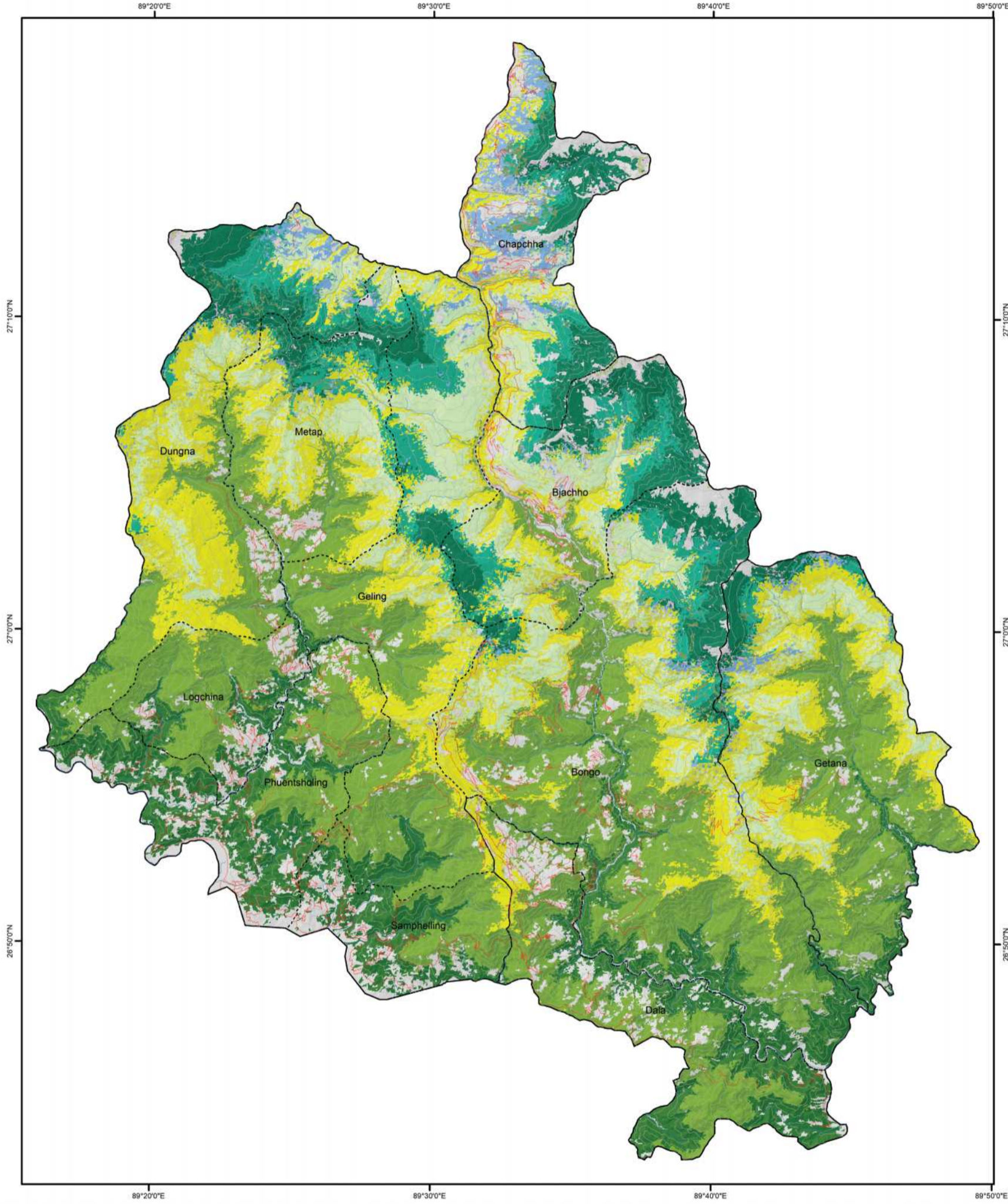
The Warm broad-leaved Forest (31.49 %) dominates Chhukha, followed by the Cool broad-leaved Forest (18.10 %). In Chhukha, Subtropical Forest covers around 11.71 % and Evergreen Oak Forest covers the remaining 11.65 %. Chhukha does not have a naturally growing Chir pine Forest. High altitude mountain forests include Fir Forest (7.29 %), Hemlock Forest (5.81 %), Blue pine Forest (2.15 %), and Spruce Forest (0.63 %). Chhukha contains very little Juniper Rhododendron and Dry Alpine Scrub.

The Warm broad-leaved Forest (31.49 %) dominates Chhukha, followed by the Cool broad-leaved Forest

Forest Type	Area (Ha)	Percentage
Subtropical Forest	21794.32	11.71%
Warm Broadleaved Forest	58615.21	31.49%
Chir pine Forest	0.00	0.00%
Cool Broadleaved Forest	33683.81	18.10%
Evergreen Oak Forest	21680.58	11.65%
Blue Pine Forest	4010.52	2.15%
Spruce Forest	1174.98	0.63%
Hemlock Forest	10812.47	5.81%
Fir Forest	13574.66	7.29%
Juniper Rhododendron Scrub	601.08	0.32%
Dry Alpine Scrub	94.88	0.05%



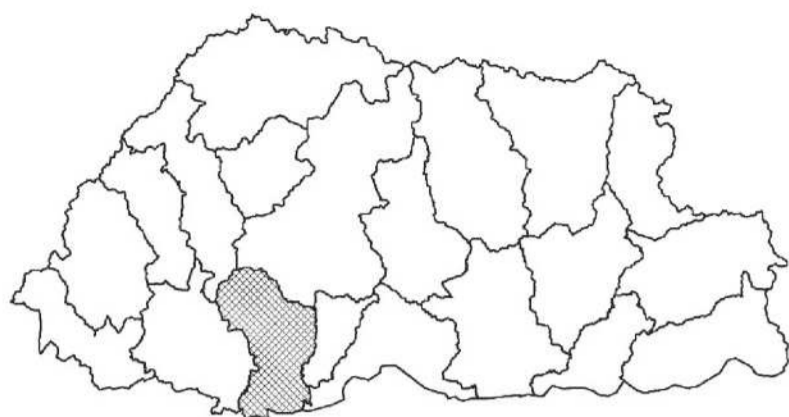
Dzongkhag: Chhukha



Legend

Dzongkhag	Forest Types	Evergreen Oak Forest	Non Forest
Gewog	Blue Pine Forest	Fir Forest	Spruce Forest
Road	Chirpine Forest	Hemlock Forest	Subtropical Forest
River	Cool Broadleaved Forest	Juniper Rhododendron Scrub	Warm Broadleaved Forest
	Dry Alpine Scrub		

DAGANA

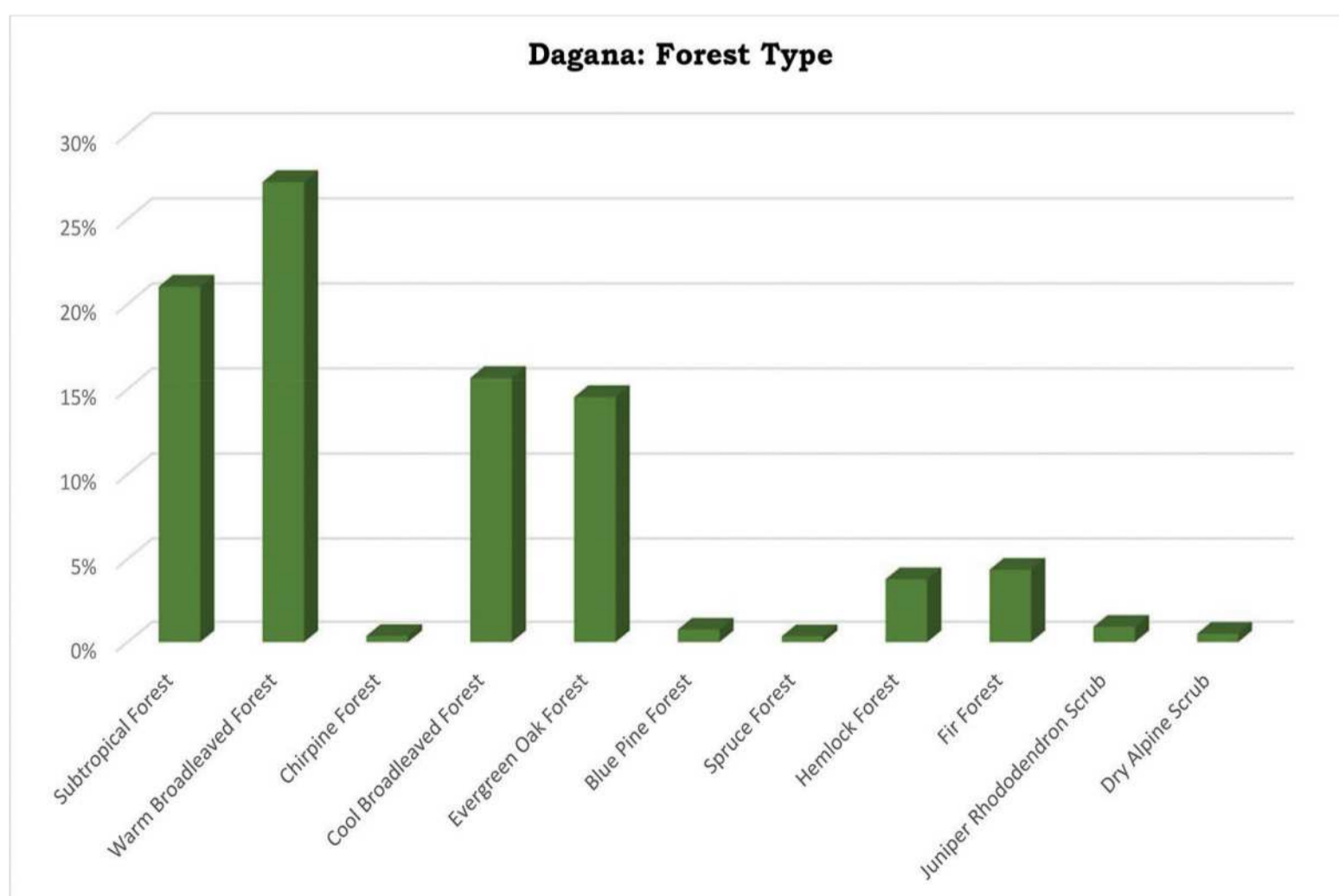


DAGANA DZONGKHAG lies between 26°41' to 27°16' latitude and 89°43' to 90°03' longitude and shares border with Chhukha and Thimphu Dzongkhags to the West, Wangdue-Phodrang Dzongkhag to the North, Tsirang Dzongkhag to the East.

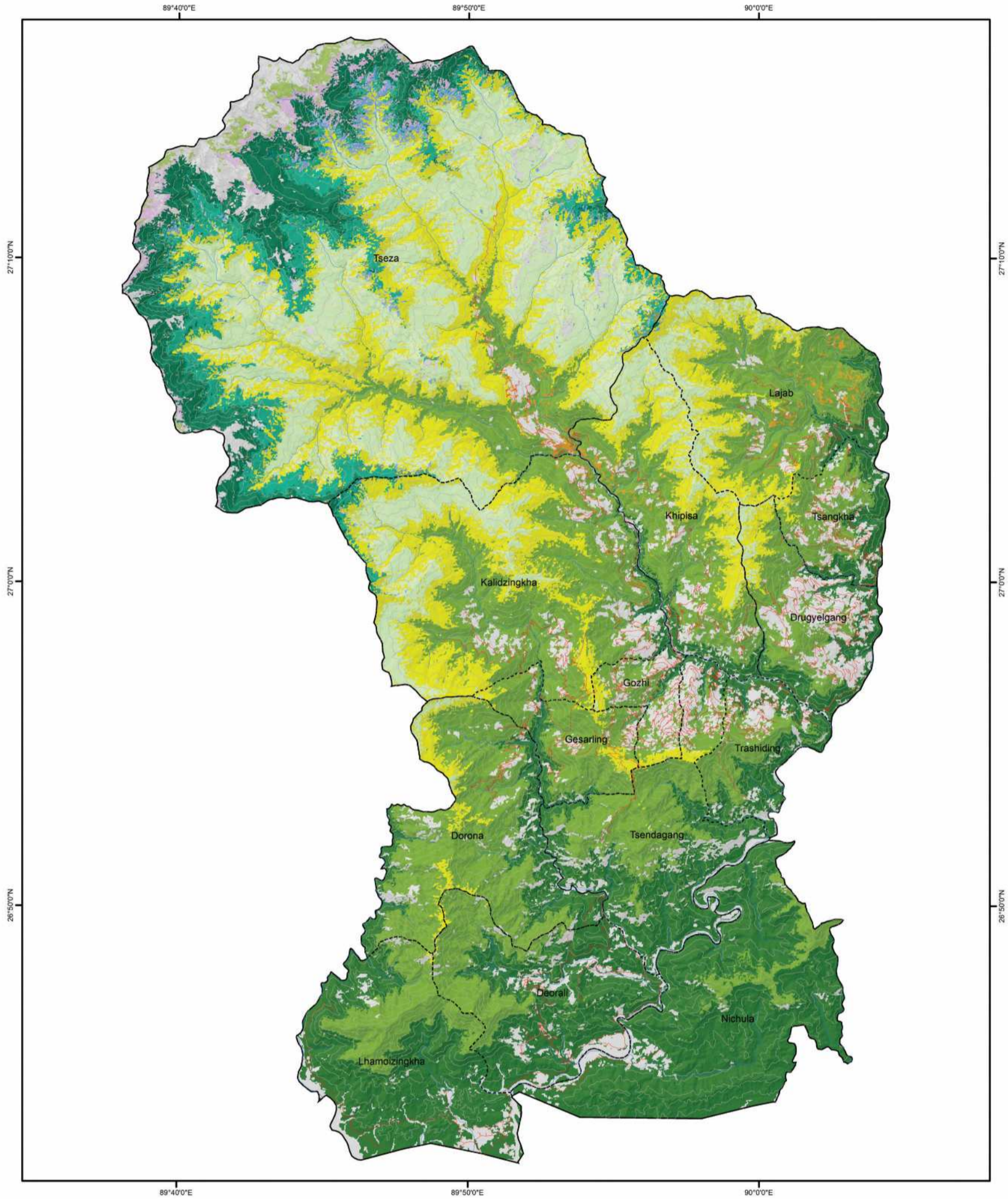
The elevation of the Dzongkhag ranges from less than 100 m to 4700 m above sea level. Northern part of Dzongkhag lies in temperate zone while the lower Southern parts of the Dzongkhag lies in subtropical zone. The annual rainfall ranges from 750 mm to 2000 mm. Phibsoo Wildlife Sanctuary also falls under this Dzongkhag.

Warm broad-leaved and Subtropical Forests dominate the Dagana forest. The region is almost equally distributed with Cool broad-leaved Forest and Evergreen Oak Forest. Dagana has a small amount of conifer forest, composed of Fir, Hemlock, Blue pine, and Spruce Forests.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	35876.72	21.03%
Warm Broadleaved Forest	46372.1	27.18%
Chir pine Forest	642.8	0.38%
Cool Broadleaved Forest	26713.72	15.66%
Evergreen Oak Forest	24798.66	14.54%
Blue Pine Forest	1298.81	0.76%
Spruce Forest	605.52	0.35%
Hemlock Forest	6466.81	3.79%
Fir Forest	7436.18	4.36%
Juniper Rhododendron Scrub	1586.68	0.93%
Dry Alpine Scrub	872.59	0.51%



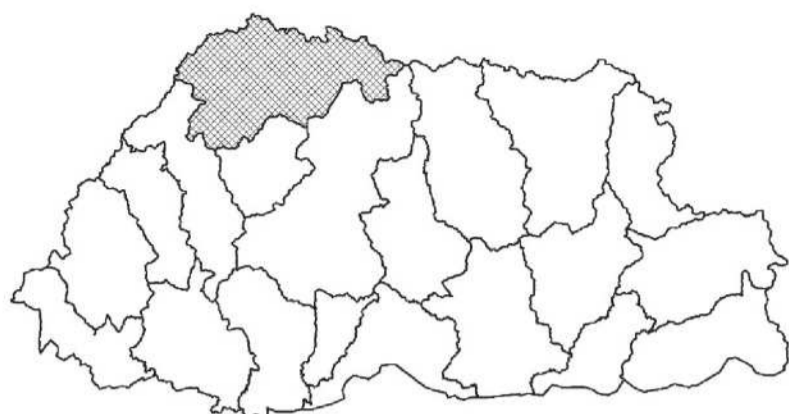
Dzongkhag: Dagana



Legend

Dzongkhag	Forest Types	Evergreen Oak Forest	Non Forest
Gewog	Blue Pine Forest	Fir Forest	Spruce Forest
Road	Chirpine Forest	Hemlock Forest	Subtropical Forest
River	Cool Broadleaved Forest	Juniper Rhododendron Scrub	Warm Broadleaved Forest
	Dry Alpine Scrub		

GASA

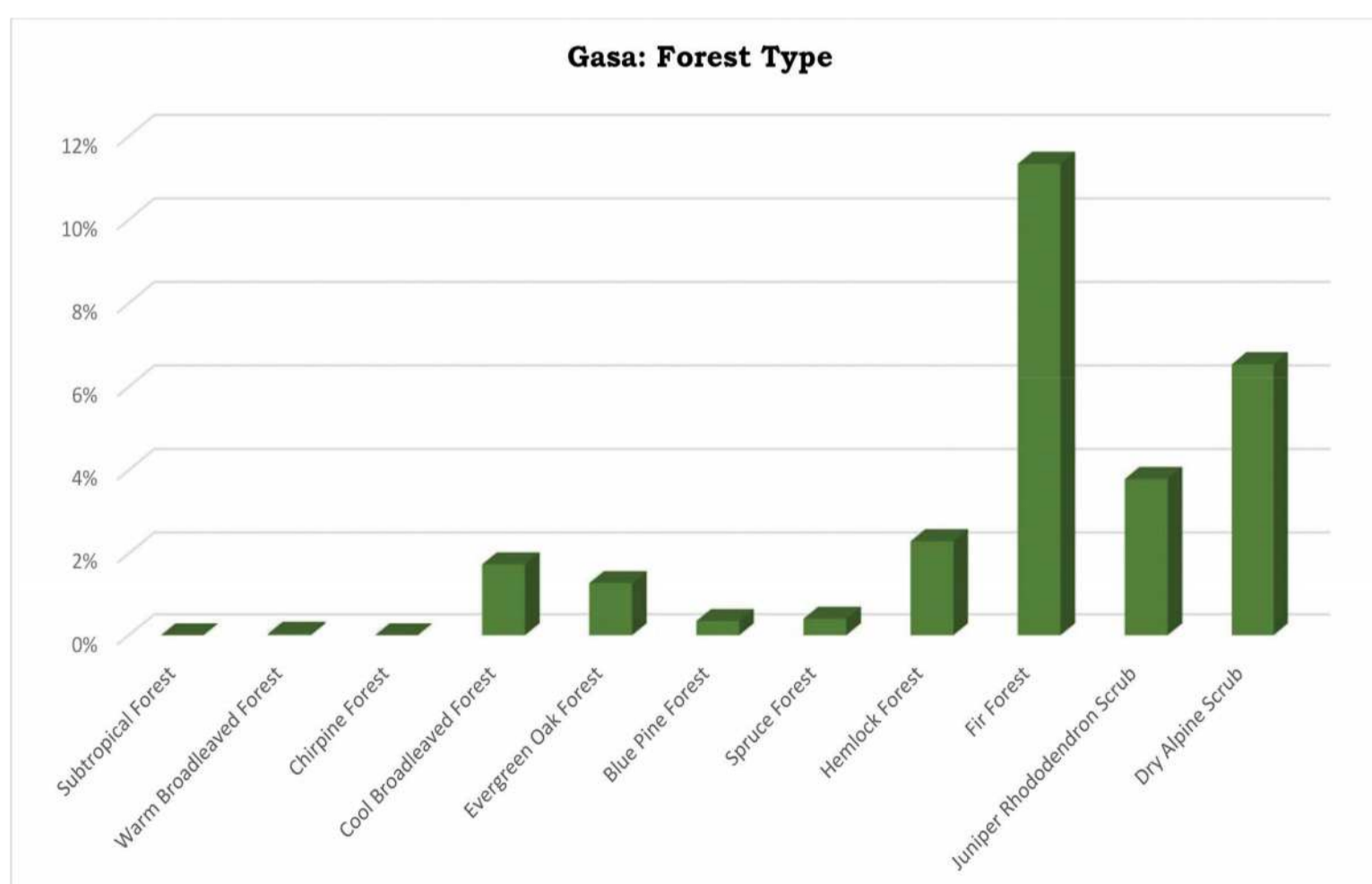


GASA DZONGKHAG lies to the North of Punakha Dzongkhag. Two main rivers, Pho Chhu and Mo Chu, originates from the snowclad catchments in the Northern part of this Dzongkhag. The elevation ranges from about 1500 m to 7500m above sea level. Gasa Dzong is located on a hill top with a small town emerging on the South-Eastern facing slope. Precipitation during autumn and spring is in the form of snow and the summers are cool. Most of the Dzongkhag is therefore covered by snow during the winter.

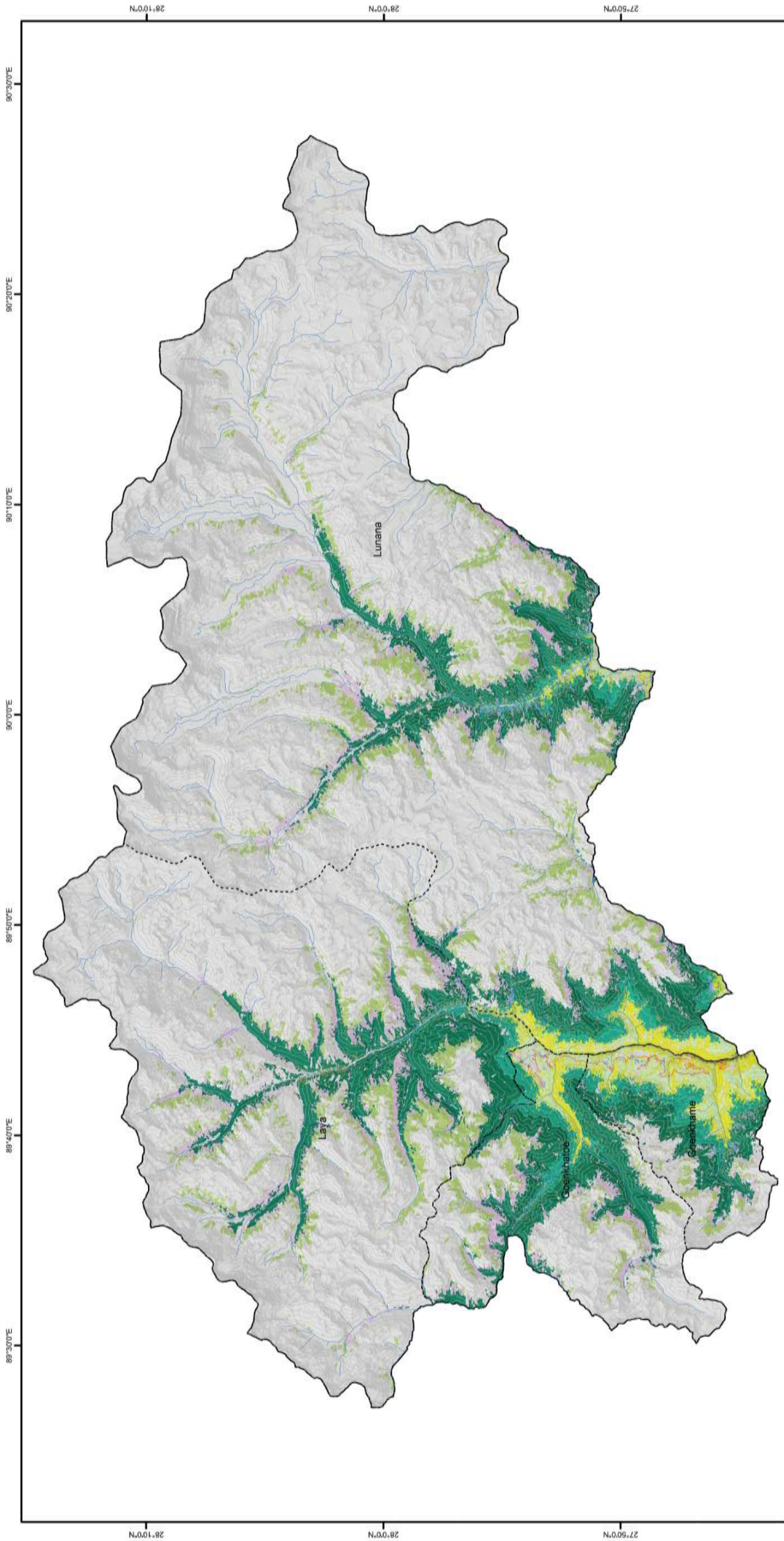
Major area of Gasa Dzongkhag falls under the Jigme Dorji National Park, and many different types of valuable medicinal plants and herbs are grown in the higher altitude areas. The national animal, Takin, is also found in this Dzongkhag.

Gasa Dzongkhag has the least forest cover, with the majority of the forest in the south of the Dzongkhag. Gasa’s forest cover is dominated by Fir Forests. This Dzongkhag lacks Subtropical, Warm broad-leaved, and Chir pine forests due to its high altitude and low temperature. Cool broad-leaved and Evergreen Oak Forest are equally spread at the Dzongkhag’s lower altitude. Dry Alpine Scrub covers around 6.54 percent of the land area.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	0.00	0.00%
Warm Broadleaved Forest	114.70	0.04%
Chir pine Forest	0.00	0.00%
Cool Broadleaved Forest	5389.04	1.74%
Evergreen Oak Forest	3960.93	1.28%
Blue Pine Forest	1078.62	0.35%
Spruce Forest	1255.47	0.40%
Hemlock Forest	7134.16	2.30%
Fir Forest	35200.40	11.34%
Juniper Rhododendron Scrub	11763.77	3.79%
Dry Alpine Scrub	20300.32	6.54%



Dzongkhag: Gasa



Legend

- Dzongkhag
- Gewog
- Road
- River

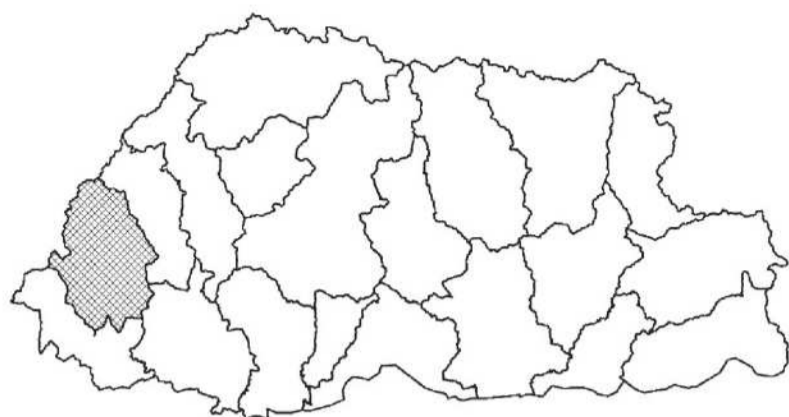
Forest Types

- Cool Broadleaved Forest
- Blue Pine Forest
- Chirpine Forest
- Dry Alpine Scrub
- Evergreen Oak Forest
- Fir Forest
- Hemlock Forest
- Juniper Rhododendron Scrub
- Non Forest
- Spruce Forest
- Subtropical Forest
- Warm Broadleaved Forest

Scale

0 2.5 5 10 15 20 Km

HAA

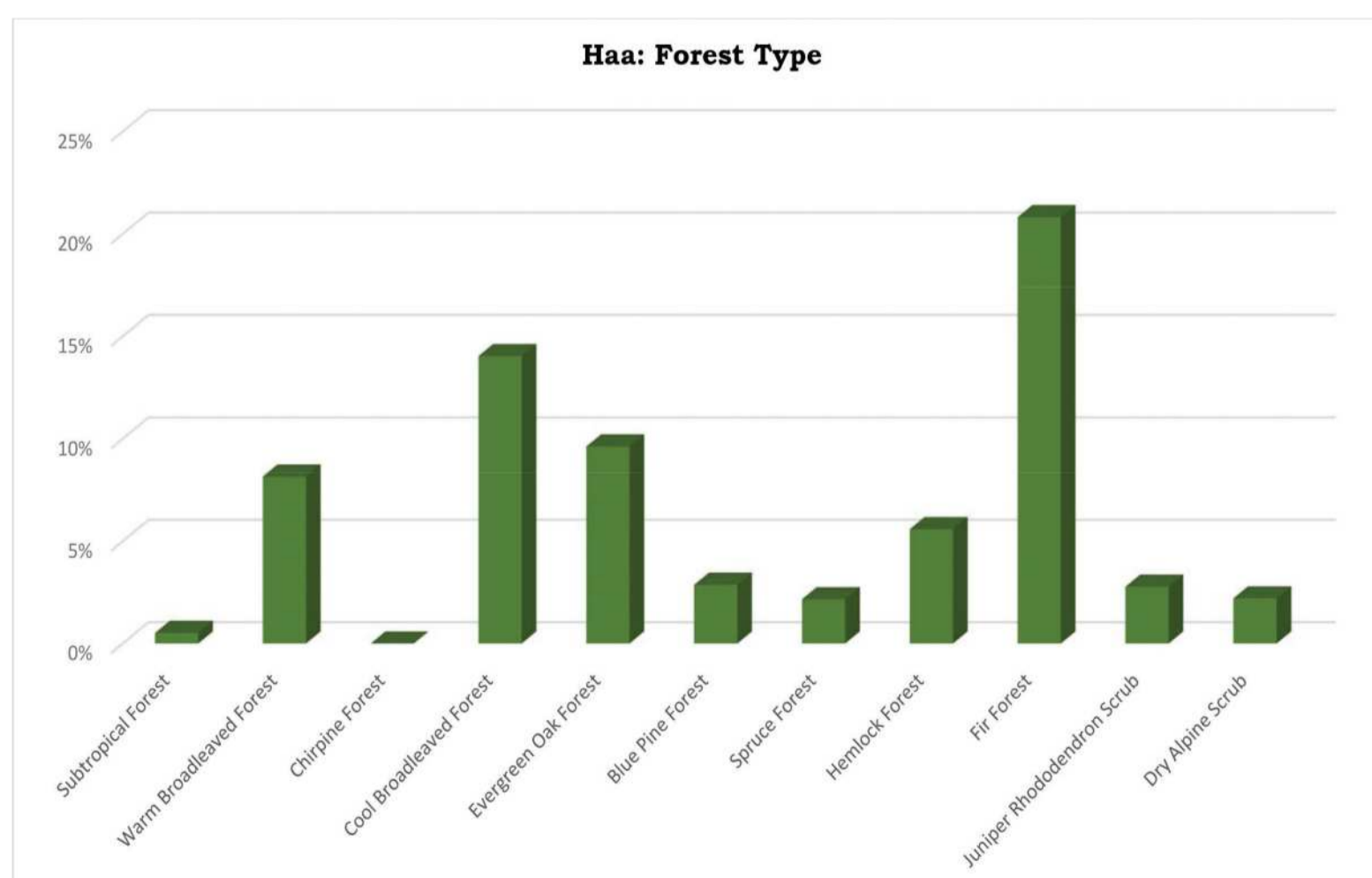


HAA DZONGKHAG lies in the extreme West of the country (27°1' to 27°37' latitude and 88°54 to 89°23' longitude). It borders with Samtse and Chhukha Dzongkhags to the South and Paro Dzongkhag to the East. Towards West it borders with India and China. Ha Chhu is the main river in the Dzongkhag.

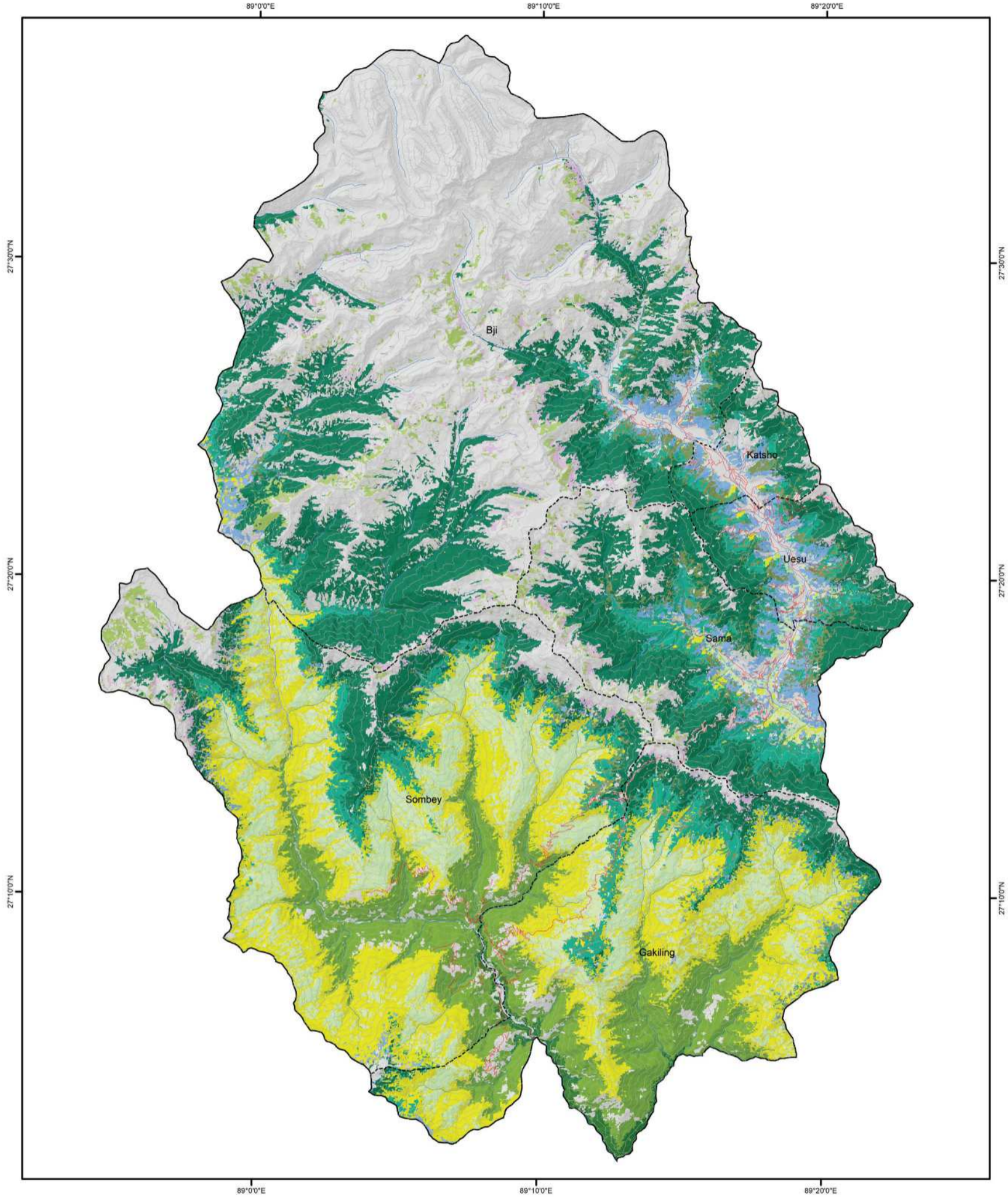
Haa Dzongkhag has an altitudinal range between 600m to 5600m asl and has a temperate climatic condition with cool summer and cold winter. The annual rainfall is about 750mm to 2000mm with precipitation in the form of snowfall during winter. The North-West part of Dzongkhag is under Jigme Khesar Strict Nature Reserve.

Conifer species dominate the forests, with Fir Forest (20.82 %) dominating the landscape. Around 9% of the land is covered with Hemlock, Spruce, and Blue pine Forests. Cool broad-leaved and Evergreen Oak Forests dominate the lower elevations. Warm broad-leaved Forest occupies river valleys along the border with Samtse Dzongkhag, accounting to around 8.15 %.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	977.19	0.52%
Warm Broadleaved Forest	15380.88	8.15%
Chir pine Forest	0.00	0.00%
Cool Broadleaved Forest	26478.81	14.04%
Evergreen Oak Forest	18150.69	9.62%
Blue Pine Forest	5409.94	2.87%
Spruce Forest	4081.76	2.16%
Hemlock Forest	10535.16	5.58%
Fir Forest	39275.70	20.82%
Juniper Rhododendron Scrub	5235.07	2.78%
Dry Alpine Scrub	4157.82	2.20%



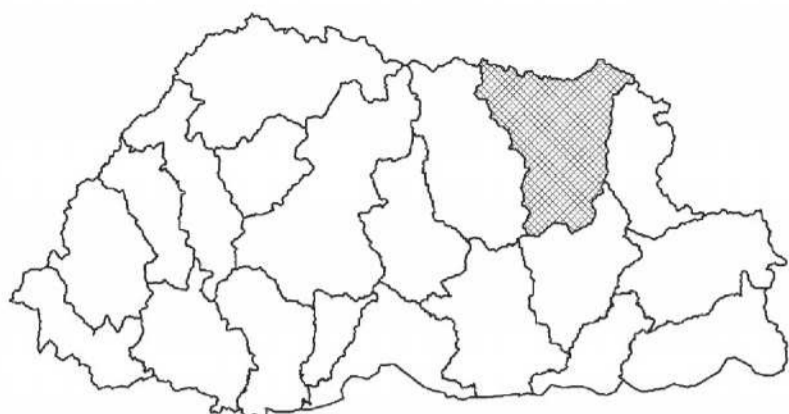
Dzongkhag: Haa



Legend

Dzongkhag	Forest Types	Evergreen Oak Forest	Non Forest
Gewog	Blue Pine Forest	Fir Forest	Spruce Forest
Road	Chirpine Forest	Hemlock Forest	Subtropical Forest
River	Cool Broadleaved Forest	Juniper Rhododendron Scrub	Warm Broadleaved Forest
	Dry Alpine Scrub		

LHUMENTSE

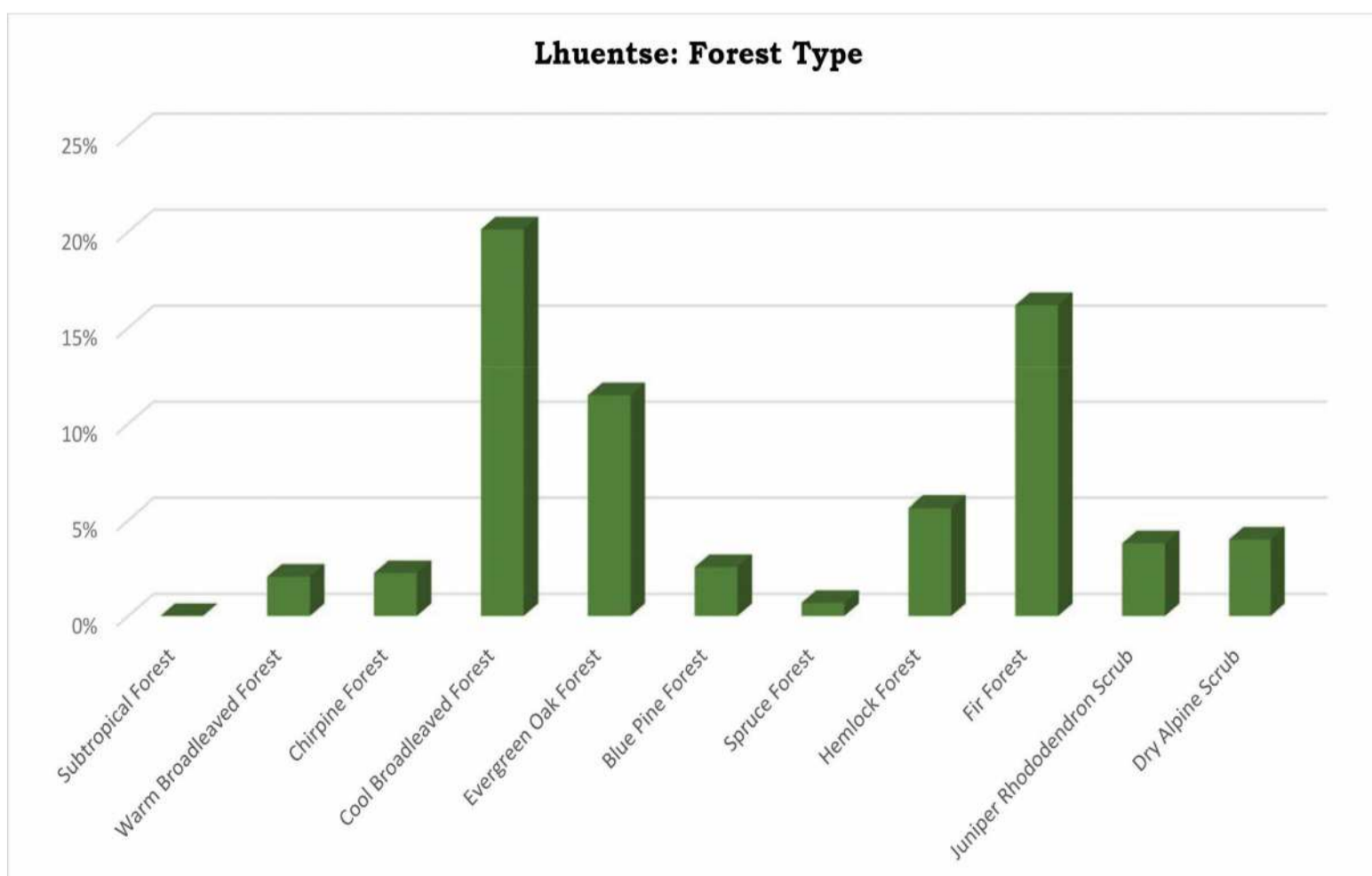


LHUMENTSE DZONGKHAG (27°23' to 28°04' latitude and 90°46' to 91°28' longitude) is bordered by Bumthang Dzongkhag to the West, Trashi Yangtse Dzongkhag to the East and Mongar Dzongkhag to the South. It borders with China to the North.

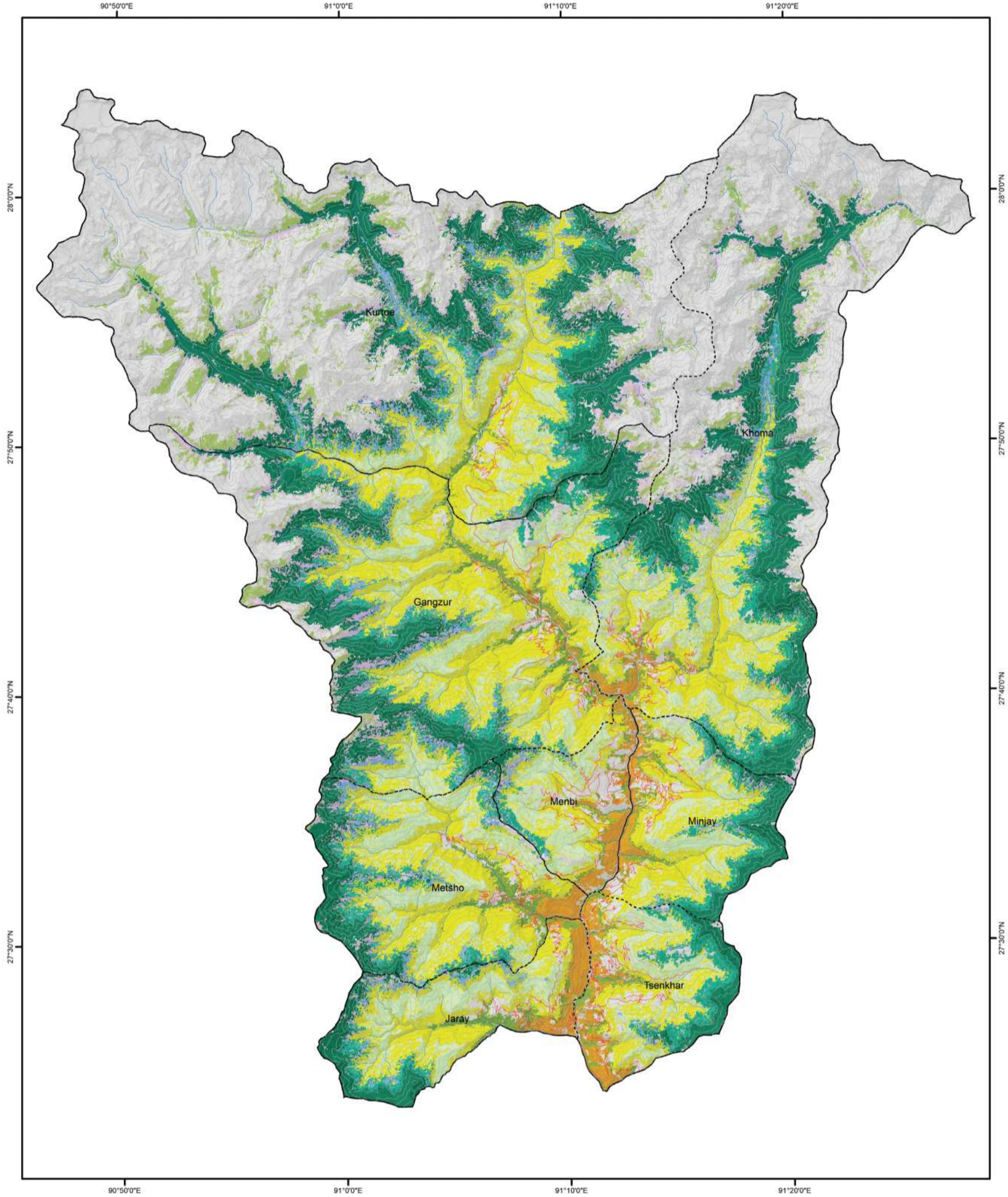
The elevation ranges from 900 m to 6300 m above sea level. The climate is characterized by warm summer and cold winter. The annual rainfall ranges from 1000mm to 1500mm. The Dzongkhag falls under Wangchuck Centennial National Park, Phrumsengla National Park, and Bumdelling Wildlife Sanctuary.

Both coniferous and broad-leaved species are present in nearly equal proportions. Cool Broad-leaved Forest covers roughly 20% of the Dzongkhag Forest area, followed by Fir Forest (16.18 %). Lower altitude river basins are dominated by Chir pine Forest (2.26 %) and Warm broad-leaved Forest (2.06 %). Lemon grass, which can be utilized to make essential oils, grows naturally under Chir pine trees.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	0.00	0.00%
Warm Broadleaved Forest	5840.03	2.06%
Chir pine Forest	6385.89	2.26%
Cool Broadleaved Forest	56975.49	20.13%
Evergreen Oak Forest	32540.31	11.49%
Blue Pine Forest	7260.21	2.56%
Spruce Forest	1956.61	0.69%
Hemlock Forest	15972.17	5.64%
Fir Forest	45811.39	16.18%
Juniper Rhododendron Scrub	10795.00	3.81%
Dry Alpine Scrub	11360.35	4.01%



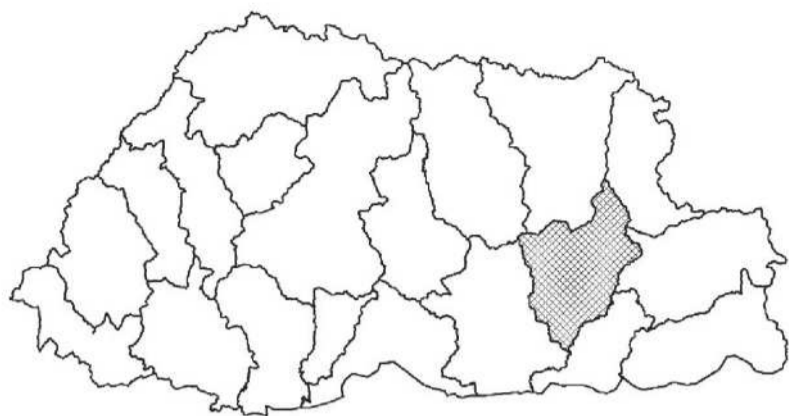
Dzongkhag: Lhuentse



Legend

Dzongkhag	Forest Types	Evergreen Oak Forest	Non Forest
Gewog	Blue Pine Forest	Fir Forest	Spruce Forest
Road	Chirpine Forest	Hemlock Forest	Subtropical Forest
River	Cool Broadleaved Forest	Juniper Rhododendron Scrub	Warm Broadleaved Forest
	Dry Alpine Scrub		

MONGAR

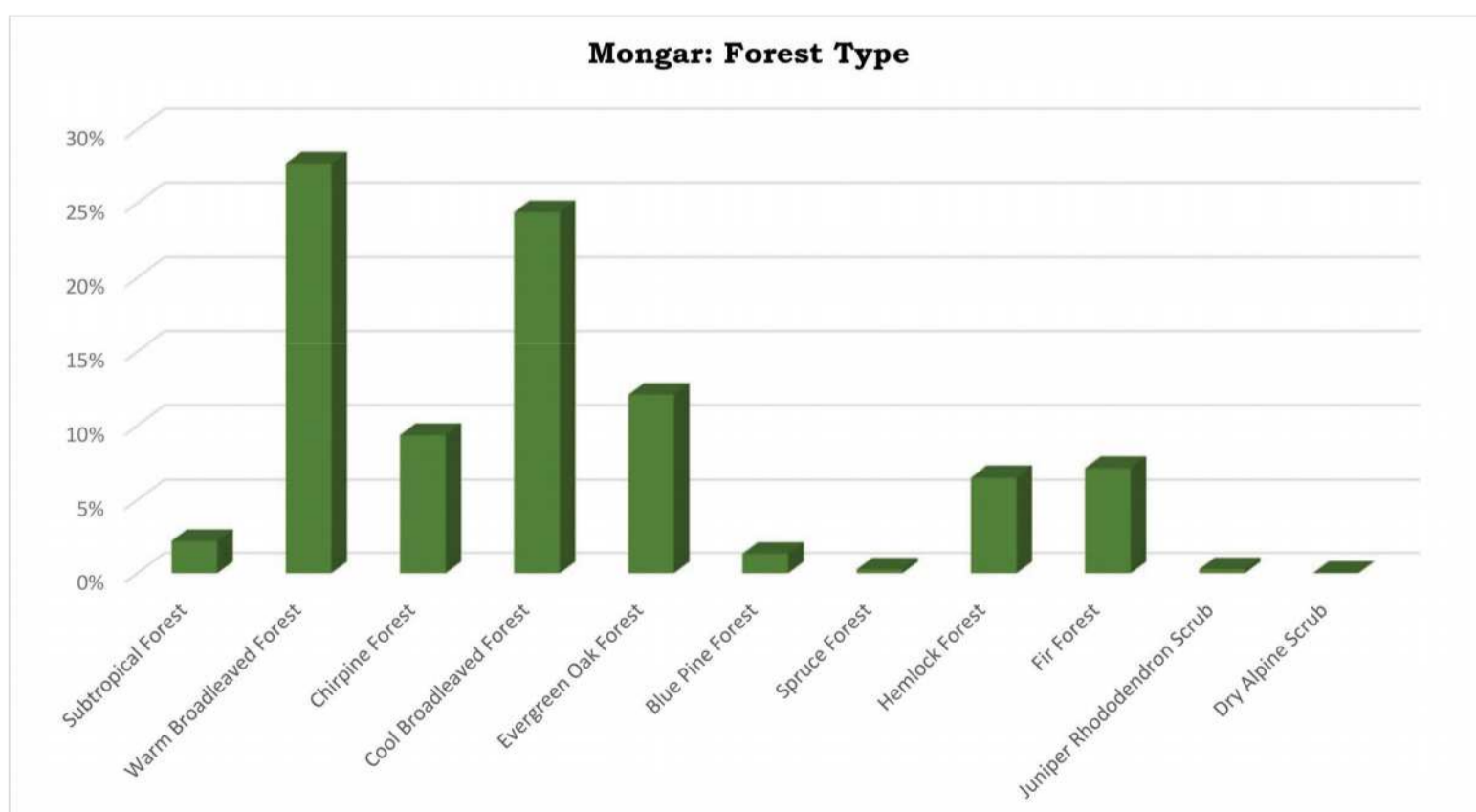


MONGAR DZONGKHAG lies in the Eastern part of the country. (26°55' to 27°36' latitude and 90°57' to 91°29' longitude). Dzongkhag share its border with Lhuentse to the North, Zhemgang to the West and the Trashi Yangtse, Trashigang and Pemagatshel Dzongkhags to the East and South-East.

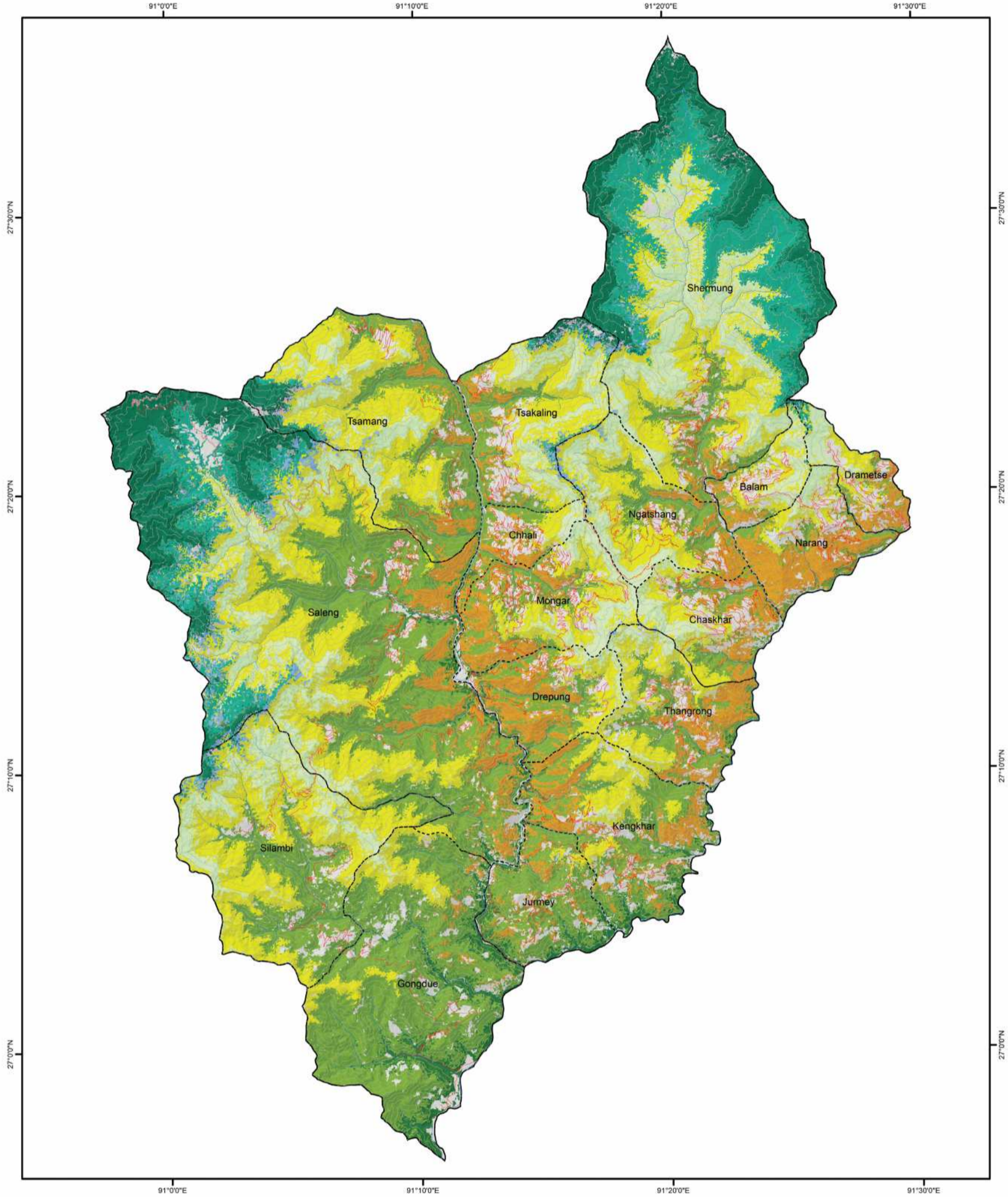
The altitude varies from 300 m to 4200 m above sea level. The climatic zones are subtropical in the lower and Southern part of the Dzongkhag, and temperate in the North and at the higher altitudes. The annual precipitation ranges from 1000mm to 2000mm. The summer is hot and the winters is cold. The Dzongkhag partly covers Phrumsengla National Park and Bumdelling Wildlife Sanctuary.

The forest landscape is dominated by Warm broad-leaved Forest (27.68 %), followed by Cool broad-leaved Forest (24.38 %). The drier side of the river valley is occupied by Chir pine Forests, which also provide an ambient climate for the growth of lemon grass, which is used in the manufacture of essential oils. Evergreen Oak Forest covers around 12% of Mongar Dzongkhag’s land area. Conifer forests are far rarer than broad-leaved forests. Fir and Hemlock Forests can be found on high-altitude mountain ranges.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	4245.06	2.20%
Warm Broadleaved Forest	53284.83	27.68%
Chir pine Forest	18017.64	9.36%
Cool Broadleaved Forest	46939.96	24.38%
Evergreen Oak Forest	23266.08	12.08%
Blue Pine Forest	2557.33	1.33%
Spruce Forest	494.07	0.26%
Hemlock Forest	12539.80	6.51%
Fir Forest	13713.40	7.12%
Juniper Rhododendron Scrub	532.83	0.28%
Dry Alpine Scrub	61.20	0.03%



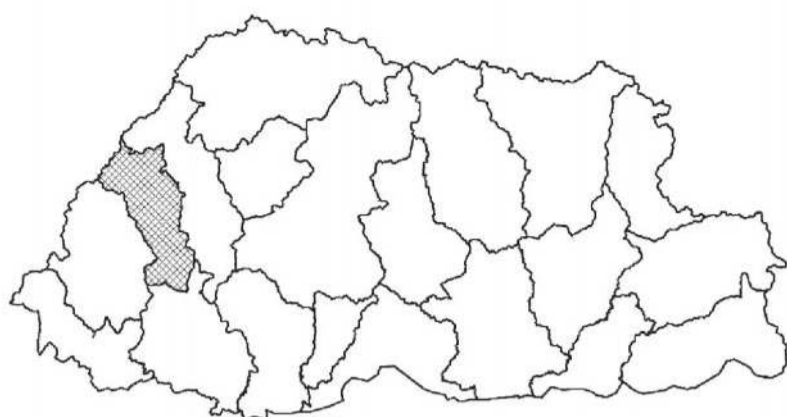
Dzongkhag: Mongar



Legend

Dzongkhag	Forest Types	Evergreen Oak Forest	Non Forest
Gewog	Blue Pine Forest	Fir Forest	Spruce Forest
Road	Chirpine Forest	Hemlock Forest	Subtropical Forest
River	Cool Broadleaved Forest	Juniper Rhododendron Scrub	Warm Broadleaved Forest
	Dry Alpine Scrub		

PARO

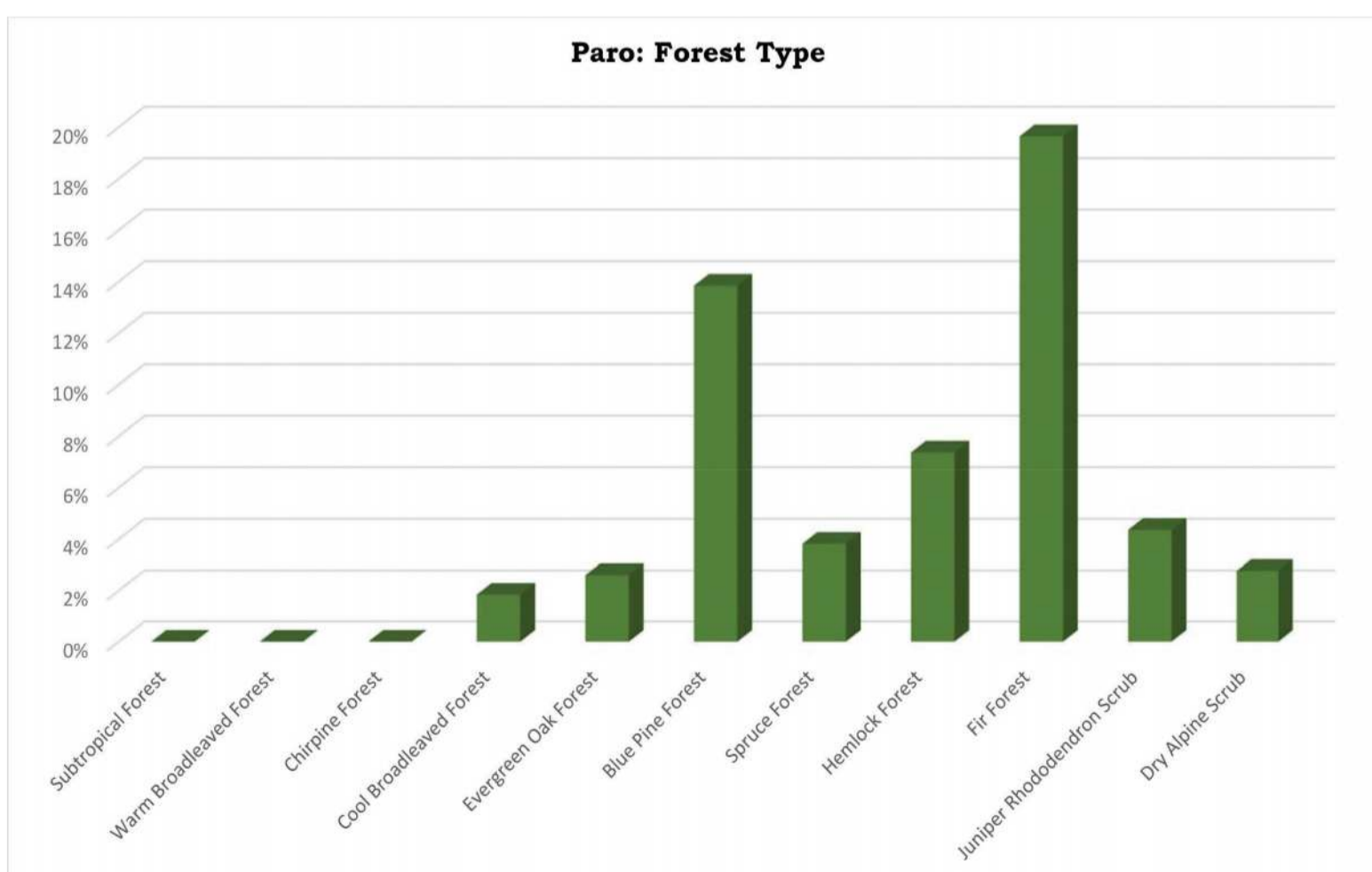


PARO DZONGKHAG (27°11' to 27°46' latitude and 89°07' to 89°32' longitude) lies to the East of Haa and West of Thimphu. The Paro Valley is considered as one of the most beautiful valleys in Bhutan. Pa Chhu, which originates from Jumolhari mountain range flows through the Dzongkhag.

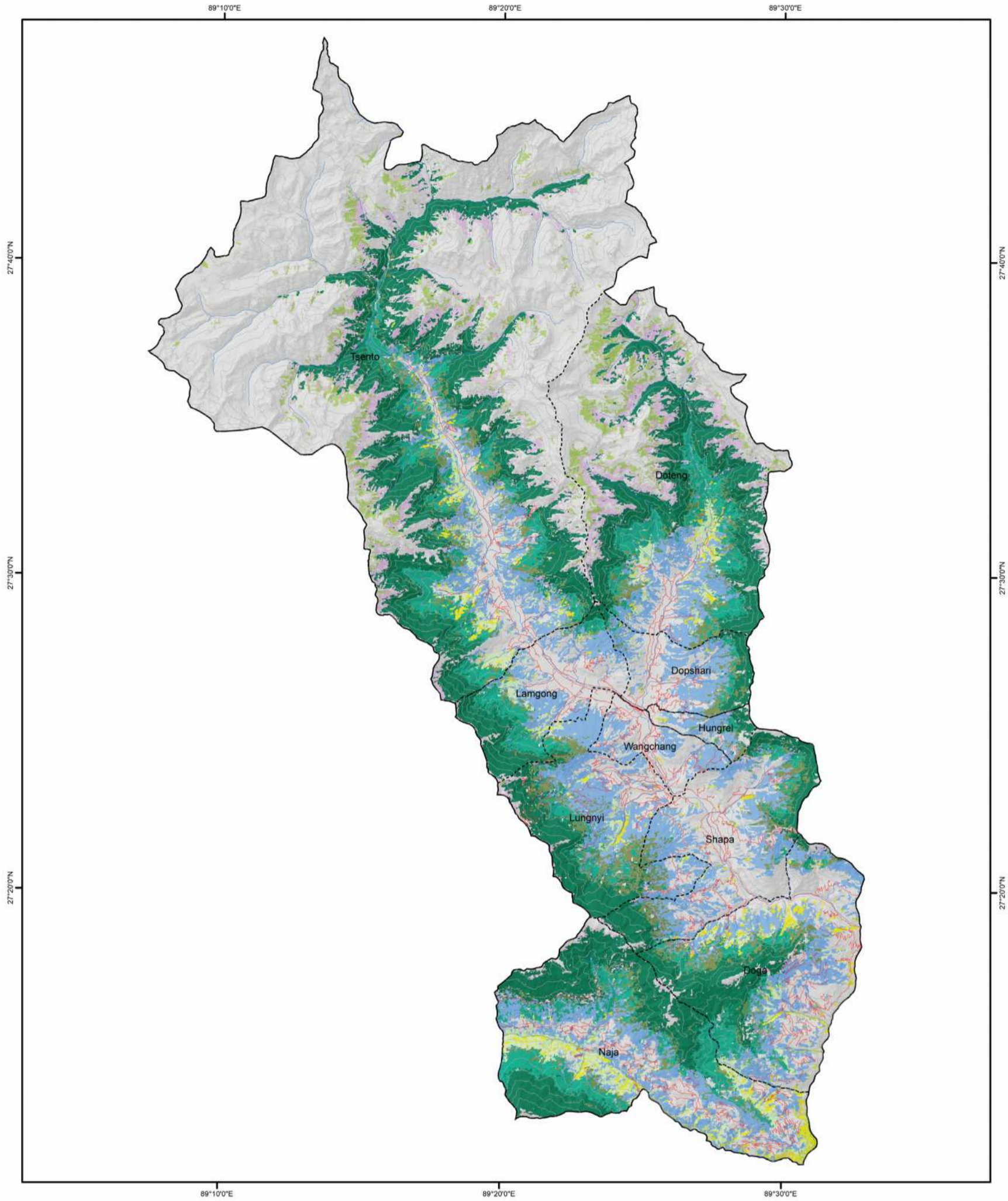
Paro Dzongkhag has an altitudinal range between 2000m to 5600m asl and has a temperate climatic condition with warm summer and cold and dry winter. The annual rainfall in the Dzongkhag varies between 500mm and 1000mm. Northern part of Dzongkhag falls under the Jigme Dorji National Park.

The Paro valley is dominated by coniferous forest. Blue pine Forest thrives in Paro Valley, accounting for around 13.8 % of the total land area. Hemlock Forest (7.37 %) and Spruce Forest (3.82 %) are found at greater altitudes than Blue pine Forest, and Fir Forest dominates the tallest ridges (19.65 %). In Paro Valley, there are only a few broad-leaved forests, such as Cool broad-leaved and Evergreen Oak Forests.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	0.00	0.00%
Warm Broadleaved Forest	0.00	0.00%
Chir pine Forest	0.00	0.00%
Cool Broadleaved Forest	2357.02	1.85%
Evergreen Oak Forest	3321.76	2.61%
Blue Pine Forest	17646.60	13.84%
Spruce Forest	4872.86	3.82%
Hemlock Forest	9392.14	7.37%
Fir Forest	25039.80	19.65%
Juniper Rhododendron Scrub	5558.46	4.36%
Dry Alpine Scrub	3528.62	2.77%



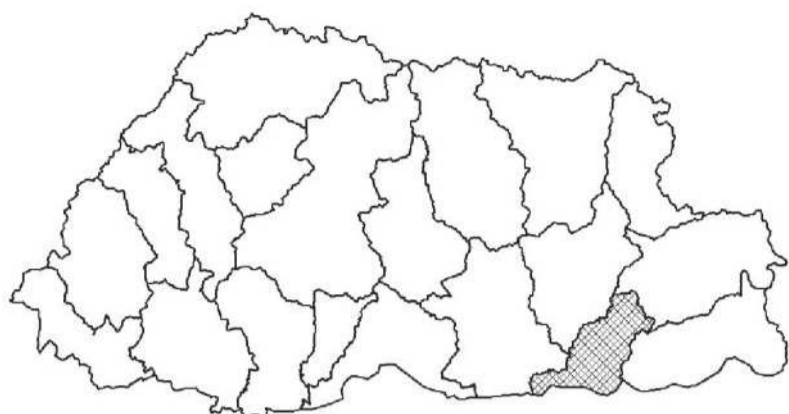
Dzongkhag: Paro



Legend

Dzongkhag	Forest Types	Evergreen Oak Forest	Non Forest
Gewog	Blue Pine Forest	Fir Forest	Spruce Forest
Road	Chirpine Forest	Hemlock Forest	Subtropical Forest
River	Cool Broadleaved Forest	Juniper Rhododendron Scrub	Warm Broadleaved Forest
	Dry Alpine Scrub		

PEMAGATSHEL

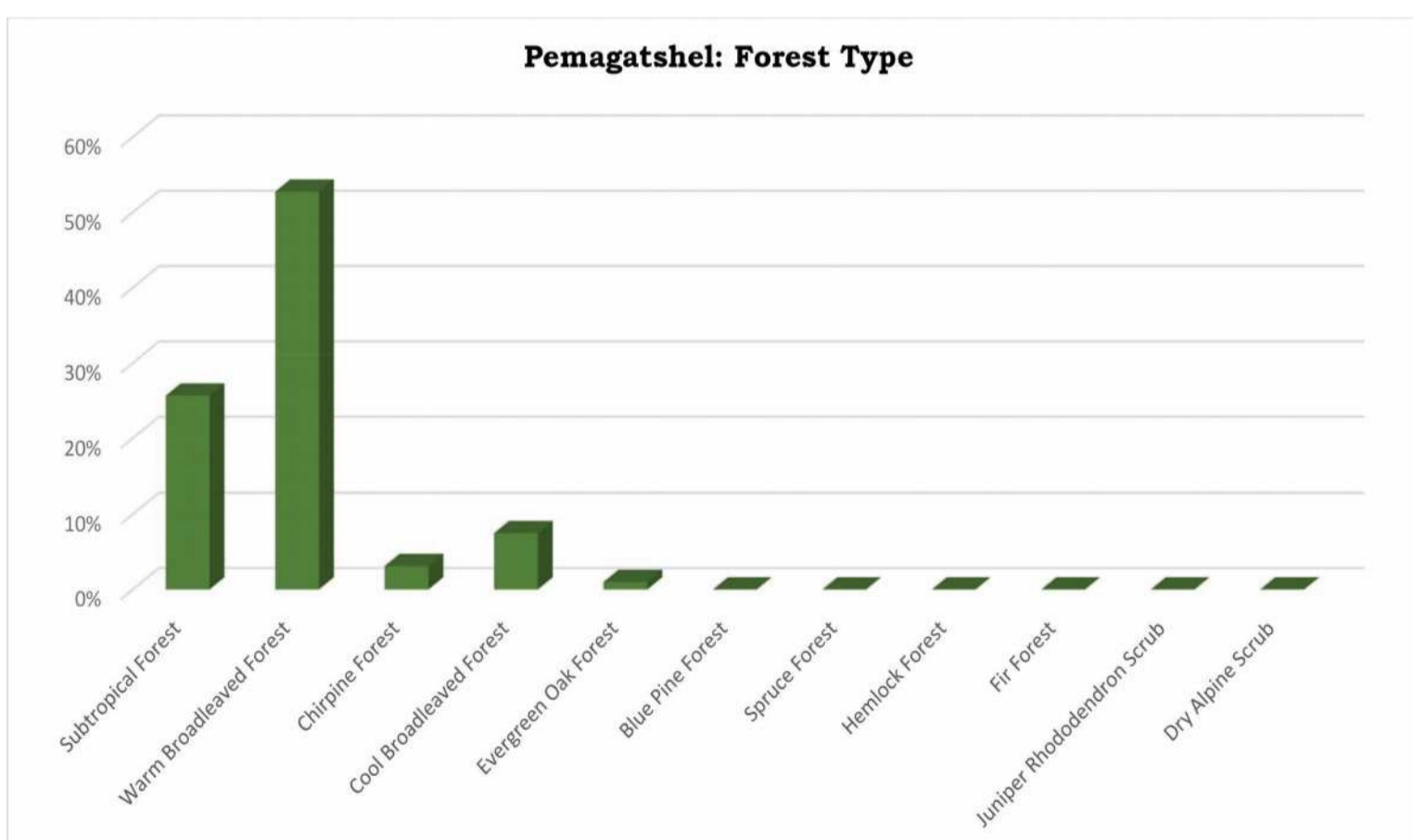


PEMAGATSHEL DZONGKHAG (26°46' to 27°10' latitude and 91°00' to 91°33' longitude) is bordered with Mongar, Trashigang, Samdrupjongkhar and Zhemgang Dzongkhags and Indian state of Assam to the South.

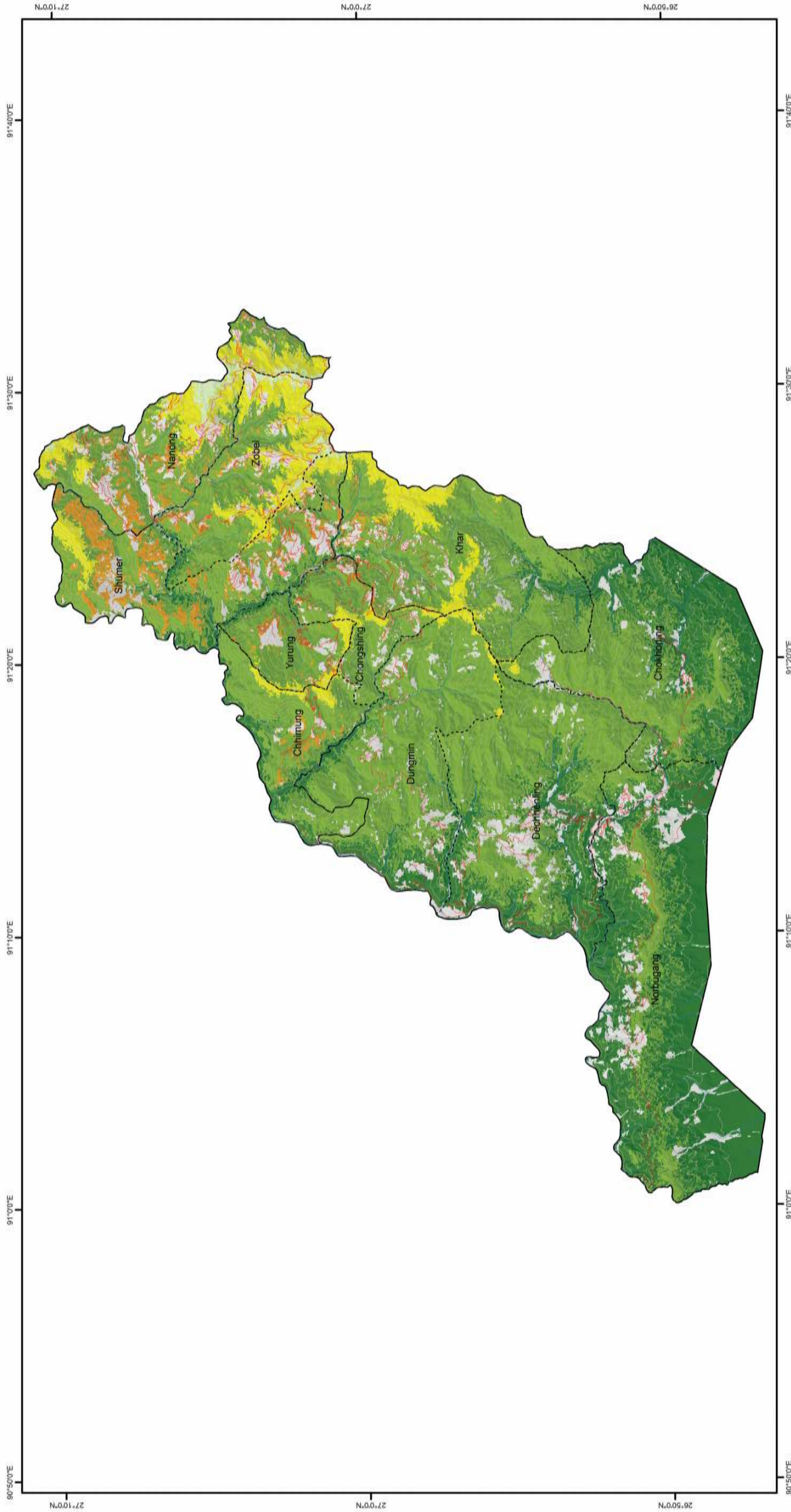
The elevation ranges from 200m to 2700m above sea level. The summer is hot, and winter is dry and cool. The annual rainfall is between 1500mm and 3000mm. The lower part of the Dzongkhag falls under the Royal Manas National Park.

Almost 90% of the entire area of the Dzongkhag is covered by forest, with Warm broad-leaved Forest covering nearly 50% of the Dzongkhag landscape. Pemagatshel contains approximately 25.65% Subtropical Forest due to its climatic conditions.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	25963.15	25.65%
Warm Broadleaved Forest	53378.10	52.74%
Chir pine Forest	3147.70	3.11%
Cool Broadleaved Forest	7571.29	7.48%
Evergreen Oak Forest	1006.72	0.99%
Blue Pine Forest	0.00	0.00%
Spruce Forest	0.00	0.00%
Hemlock Forest	0.00	0.00%
Fir Forest	0.00	0.00%
Juniper Rhododendron Scrub	0.00	0.00%
Dry Alpine Scrub	0.00	0.00%



Dzongkhag: Pemagatshel



Legend

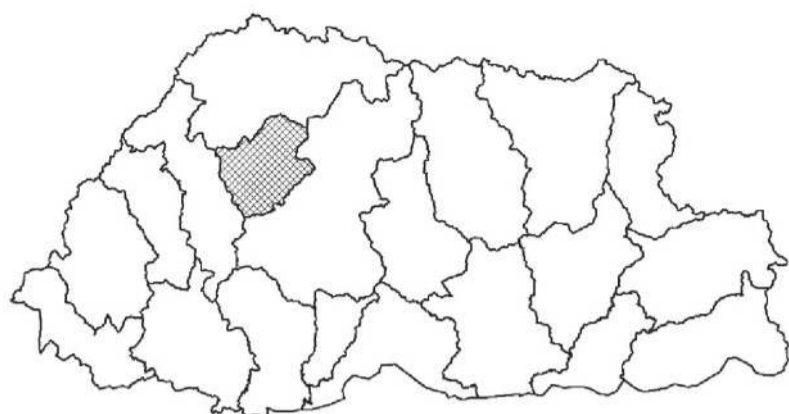
- Dzongkhag
- Gewog
- Road
- River

Forest Types

- Cool Broadleaved Forest
- Dry Alpine Scrub
- Chirpine Forest
- Blue Pine Forest
- Chirpine Forest
- Fir Forest
- Hemlock Forest
- Juniper Rhododendron Scrub
- Warm Broadleaved Forest
- Non Forest
- Spruce Forest
- Subtropical Forest

0
 1.75
 3.5
 7
 10.5
 14 Km

PUNAKHA

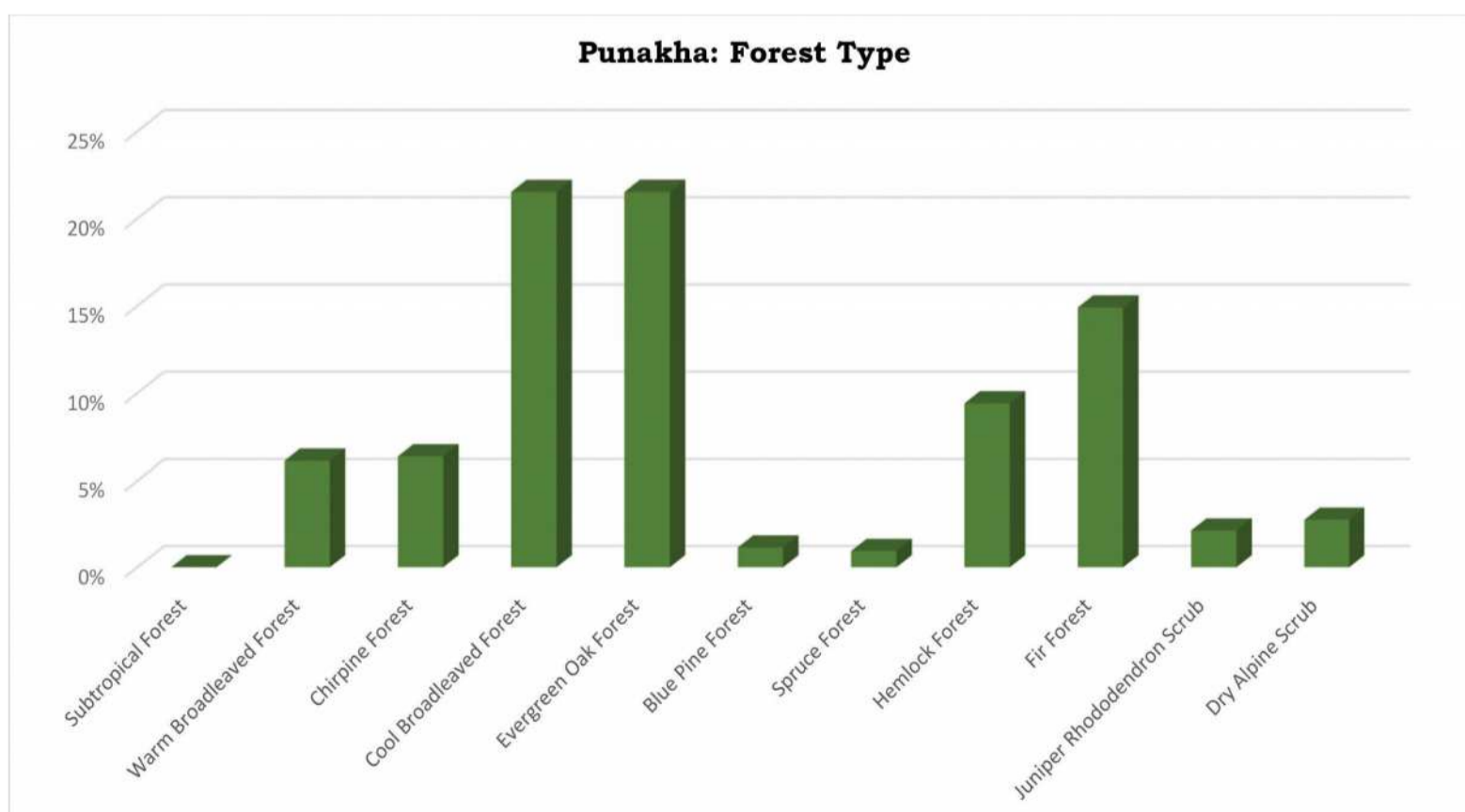


PUNAKHA DZONGKHAG lies to the East of Thimphu Dzongkhag and it is an entry point to Gasa Dzongkhag to the North. The elevation ranges from 1300 m to 4800 m above sea level.

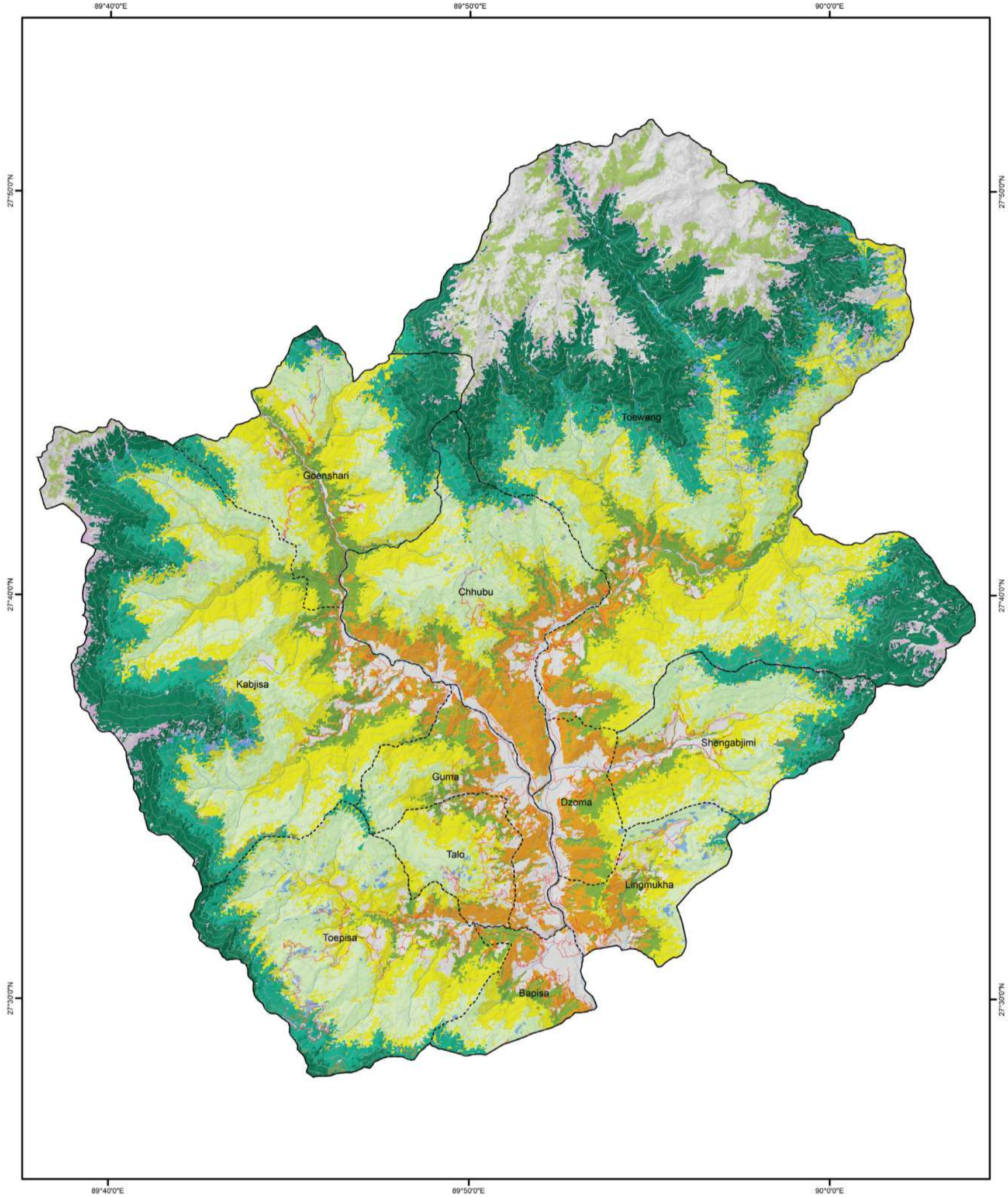
The Punakha Dzong lies on the confluence of the Pho Chhu and the Mo Chhu. Until 1964, Punakha was the capital of Bhutan. Today it functions as the winter residence of the Monk body. The valley of Punakha enjoys a subtropical climate with cool winters and warm to hot summer. The annual precipitation ranges from 500mm to 1500mm. Some parts of the Dzongkhag fall under the Jigme Dorji National Park where wide varieties of flora and fauna are found.

Cool broad-leaved Forest and Evergreen Oak Forest cover around 40% of the Punakha Dzongkhag. Chir pine Forests, which cover around 6.38 % of the dzongkhag area, can be seen on the drier portions of the valleys on either side of the Punatshangchhu river. Hemlock (9.42 %) and Fir Forests (14.91 %) dominate higher altitude ridges. Warm broad-leaved Forest (6.13 %) dominates deeper valleys towards the South.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	0.00	0.00%
Warm Broadleaved Forest	6738.17	6.13%
Chir pine Forest	7009.45	6.38%
Cool Broadleaved Forest	23657.86	21.53%
Evergreen Oak Forest	23661.72	21.53%
Blue Pine Forest	1262.27	1.15%
Spruce Forest	1038.46	0.95%
Hemlock Forest	10346.00	9.42%
Fir Forest	16382.03	14.91%
Juniper Rhododendron Scrub	2348.93	2.14%
Dry Alpine Scrub	3032.70	2.76%



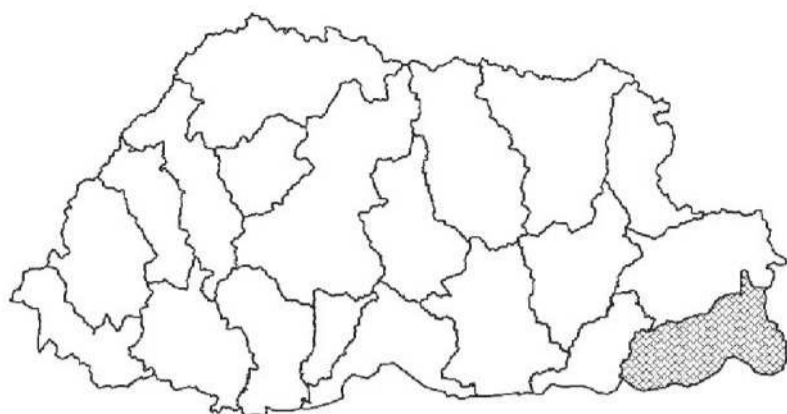
Dzongkhag: Punakha



Legend

Dzongkhag	Forest Types	Evergreen Oak Forest	Non Forest
Gewog	Blue Pine Forest	Fir Forest	Spruce Forest
Road	Chirpine Forest	Hemlock Forest	Subtropical Forest
River	Cool Broadleaved Forest	Juniper Rhododendron Scrub	Warm Broadleaved Forest
	Dry Alpine Scrub		

SAMDRUP JONGKHAR

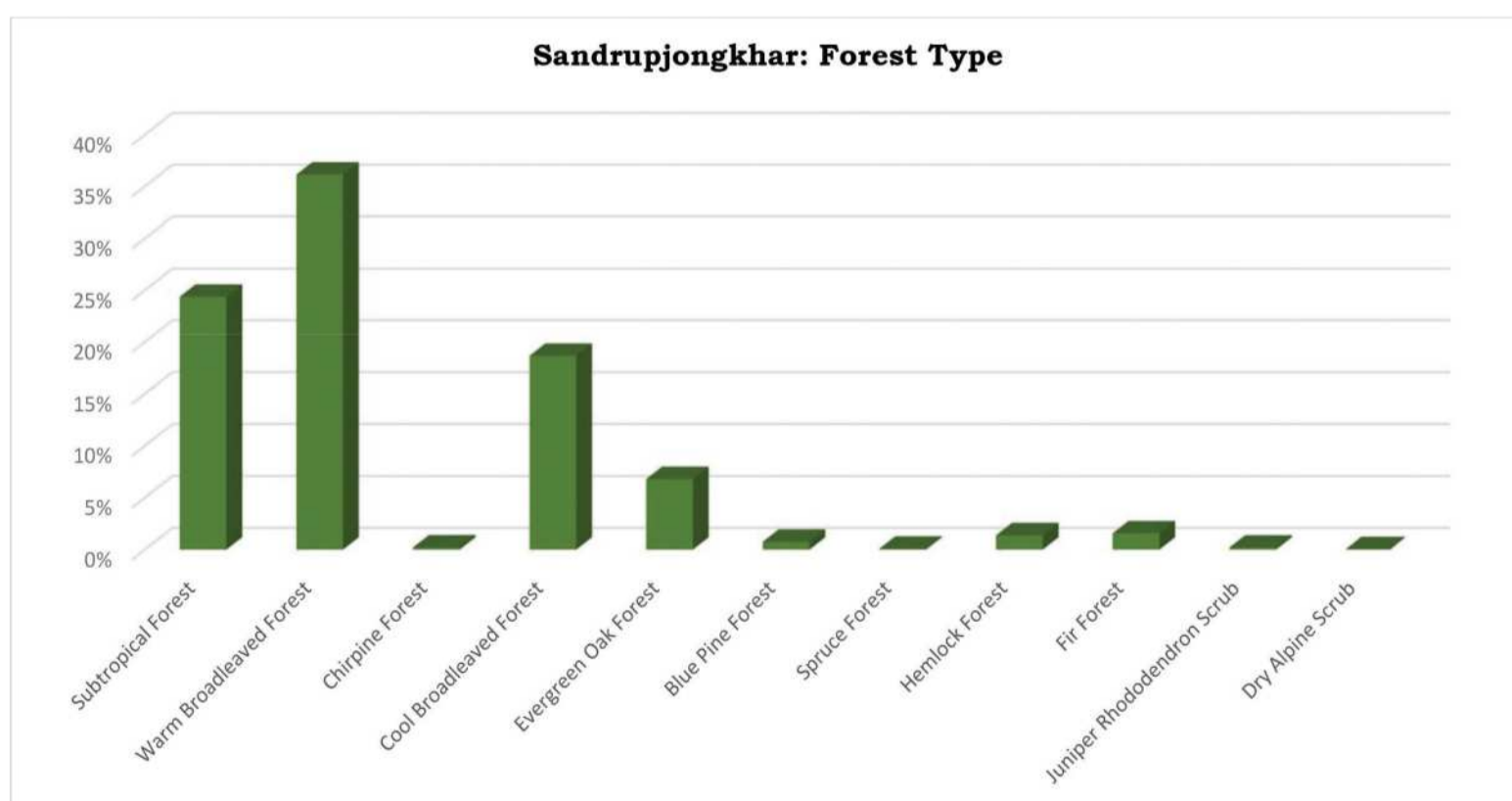


SAMDRUP JONGKHAR DZONGKHAG lies in the extreme South-Eastern part of the country (26°47' to 27°15' latitude and 91°23' to 92°07' longitude). It shares borders with Zhemgang, Pemagatshel and Trashigang Dzongkhags. Towards South and East, it borders with India.

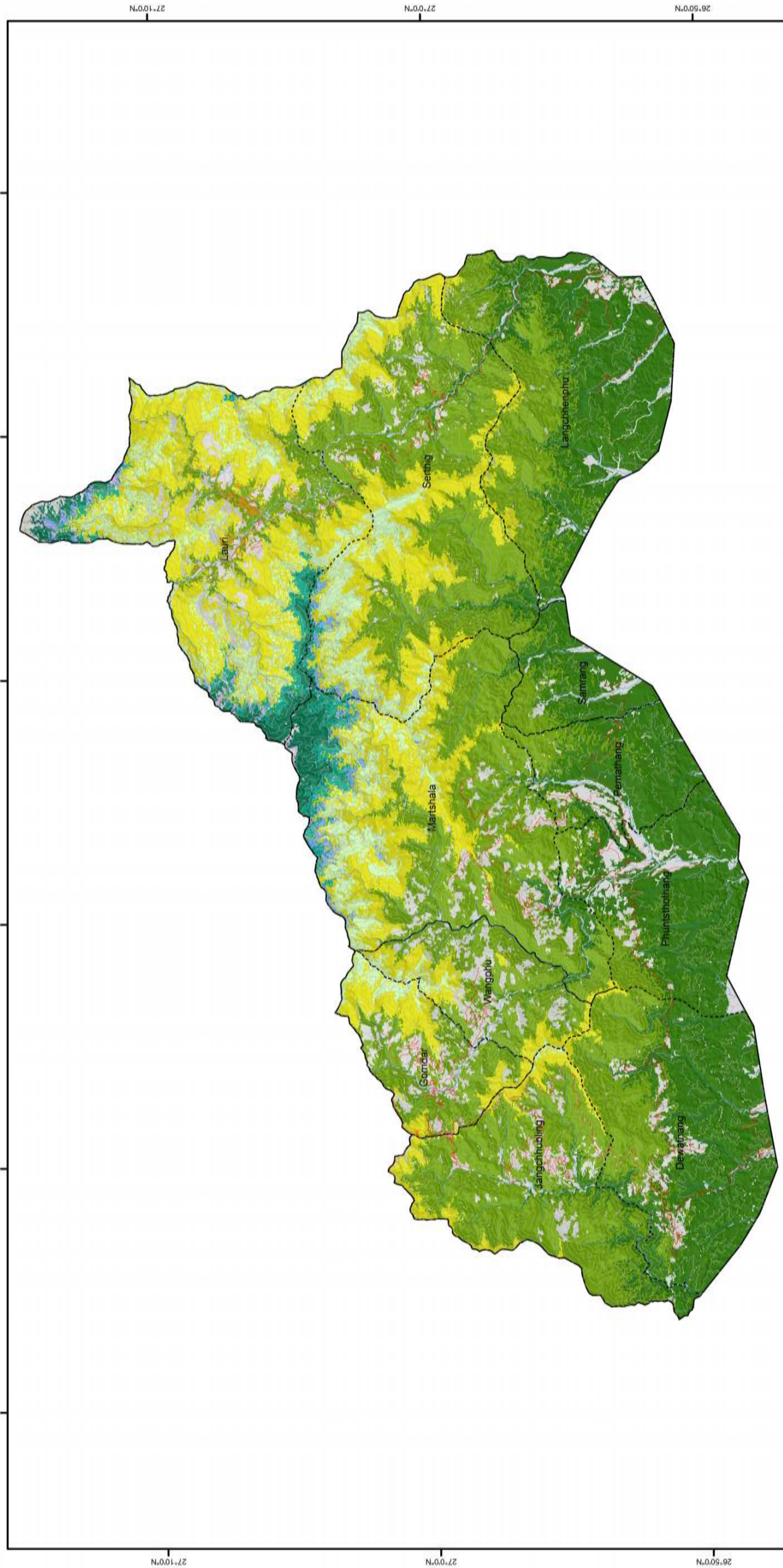
The elevation ranges from 200m to 4500m above sea level. Samdrup Jongkhar has subtropical climate with hot and humid summer and dry and cool winter. The annual rainfall is between 1000mm and 5000mm. The Dzongkhag falls under the Jomotsangkha Wildlife sanctuary.

The forest landscape is characterized by broad-leaved forests due to its climatic conditions. Warm broad-leaved and Subtropical Forests cover more than half of the Dzongkhag's region. A mixture of Cool broad-leaved and Evergreen Oak Forests cover around 23% of the land. The highest ridges have a small proportion of conifer species such as Fir and Hemlock Forests.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	45330.12	24.39%
Warm Broadleaved Forest	67207.15	36.16%
Chir pine Forest	391.85	0.21%
Cool Broadleaved Forest	34722.47	18.68%
Evergreen Oak Forest	12650.08	6.81%
Blue Pine Forest	1419.76	0.76%
Spruce Forest	181.06	0.10%
Hemlock Forest	2577.04	1.39%
Fir Forest	2931.72	1.58%
Juniper Rhododendron Scrub	369.08	0.20%
Dry Alpine Scrub	101.56	0.05%

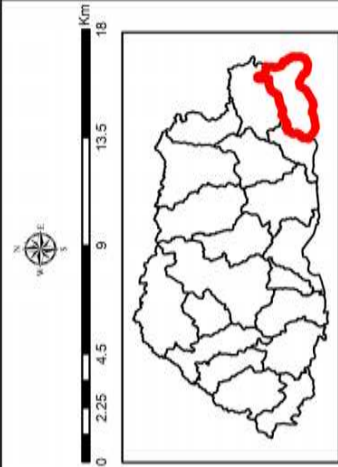


Dzongkhag: Samdrupjongkhar

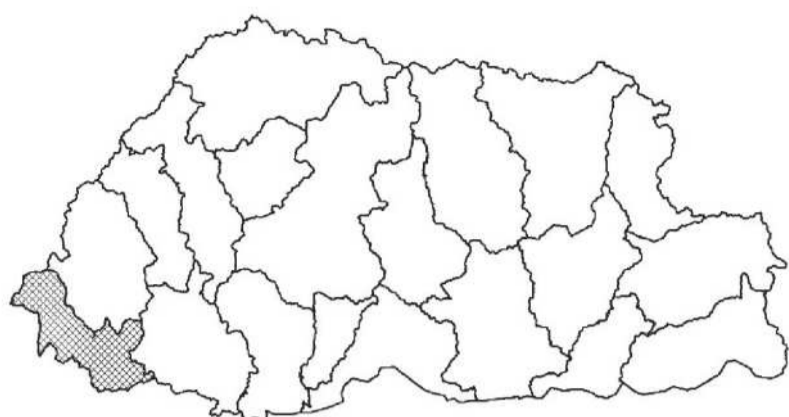


Legend

- Dzongkhag
- Gewog
- Road
- River
- Blue Pine Forest
- Chirpine Forest
- Cool Broadleaved Forest
- Dry Alpine Scrub
- Evergreen Oak Forest
- Fir Forest
- Hemlock Forest
- Juniper Rhododendron Scrub
- Non Forest
- Spruce Forest
- Subtropical Forest
- Warm Broadleaved Forest



SAMTSE

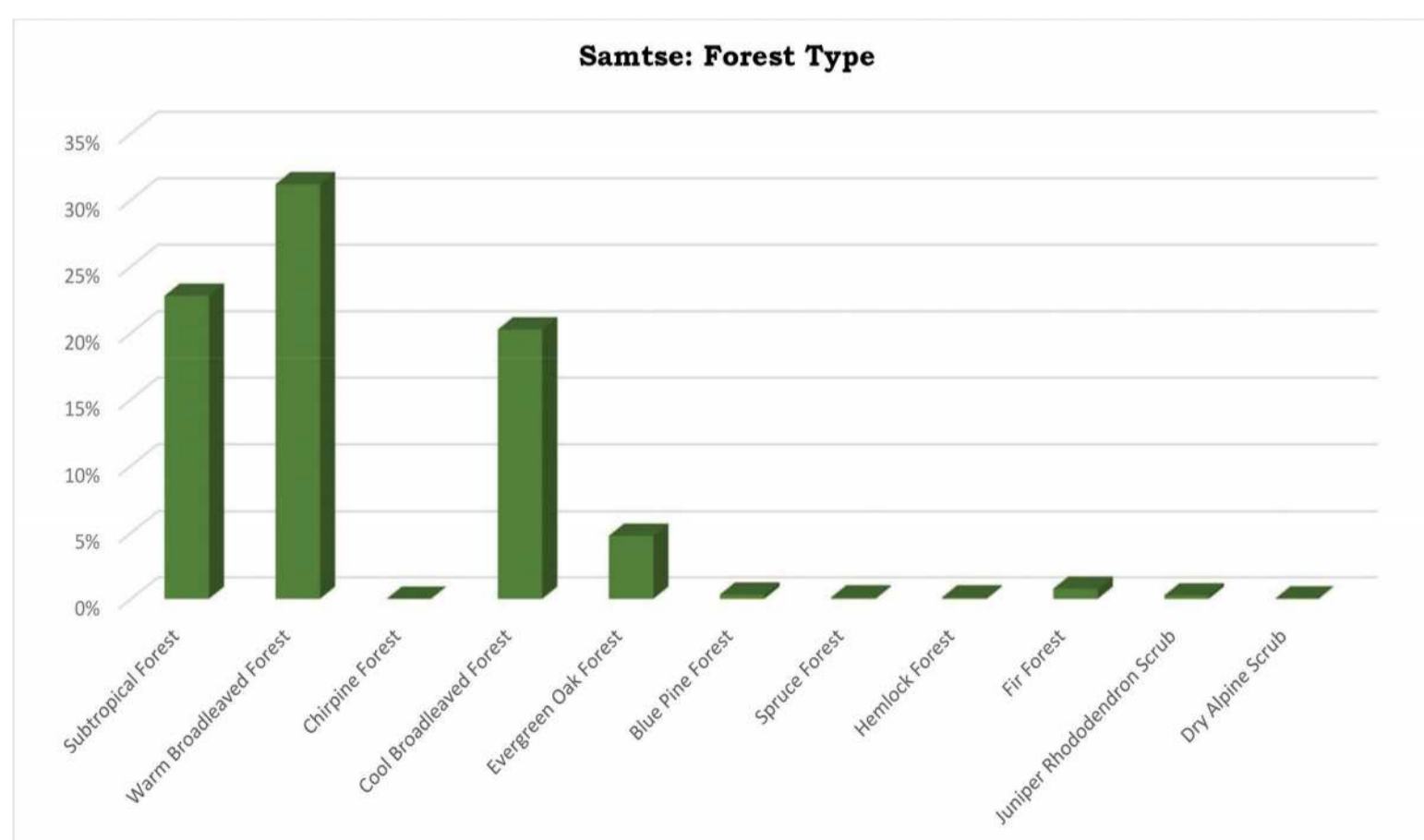


SAMTSE DZONGKHAG lies in the South-West of the country (26°48' to 27°16' latitude and 88°44' to 89°22' longitude) and shares border with the Indian plains to the South, Haa to the North and Chhukha Dzongkhags to the East.

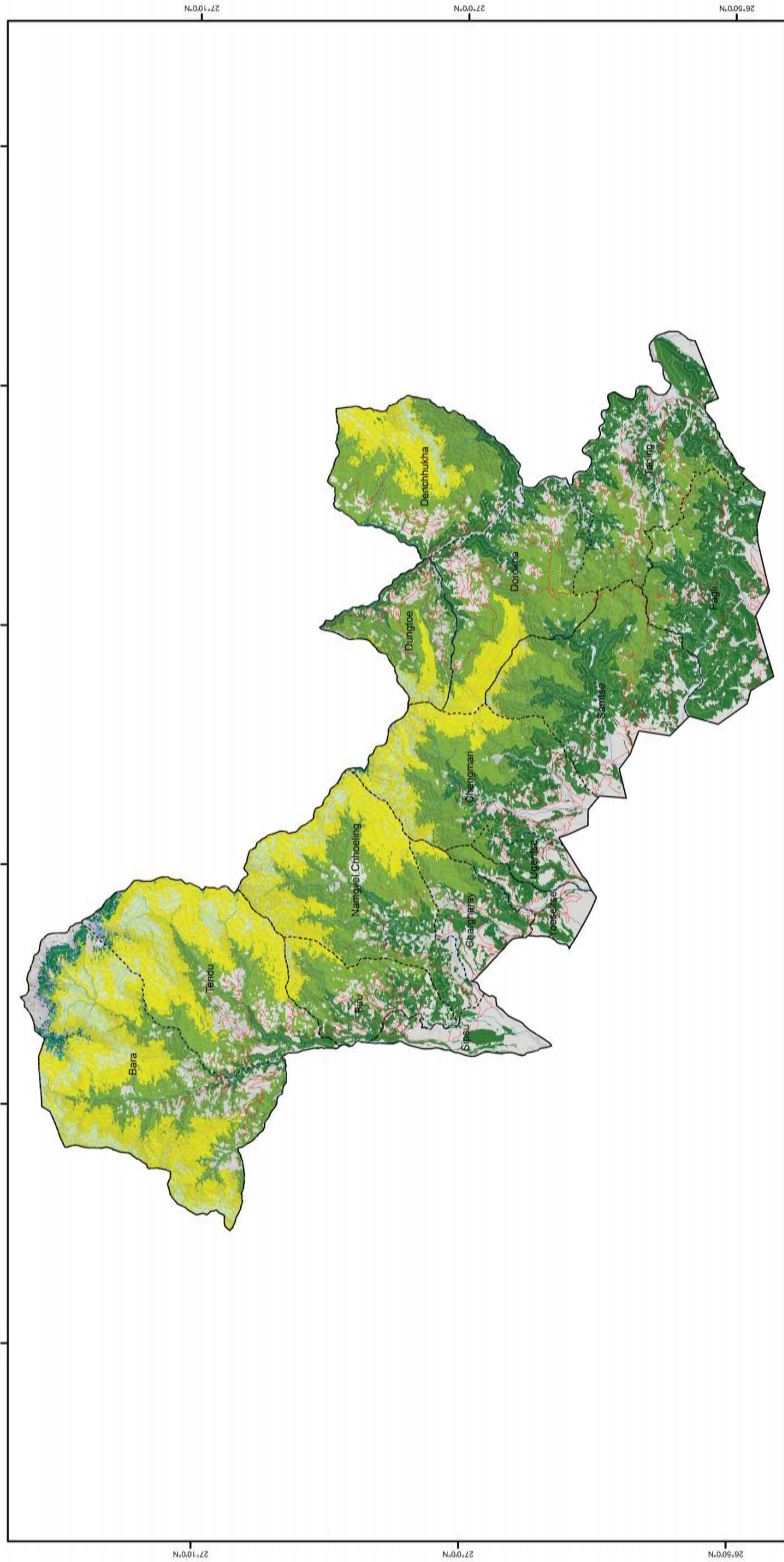
The Samtse Dzongkhag has an altitudinal range between 200m to 4400m asl and the summers are hot and humid, while the winters are dry and cool. The annual rainfall ranges 1500 mm to 4000 mm. Small portion of Samtse Dzongkhag in the North falls under Jigme Khesar Strict Nature Reserve.

More than 70% of Dzongkhag area is occupied by broad-leaved forests. Around 50% of the forest is dominated by Warm broad-leaved Forest (31.18%) and Subtropical Forest (22.78%). Another 20% of the land is occupied by Cool broad-leaved Forest. Very small proportion of conifer species like Fir, Blue pine, Hemlock, and Spruce Forests are present in the high mountain tops.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	29433.18	22.78%
Warm Broadleaved Forest	40286.32	31.18%
Chir pine Forest	0.00	0.00%
Cool Broadleaved Forest	26162.20	20.25%
Evergreen Oak Forest	6161.79	4.77%
Blue Pine Forest	418.00	0.32%
Spruce Forest	133.52	0.10%
Hemlock Forest	141.14	0.11%
Fir Forest	992.26	0.77%
Juniper Rhododendron Scrub	333.04	0.26%
Dry Alpine Scrub	39.66	0.03%



Dzongkhag: Samtse

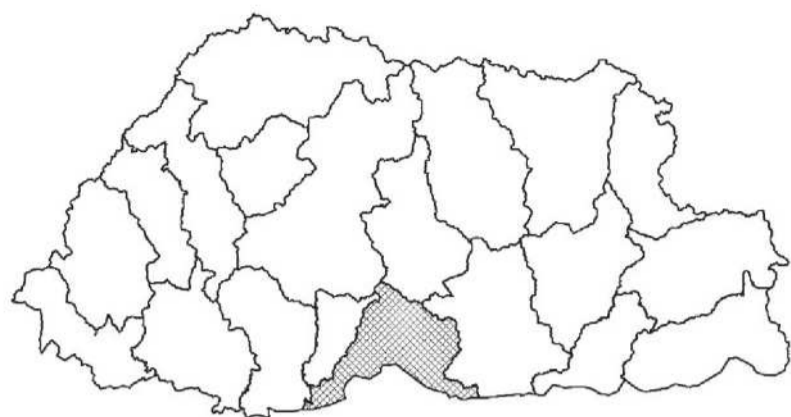


Legend

Dzongkhag	Road	Forest Types	Cool Broadleaved Forest	Fir Forest	Warm Broadleaved Forest
Gewog	River	Blue Pine Forest	Dry Alpine Scrub	Hemlock Forest	Non Forest
		Chirpine Forest	Evergreen Oak Forest	Juniper Rhododendron Scrub	Spruce Forest
					Subtropical Forest

Scale: 0 2.25 4.5 9 13.5 18 Km

SARPANG

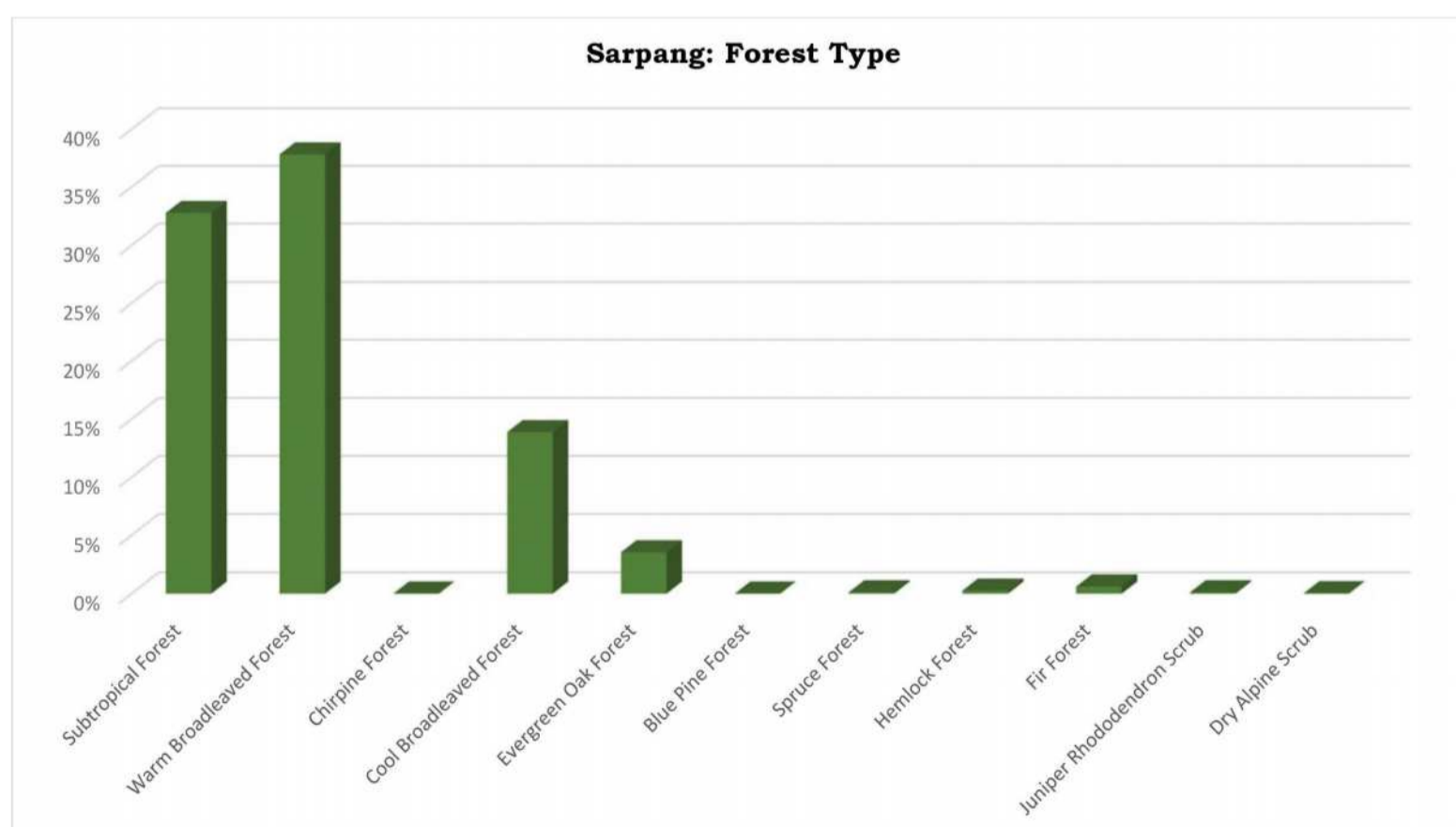


SARPANG DZONGKHAG lies in the South of the country (26°43' to 27°13' latitude and 90°00' to 90°46' longitude) where it borders Dagana, Tsirang, Wangdue Phodrang, Trongsa and Zhemgang Dzongkhags. Towards the Southern part of Dzongkhag, it shares the border with India.

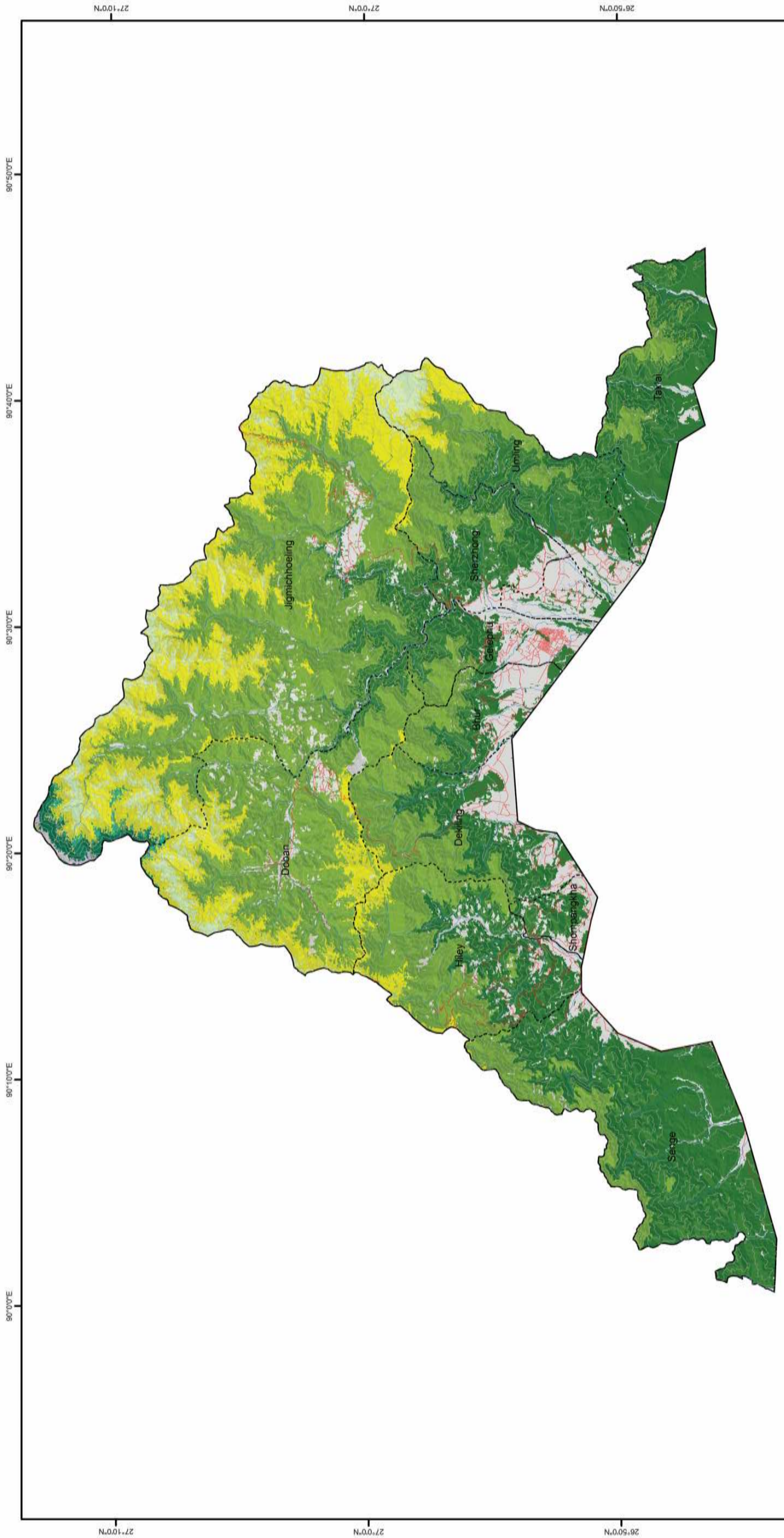
The elevation of Sarpang Dzongkhag ranges from less than 200 m to 4200 m above sea level. The summer is hot and humid while the winter is dry and warm. The average annual rainfall ranges from 1500 mm to 5000mm. The Dzongkhag falls under Royal Manas National Park, and Phibsoo Wildlife Sanctuary linking to the Indian Buxa Tiger Reserve.

More than 80% of the Dzongkhag's entire area is covered by forest, which is largely composed of broad-leaved species. Warm broad-leaved and Subtropical Forests cover around 60% of the land. Cool broad-leaved and Evergreen Oak Forests account to around 17 % of the forest.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	53691.45	32.75%
Warm Broadleaved Forest	61989.01	37.81%
Chir pine Forest	0.00	0.00%
Cool Broadleaved Forest	22737.57	13.87%
Evergreen Oak Forest	5803.09	3.54%
Blue Pine Forest	0.00	0.00%
Spruce Forest	166.96	0.10%
Hemlock Forest	418.31	0.26%
Fir Forest	999.13	0.61%
Juniper Rhododendron Scrub	170.23	0.10%
Dry Alpine Scrub	55.28	0.03%

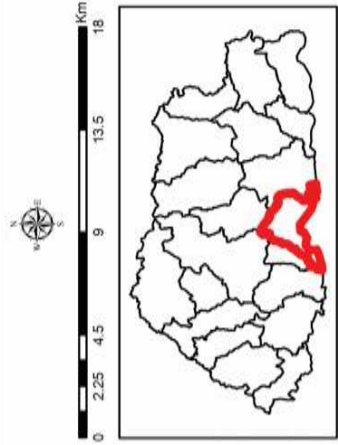


Dzongkhag: Sarpang

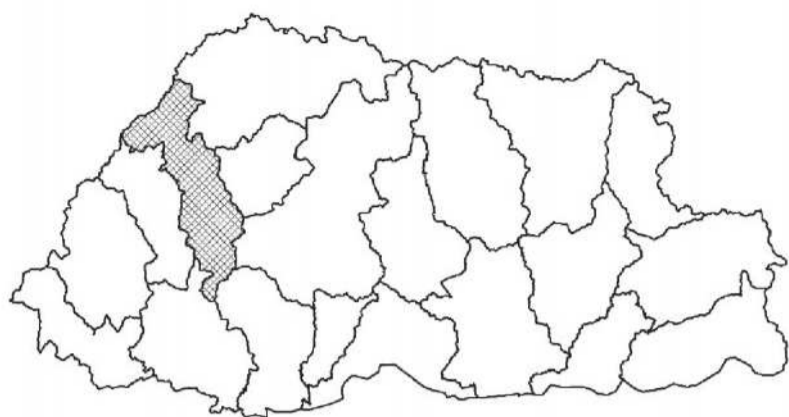


Legend

- Dzongkhag
- Gewog
- Road
- River
- Cool Broadleaved Forest
- Blue Pine Forest
- Chirpine Forest
- Fir Forest
- Dry Alpine Scrub
- Evergreen Oak Forest
- Hemlock Forest
- Juniper Rhododendron Scrub
- Non Forest
- Spruce Forest
- Subtropical Forest
- Warm Broadleaved Forest



THIMPHU

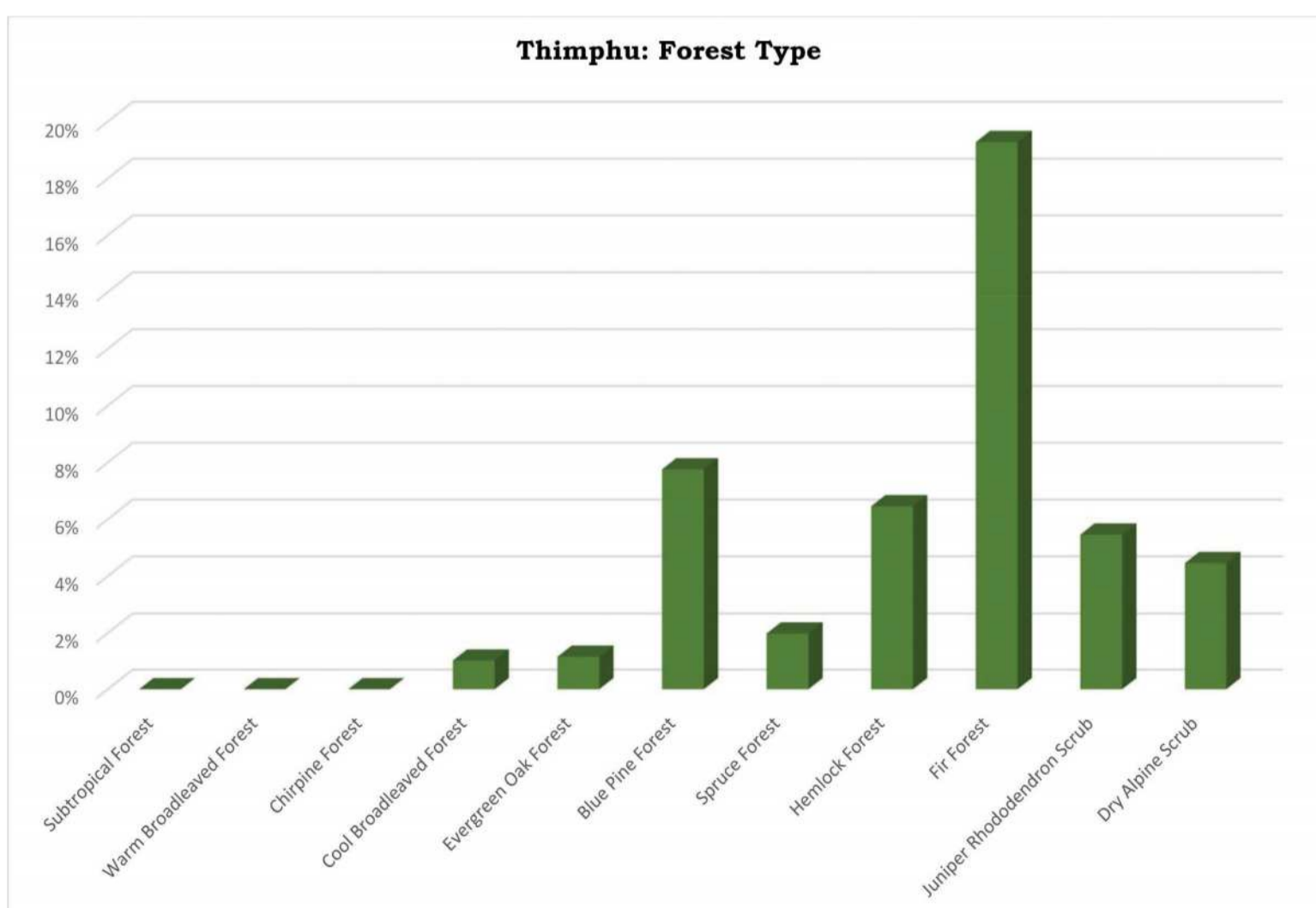


THIMPHU DZONGKHAG lies in the Western part of the country (27°8' to 27°59' latitude and 89°13 to 89°46' longitude). It borders with China in the North, Paro Dzongkhag in the West, Chhukha Dzongkhag in the South and Punakha Dzongkhag in the East. Thimphu is the capital of the country.

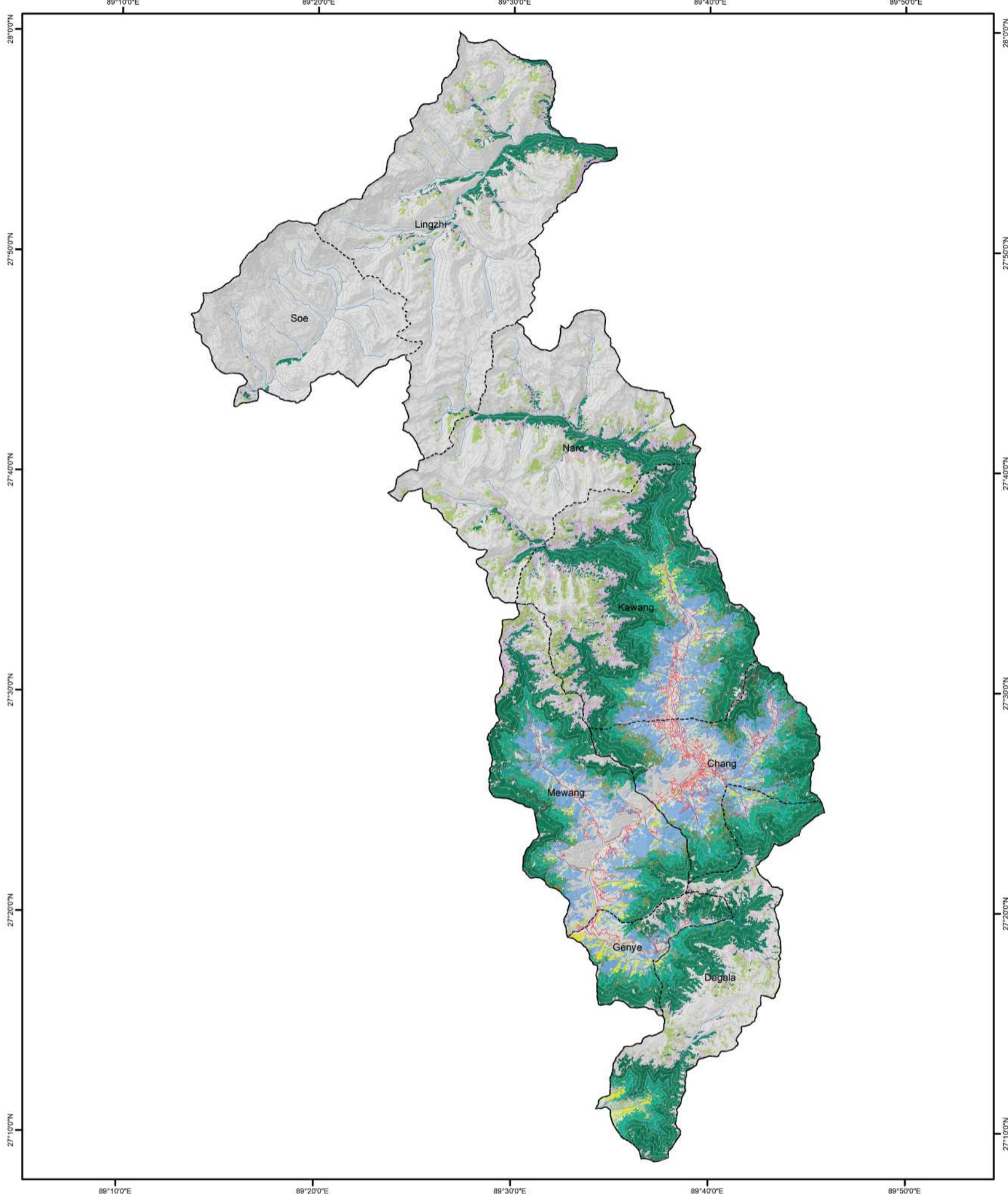
Thimphu Dzongkhag has an altitudinal range between 2100m to 6800m asl and has a temperate climatic condition with warm summer and cold and dry winter. The annual rainfall in the Dzongkhag varies between 500mm and 1000mm. The Northern part of Dzongkhag falls under the Jigme Dorji National Park.

Thimphu's forest is largely made up of coniferous trees. The lower valley of Thimphu is characterized by Bluepine Forest (7.76 %), whereas the uppermost hills are dominated by Fir Forests (19.28 %). Between the Bluepine and Fir Forests, there is a small fraction of Hemlock Forest (6.46 %) and Spruce Forest (1.98 %). A mixture of Cool broad-leaved and Evergreen Oak Forests cover around 2% of the Dzongkhag area. Thimphu lacks Subtropical and Warm broad-leaved Forest due to its high altitude and cold climate.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	0.00	0.00%
Warm Broadleaved Forest	0.00	0.00%
Chir pine Forest	0.00	0.00%
Cool Broadleaved Forest	1817.66	1.02%
Evergreen Oak Forest	2054.38	1.16%
Blue Pine Forest	13800.89	7.76%
Spruce Forest	3529.96	1.98%
Hemlock Forest	11488.48	6.46%
Fir Forest	34291.46	19.28%
Juniper Rhododendron Scrub	9710.09	5.46%
Dry Alpine Scrub	7925.37	4.46%



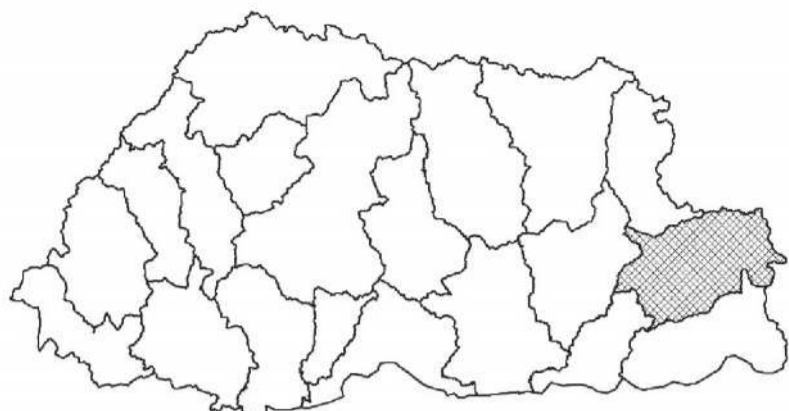
Dzongkhag: Thimphu



Legend

Dzongkhag	Forest Types	Evergreen Oak Forest	Non Forest
Gewog	Blue Pine Forest	Fir Forest	Spruce Forest
Road	Chirpine Forest	Hemlock Forest	Subtropical Forest
River	Cool Broadleaved Forest	Juniper Rhododendron Scrub	Warm Broadleaved Forest
	Dry Alpine Scrub		

TRASHIGANG

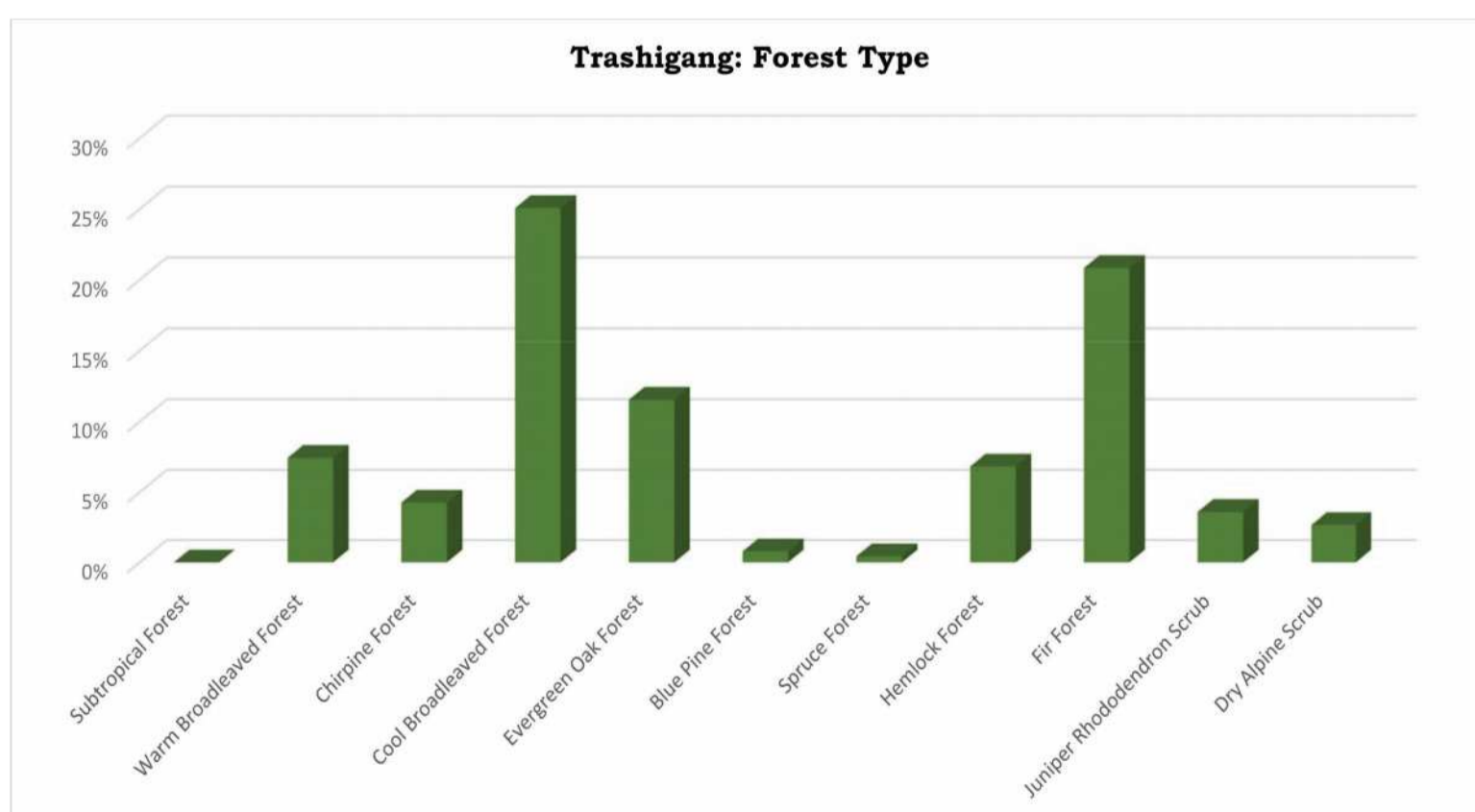


TRASHIGANG DZONGKHAG (27°22' to 27°29' latitude and 91°22' to 92°07' longitude) lies to the North of Samdrup Jongkhar Dzongkhag. Dzongkhag shares its border with Trashi Yangtse, Mongar, Pemagatshel and towards the North and East it borders with India. The Dzongkhag covers an area of approximately 2204.21km².

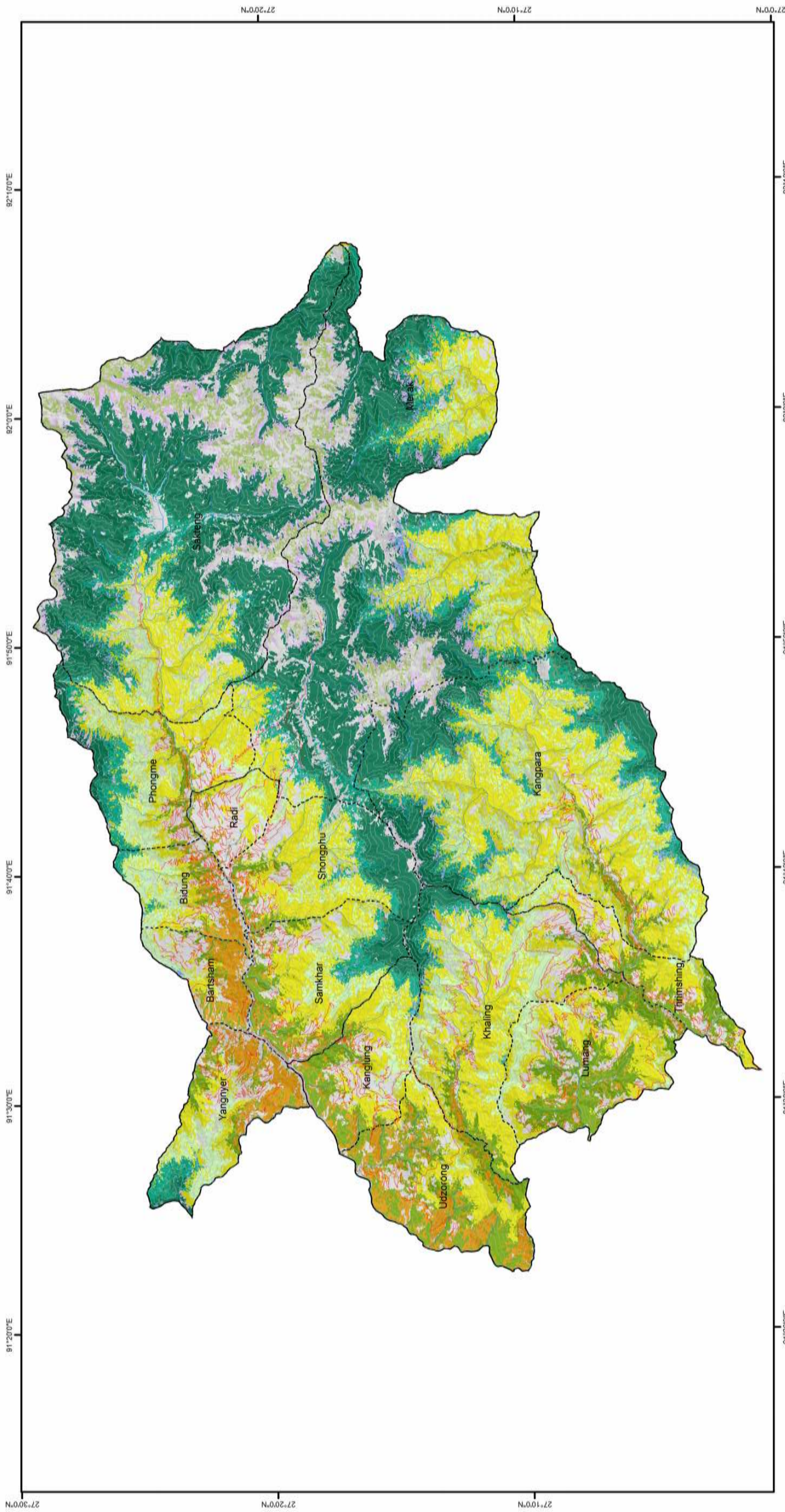
The altitude varies from 500 m to 4500 m asl. The climate is warm during the summer and cold during the winter. The annual rainfall ranges from 1000mm to 2000mm. The Dzongkhag falls under Sakteng Wildlife Sanctuary.

Forests of both broad-leaved and conifer species can be found in this Dzongkhag due to its geographical location. Warm broad-leaved forest (7.44%) occupies the valley's lower and wetter sides, whereas Chir pine Forest (4.26%) occupies the lower and drier sides of valley. Upper cooler valley is dominated by a mixture of Cool broad-leaved Forest (25.06 %) and Evergreen Oak Forest (11.54 %). Fir Forest dominates the highest mountain ridges.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	0.00	0.00%
Warm Broadleaved Forest	16231.23	7.44%
Chir pine Forest	9290.58	4.26%
Cool Broadleaved Forest	54702.56	25.06%
Evergreen Oak Forest	25190.67	11.54%
Blue Pine Forest	1706.50	0.78%
Spruce Forest	941.58	0.43%
Hemlock Forest	14900.72	6.83%
Fir Forest	45476.41	20.84%
Juniper Rhododendron Scrub	7841.60	3.59%
Dry Alpine Scrub	5815.07	2.66%



Dzongkhag: Trashigang



Legend

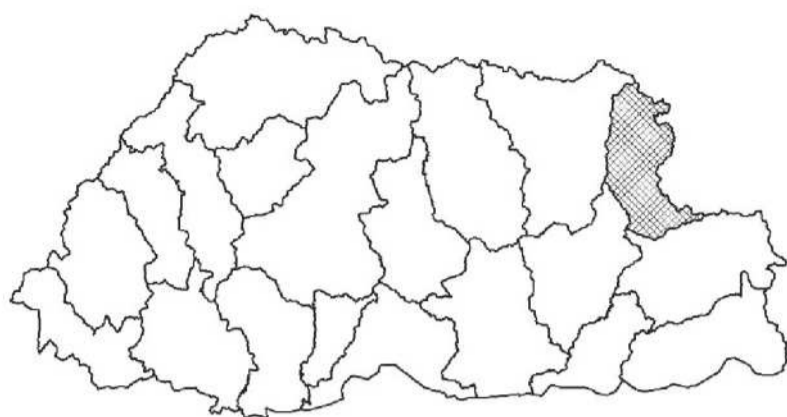
- Dzongkhag
- Gewog
- Road
- River

Forest Types

- Cool Broadleaved Forest
- Blue Pine Forest
- Chirpine Forest
- Dry Alpine Scrub
- Evergreen Oak Forest
- Fir Forest
- Hemlock Forest
- Juniper Rhododendron Scrub
- Non Forest
- Spruce Forest
- Subtropical Forest
- Warm Broadleaved Forest

Scale: 0 2.25 4.5 9 13.5 18 Km

TRASHI YANGTSE

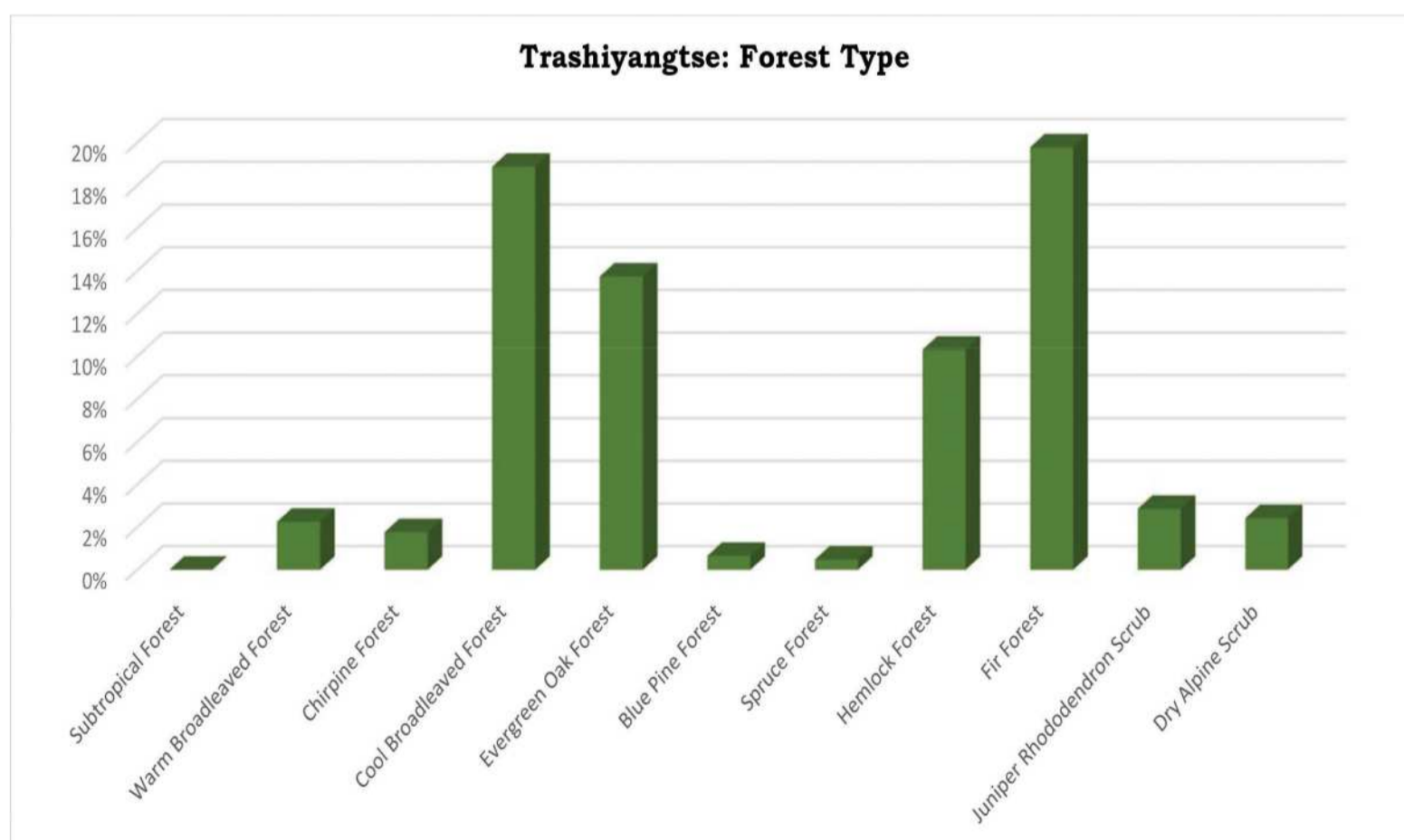


TRASHI YANGTSE DZONGKHAG lies in the North-East of the country. (27°22' to 27°58' latitude and 91°20' to 92°46' longitude). It borders with Lhuentse, Mongar and Trashigang Dzongkhags. Towards the East and North-East it borders with India and China respectively.

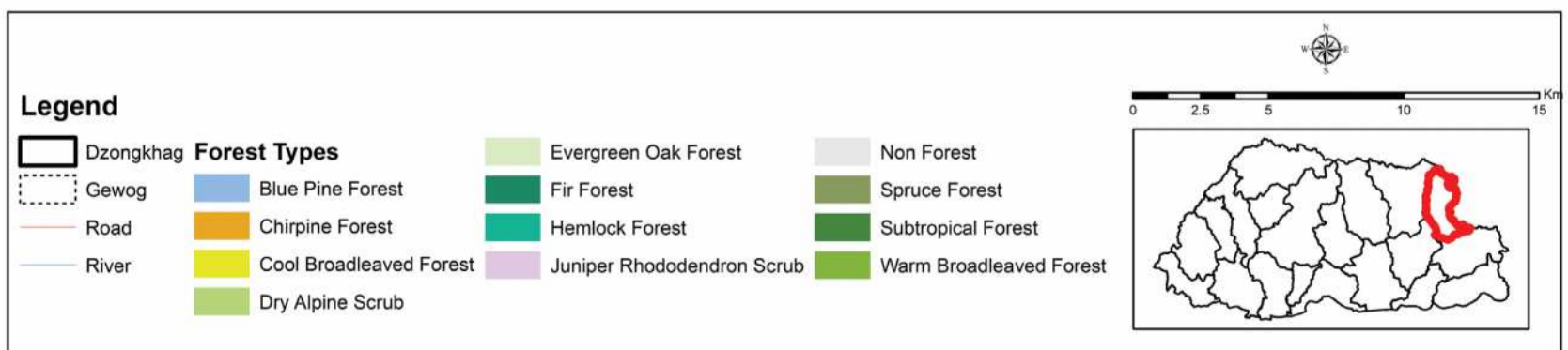
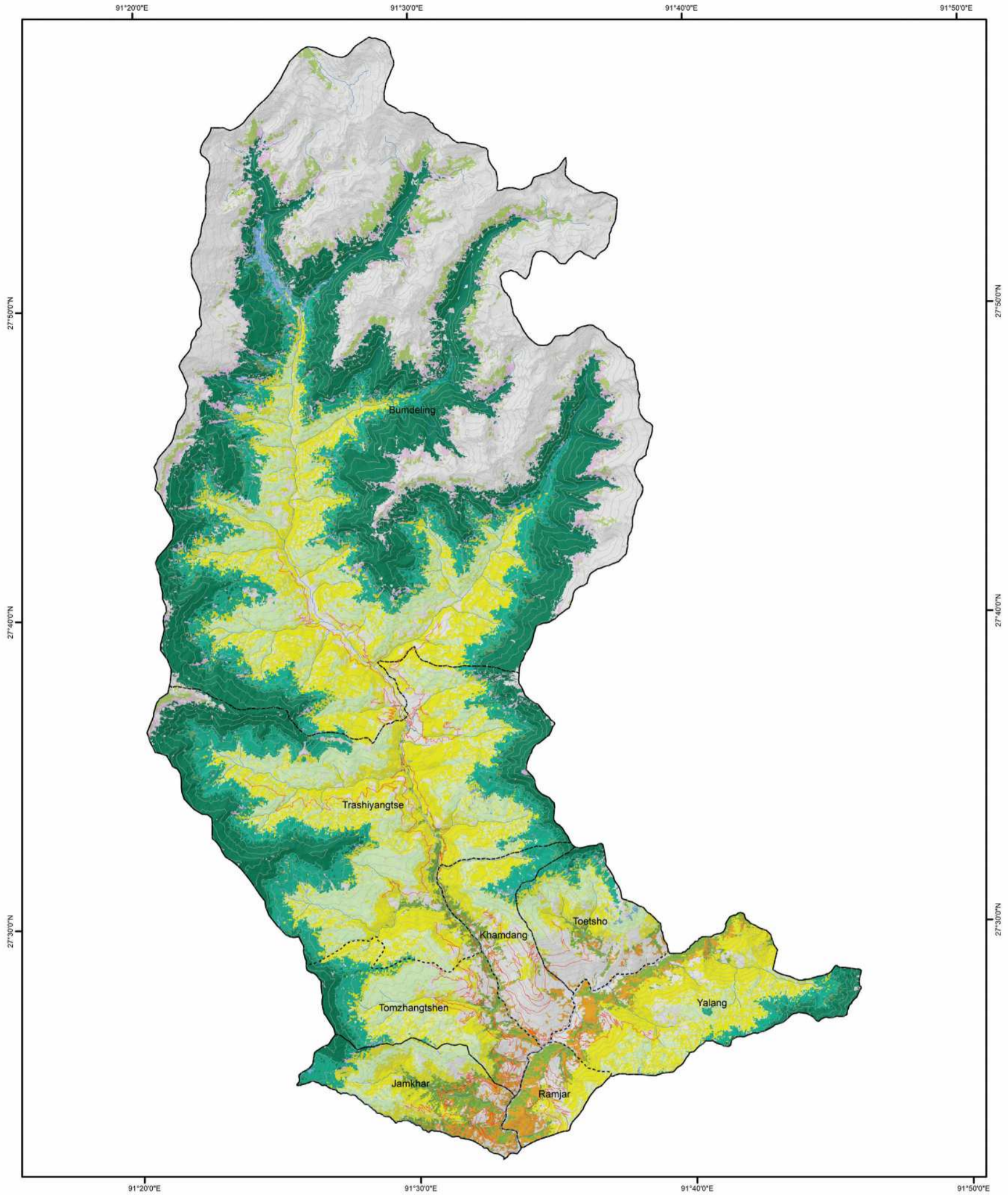
The elevation of the Dzongkhag ranges from 800 m to 6000 m above sea level. The annual rainfall is between 1000mm and 1500mm. The winter is cold while the summer is hot. The Dzongkhag falls under Bumdelling Wildlife Sanctuary which is the important winter nesting place for the black-necked cranes.

This dzongkhag has an almost equal proportion of broad-leaved and conifer species. The landscape is equally dominated by Fir Forest (19.79%) and Cool Broad-leaved Forest (18.88%). The drier valleys also include a small proportion of Chir pine Forests. Cool broad-leaved and Evergreen Oak Forests cover around 31 % of the land.

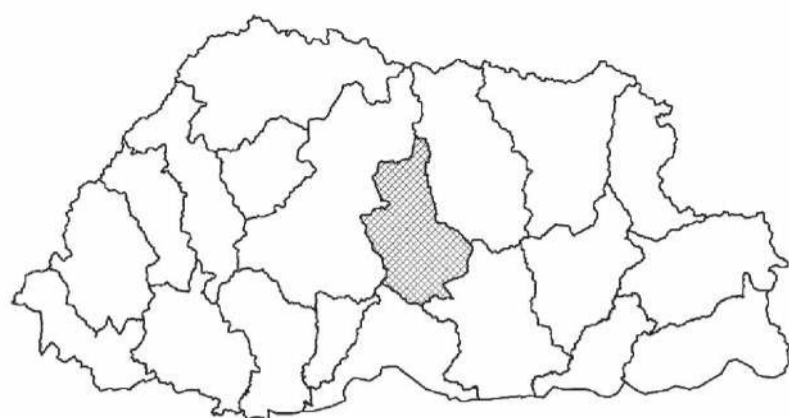
Forest Type	Area (Ha)	Percentage
Subtropical Forest	0.00	0.00%
Warm Broadleaved Forest	3231.92	2.25%
Chir pine Forest	2531.72	1.76%
Cool Broadleaved Forest	27088.25	18.88%
Evergreen Oak Forest	19717.64	13.74%
Blue Pine Forest	941.54	0.66%
Spruce Forest	692.50	0.48%
Hemlock Forest	14803.49	10.32%
Fir Forest	28391.08	19.79%
Juniper Rhododendron Scrub	4105.88	2.86%
Dry Alpine Scrub	3473.68	2.42%



Dzongkhag: Trashiyangtse



TRONGSA

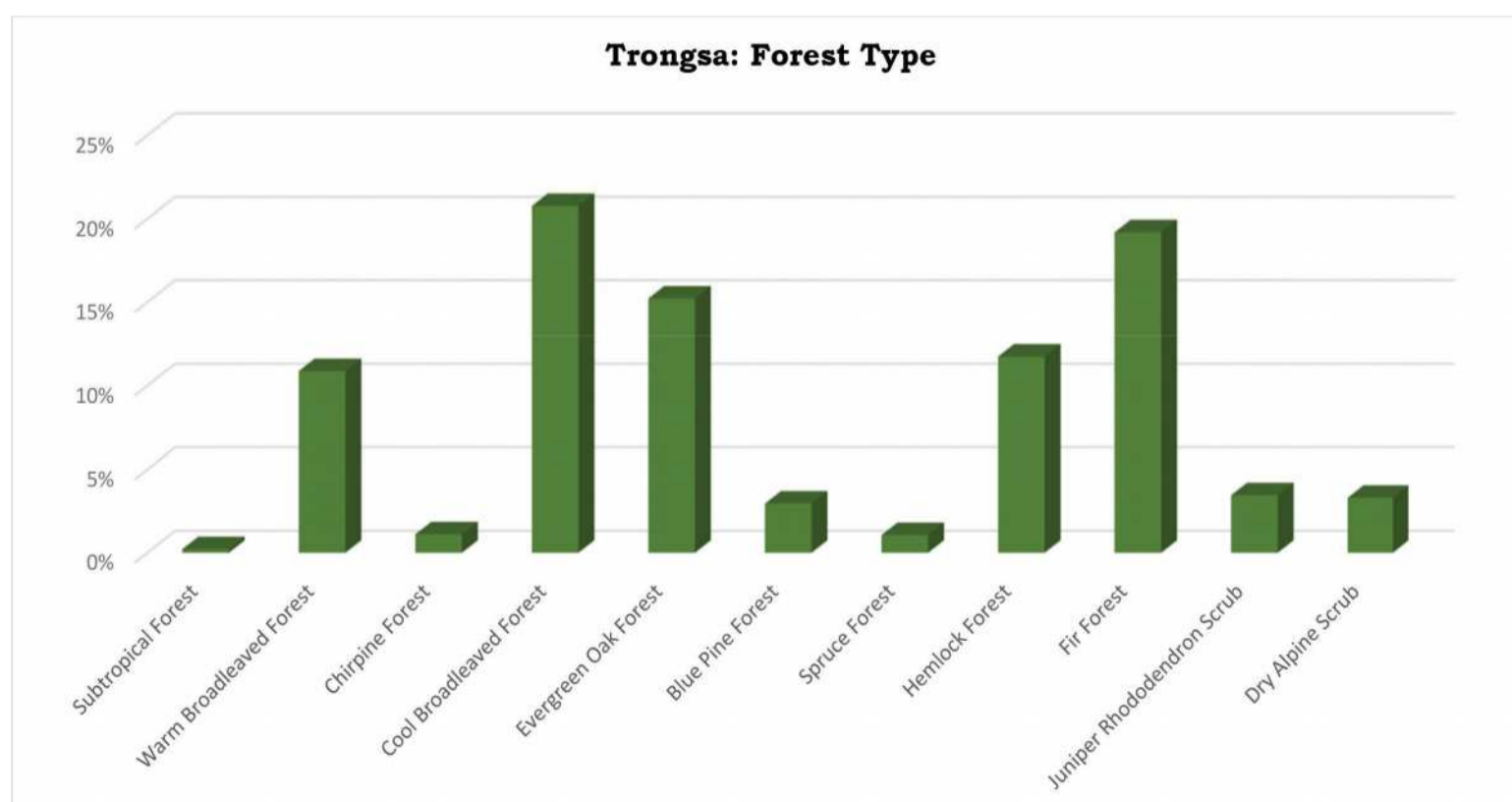


TRONGSA DZONGKHAG lies within 27°08' to 27°47' latitude and 90°15' to 91°45' longitude. It borders with Wangdue Phodrang Dzongkhag in the West, Bumthang Dzongkhag in the East and Sarpang and Zhemgang Dzongkhags in the South. The Trongsa Dzong is historically important both from political and religious aspects.

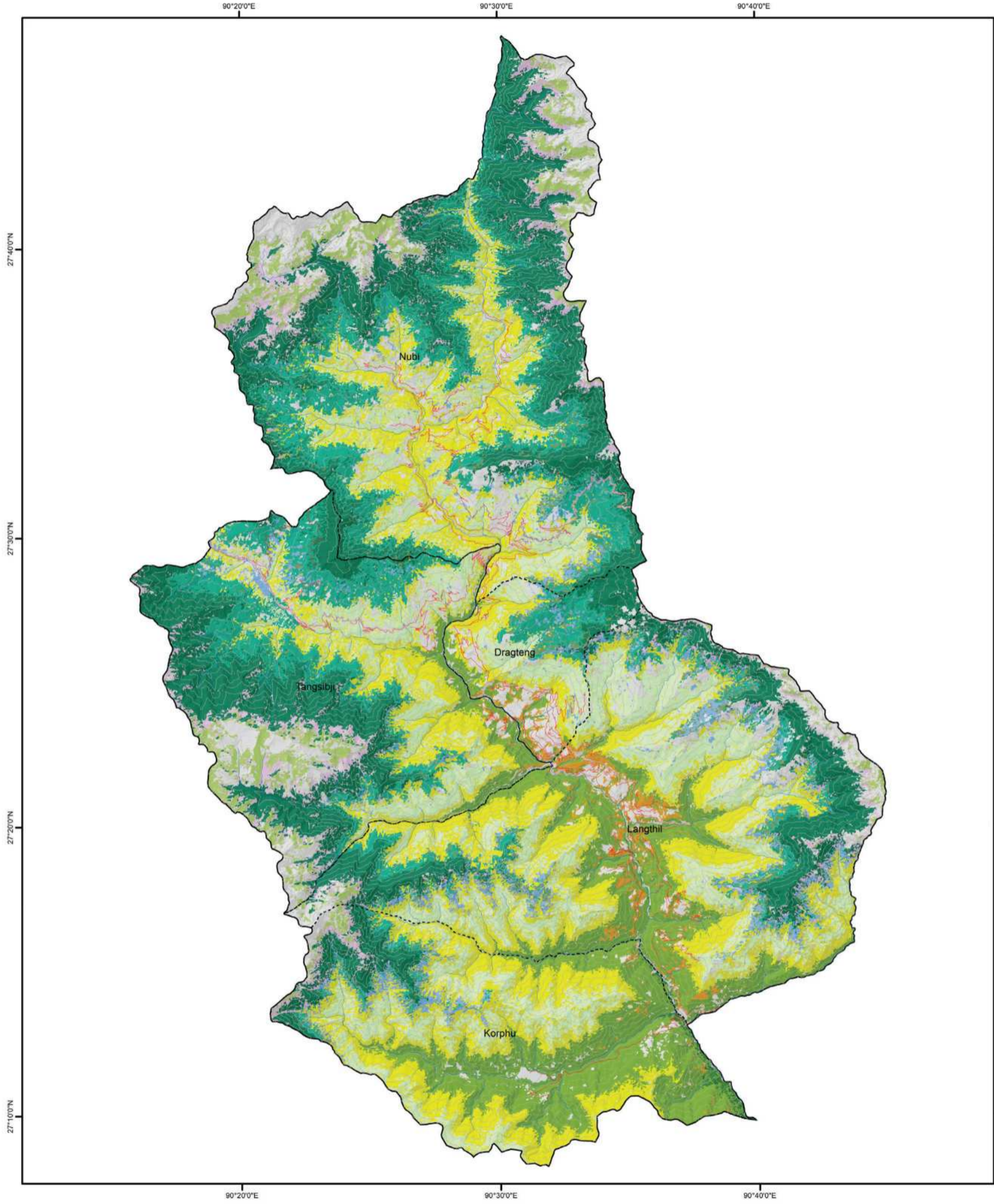
The elevation ranges from 600 m to 5100 m asl. Climate is warm in summer and cold in winter. The annual rainfall ranges from 1500 mm to 3000 mm. The Dzongkhag falls under the Jigme Singye Wangchuck National Park and Wangchuck Centennial National Park.

Because of its geographical location, this Dzongkhag contains both broad-leaved and conifer forests. This is one of the Dzongkhags with a diversity of forest types. Warm broad-leaved Forest (10.88), Cool broad-leaved Forest (20.77), and Evergreen Oak Forest (15.23 %) dominate the lower and warmer valleys. The upper cooler zone is characterized by Hemlock Forest (11.74 %), whereas the uppermost ridges are dominated by Fir Forest (19.19 %). Blue pine Forest occupies around 2.9 % of the area, which is most visible between the Cool broad-leaved Forest and Hemlock Forest.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	385.91	0.21%
Warm Broadleaved Forest	19533.15	10.88%
Chir pine Forest	1990.91	1.11%
Cool Broadleaved Forest	37302.89	20.77%
Evergreen Oak Forest	27349.06	15.23%
Blue Pine Forest	5311.01	2.96%
Spruce Forest	1908.43	1.06%
Hemlock Forest	21092.27	11.74%
Fir Forest	34462.51	19.19%
Juniper Rhododendron Scrub	6223.31	3.46%
Dry Alpine Scrub	5938.80	3.31%



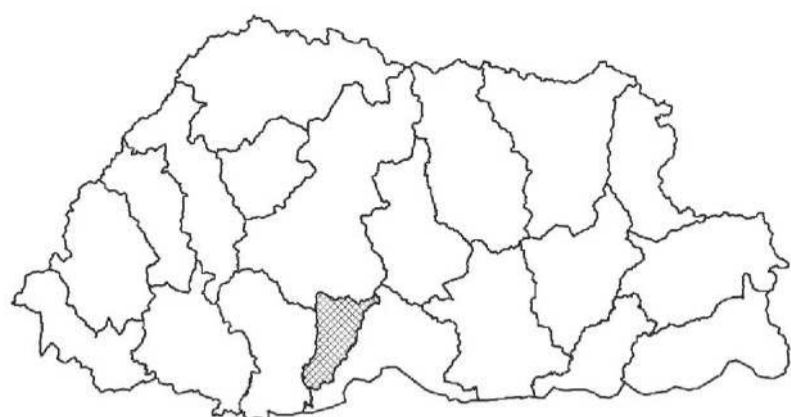
Dzongkhag: Trongsa



Legend

Dzongkhag	Forest Types	Evergreen Oak Forest	Non Forest
Gewog	Blue Pine Forest	Fir Forest	Spruce Forest
Road	Chirpine Forest	Hemlock Forest	Subtropical Forest
River	Cool Broadleaved Forest	Juniper Rhododendron Scrub	Warm Broadleaved Forest
	Dry Alpine Scrub		

TSIRANG



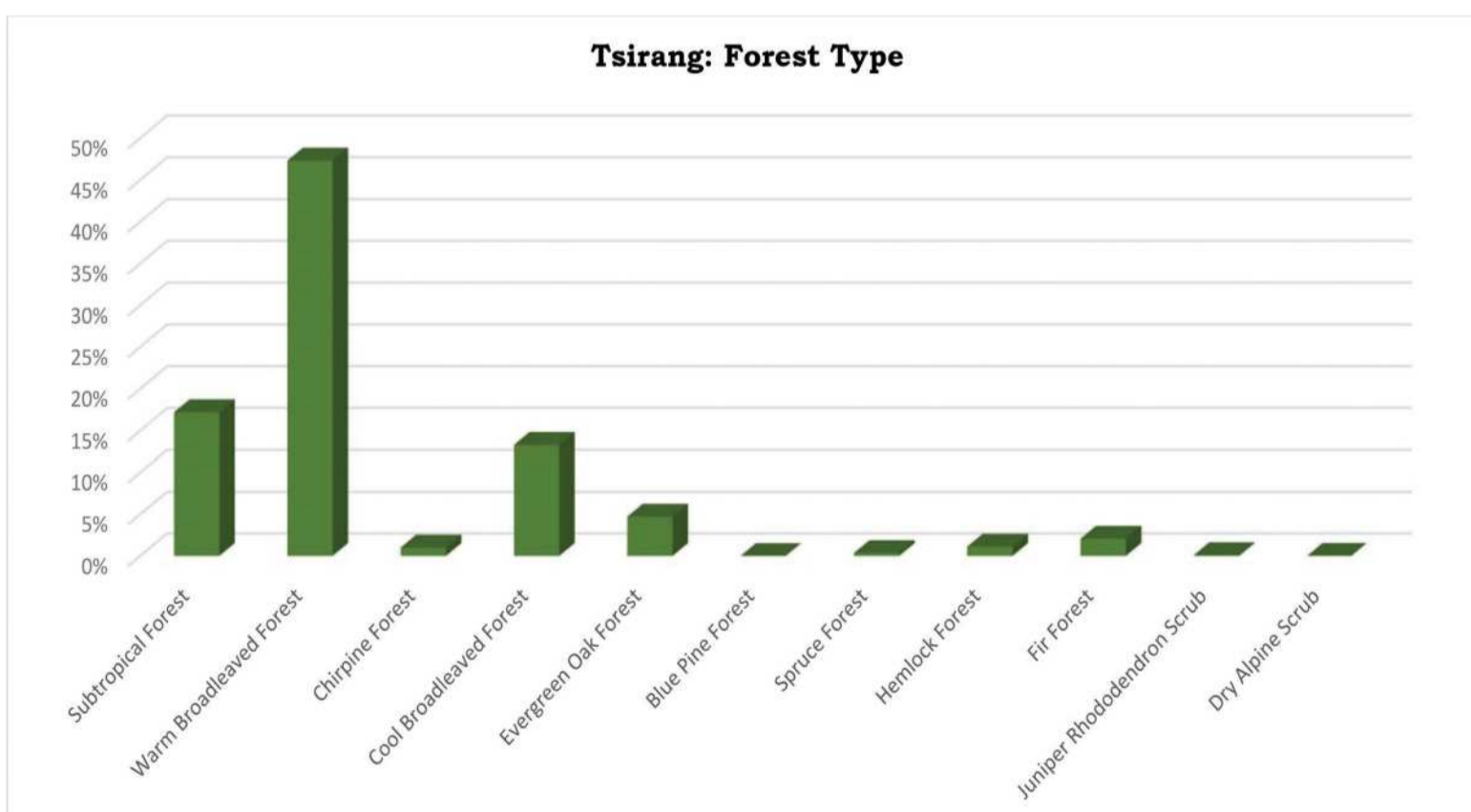
TSIRANG DZONGKHAG lies in the South of the country within 26°49' to 27°11' latitude and 90°00' to 90° 20' longitude. It borders with Wangdue Phodrang, Dagana and Sarpang Dzongkhags.

Tsirang Dzongkhag has an altitudinal range between 300 m to 4200 m above sea level. The summer is hot and humid while the winter is dry and moderately cold. The rainfall is between 1000 mm and 3000 mm per year.

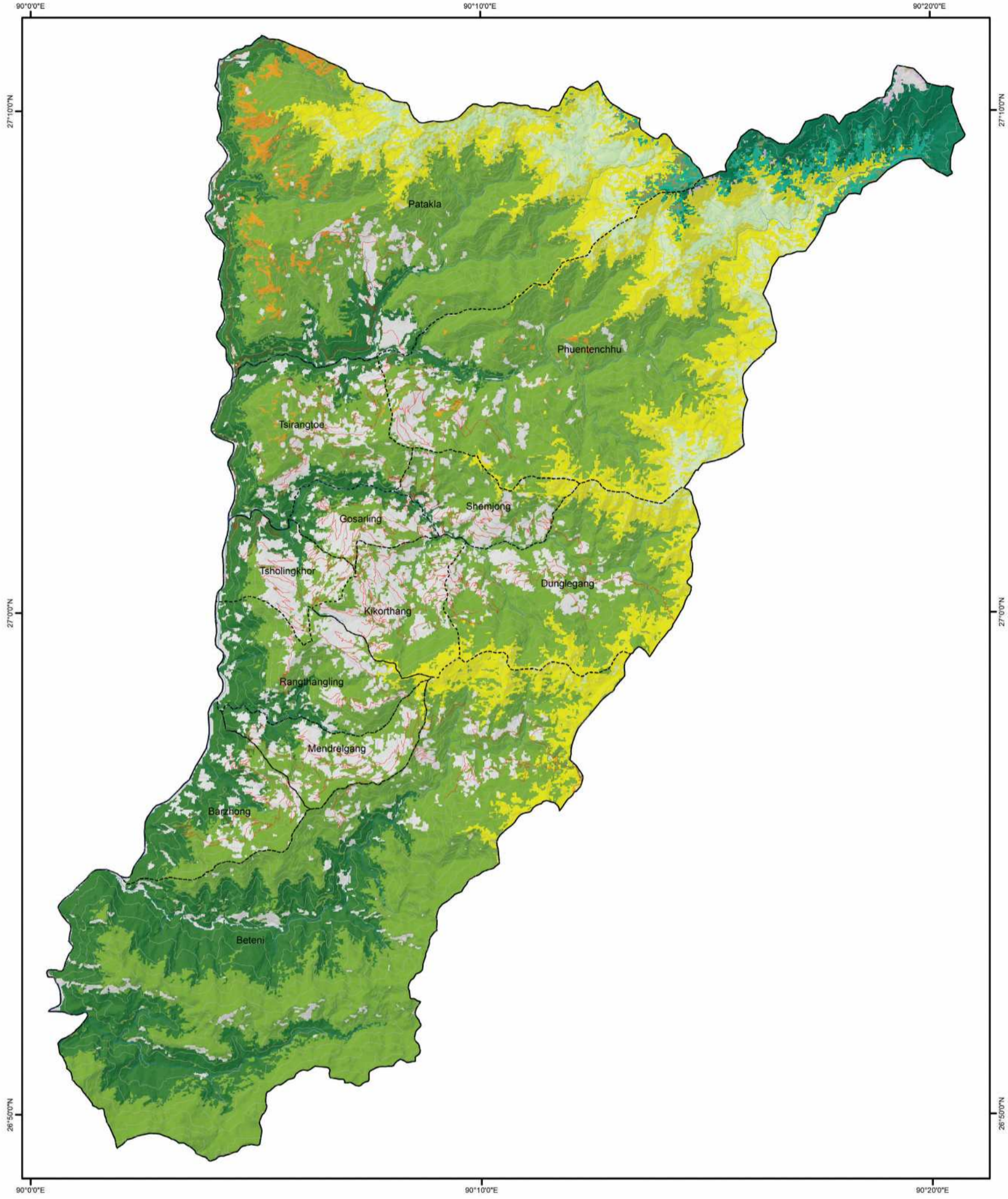
Tsirang Dzongkhag's forest landscape is dominated by broad-leaved forests. Subtropical Forest (17.2 %) occupies hot and moist deep valleys to the South. The majority of the forest landscape is covered with warm broad-leaved forest

(47.32 %). Around 17% of the forest is composed of a mixture of Cool broad-leaved and Evergreen Oak Forests. A small fraction of the Chir pine Forests can also be found in isolated portion of dry valleys.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	10865.06	17.20%
Warm Broadleaved Forest	29886.71	47.32%
Chir pine Forest	634.21	1.00%
Cool Broadleaved Forest	8395.90	13.29%
Evergreen Oak Forest	2991.26	4.74%
Blue Pine Forest	0.00	0.00%
Spruce Forest	214.84	0.34%
Hemlock Forest	710.07	1.12%
Fir Forest	1311.36	2.08%
Juniper Rhododendron Scrub	61.24	0.10%
Dry Alpine Scrub	7.11	0.01%



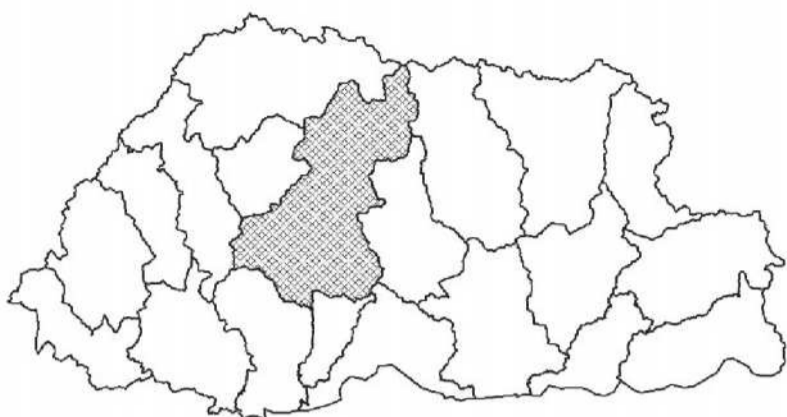
Dzongkhag: Tsirang



Legend

Dzongkhag	Forest Types	Evergreen Oak Forest	Non Forest
Gewog	Blue Pine Forest	Fir Forest	Spruce Forest
Road	Chirpine Forest	Hemlock Forest	Subtropical Forest
River	Cool Broadleaved Forest	Juniper Rhododendron Scrub	Warm Broadleaved Forest
	Dry Alpine Scrub		

WANGDUE PHODRANG

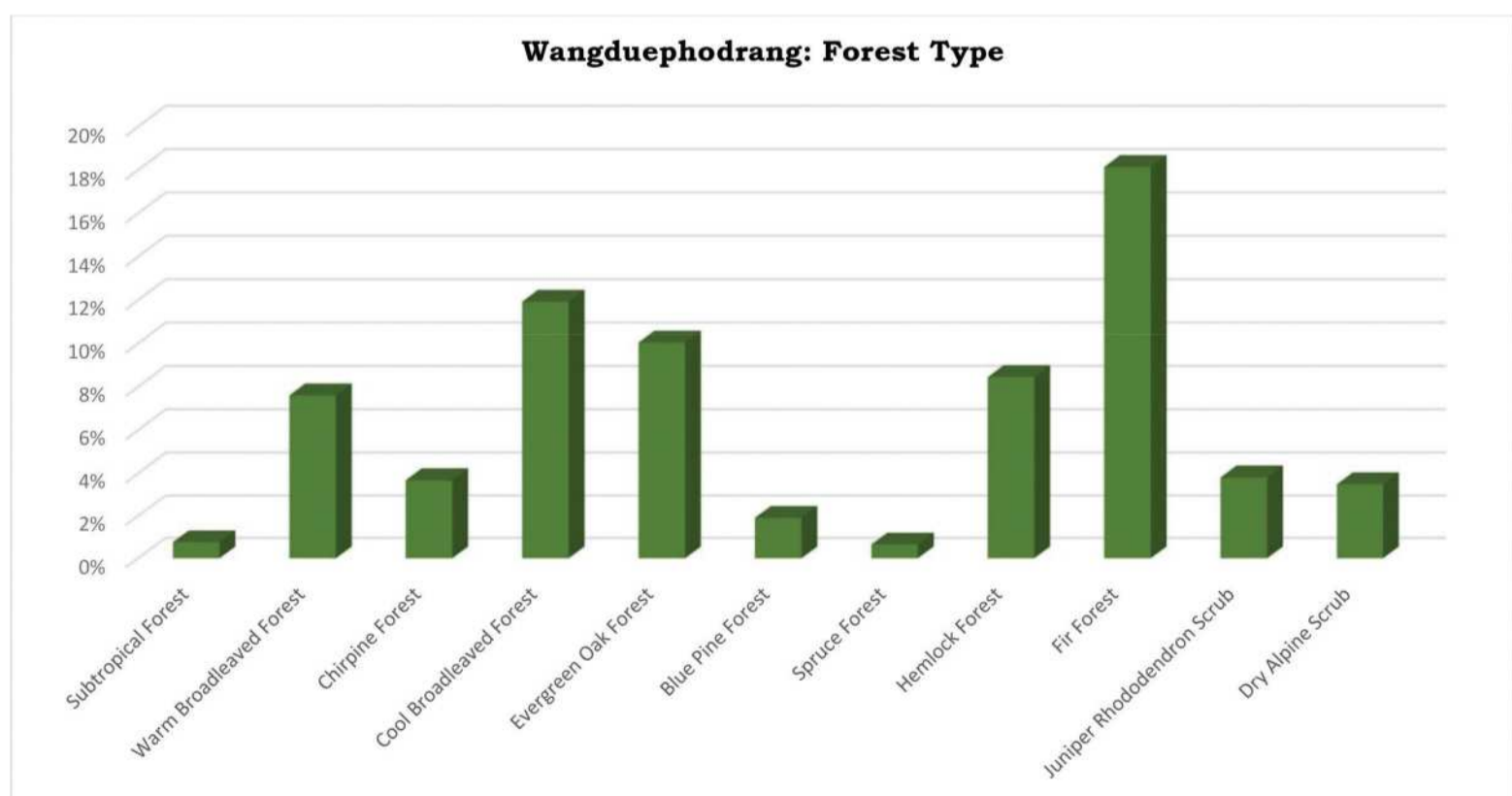


WANGDUE PHODRANG DZONGKHAG lies in the central part of Bhutan (27°06' to 28°02' latitude and 89°42' to 90° 32' longitude) and shares border with Gasa, Punakha, Thimphu, Dagana, Tsirang, Sarpang, Trongsa and Bumthang Dzongkhags. Small portion in the Northern part of the Dzongkhag borders with China.

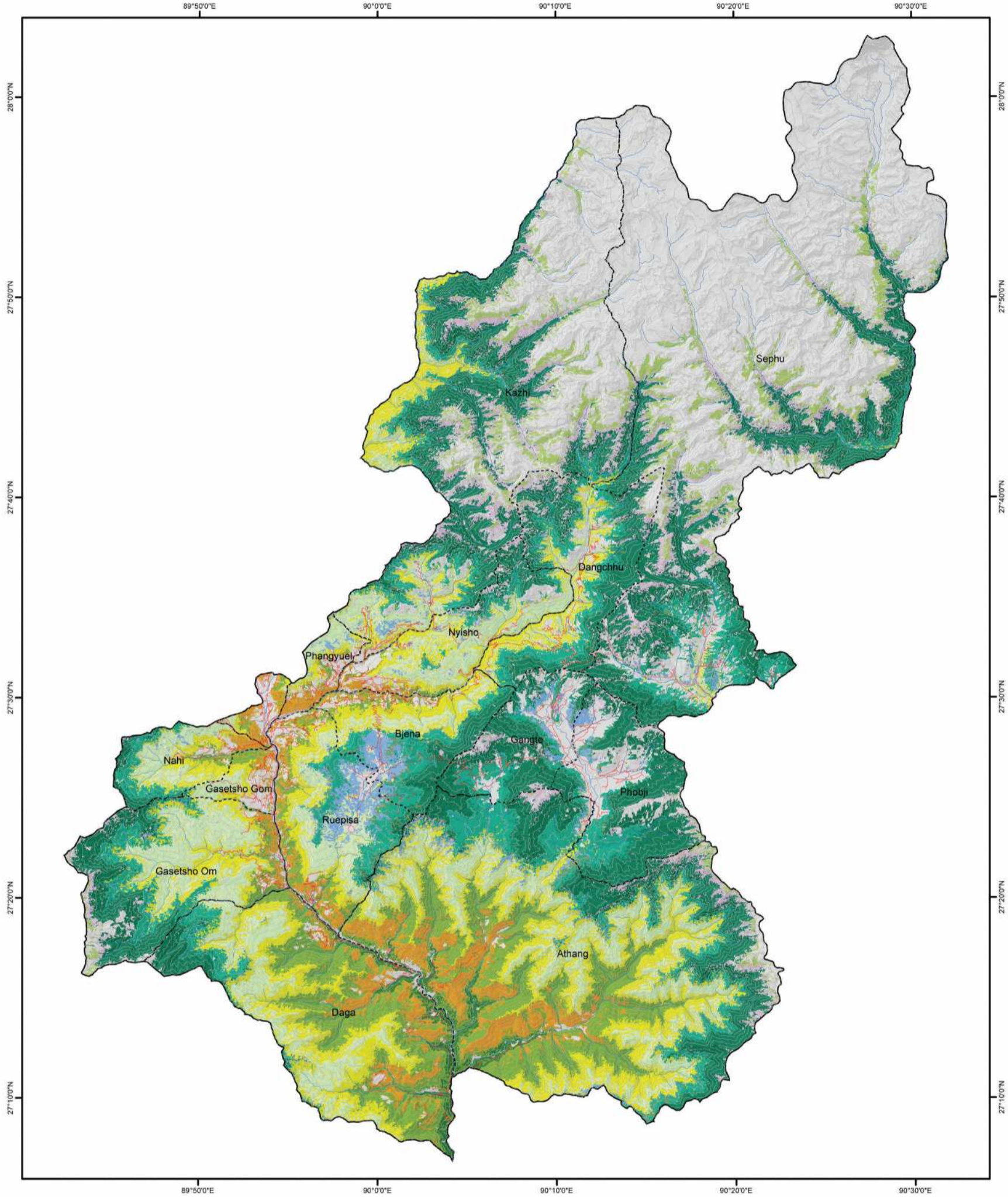
The elevation of the Dzongkhag ranges from 500 m to 7070 m above sea level. The average annual rainfall is approximately 1000mm. Northern part of the Dzongkhag receives precipitation in the form of snow. The Dzongkhag falls under the Jigme Dorji National Park, Jigme Singye Wangchuck National Park, and Wangchuck Centennial National Park. Phobjikha valley (Gangte and Phobji Gewogs) is famous as the winter resting place for the black-necked crane.

Wangdue phodrang is also one of the Dzongkhags which contains all forest types. Broad-leaved forests dominate the lower and warmer valleys, whereas conifer forests dominate the upper and cooler valleys. Warm broad-leaved Forest (7.6 %) dominates in the South, with a combination of Cool broad-leaved Forest (11.93 %) and Evergreen Oak Forest (10.04 %) in the upper cooler and wetter parts. Hemlock (8.44 %) and Blue pine Forest (1.91%) dominate at higher elevations. Fir Forest (18.14 %) dominates the highest mountain ridges. Chir pine Forest occupies around 3.69 % of the Dzongkhag area.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	3050.20	0.76%
Warm Broadleaved Forest	30374.74	7.60%
Chir pine Forest	14732.12	3.69%
Cool Broadleaved Forest	47658.98	11.93%
Evergreen Oak Forest	40116.00	10.04%
Blue Pine Forest	7642.94	1.91%
Spruce Forest	2597.72	0.65%
Hemlock Forest	33737.37	8.44%
Fir Forest	72483.21	18.14%
Juniper Rhododendron Scrub	15243.89	3.81%
Dry Alpine Scrub	13986.67	3.50%



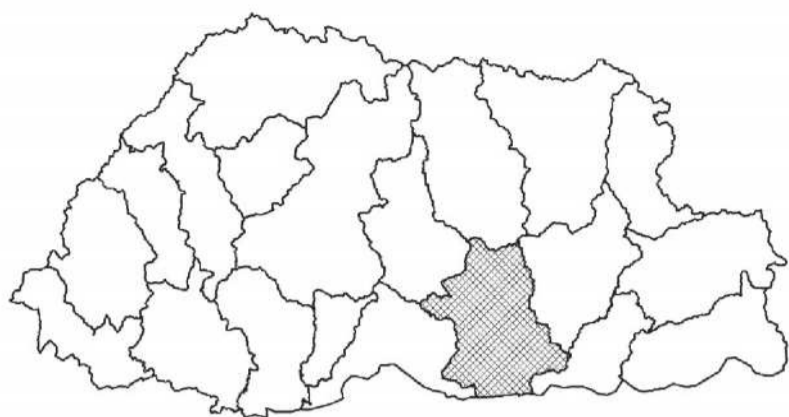
Dzongkhag: Wangduephodrang



Legend

Dzongkhag	Forest Types	Evergreen Oak Forest	Non Forest
Gewog	Blue Pine Forest	Fir Forest	Spruce Forest
Road	Chirpine Forest	Hemlock Forest	Subtropical Forest
River	Cool Broadleaved Forest	Juniper Rhododendron Scrub	Warm Broadleaved Forest
	Dry Alpine Scrub		

ZHEMGANG

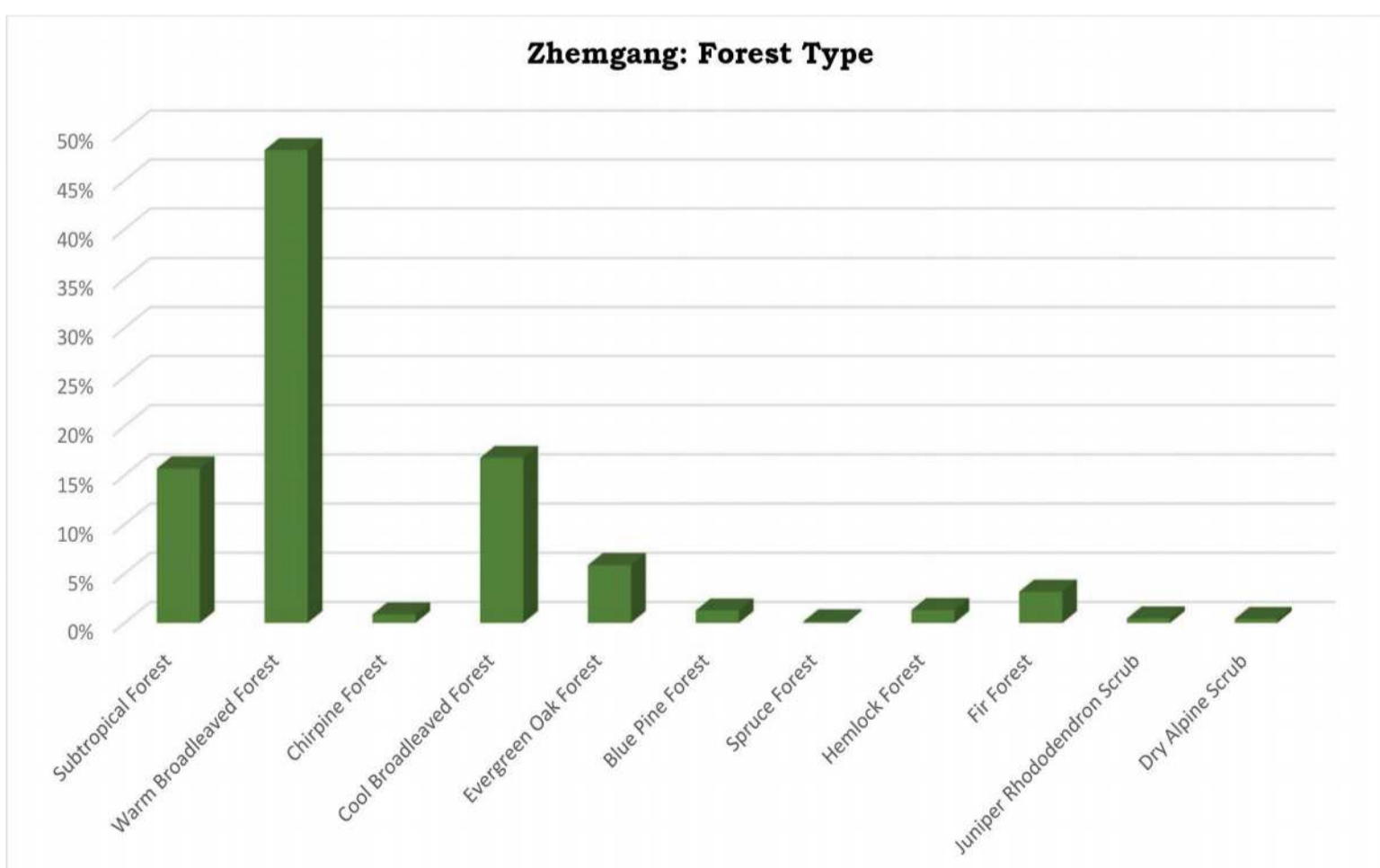


ZHEMGANG DZONGKHAG borders with the Trongsa, Sarpang, Samdrup Jongkhar, Mongar and Bumthang Dzongkhags. Two major rivers, Chamkhar Chhu and Mangde Chhu flows through this Dzongkhag. The elevation ranges from less than 100 m to 3600 m above sea level. Zhemgang is well known throughout the country, for its “Bangchungs” made from a particular cane.

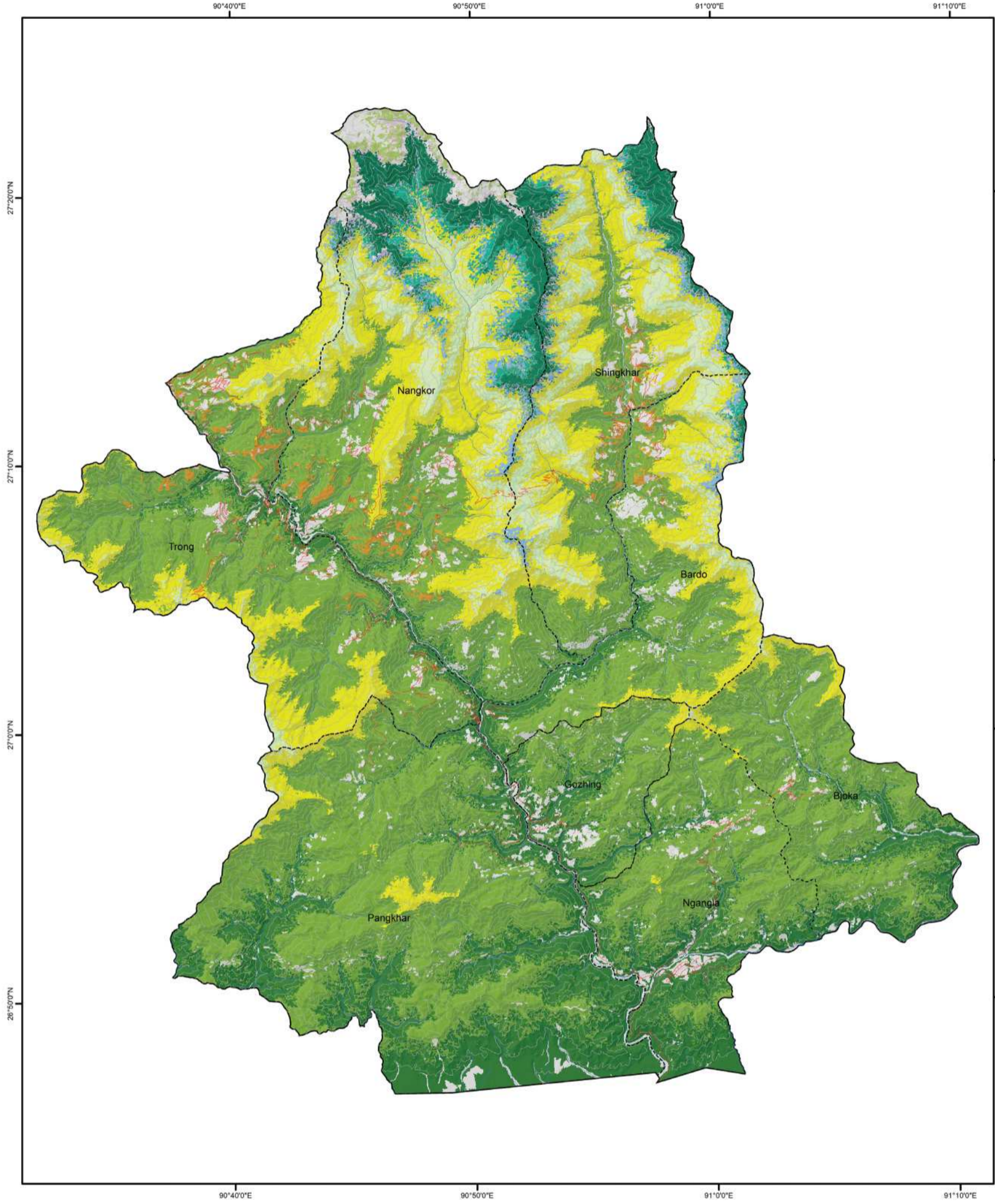
The Dzongkhag experiences temperate and subtropical climate owing to its variation of altitude. The rainfall varies from 1000 mm to 5000 mm on the Southern foothills, reaching its maximum during July and August. Dzongkhag falls under Royal Manas National Park and Jigme Singye Wangchuck National Park.

Forest covers more than 90 % of the dzongkhag’s geographical land. Because of the warm climate, the forest is largely made up of broad-leaved species. The hot and wet deep river valleys towards the Southern part of Dzongkhag include approximately 15.7 % of the Subtropical Forest. Warm broad-leaved Forest dominates nearly half of the forest landscape. Cool broad-leaved and Evergreen Oak Forests cover around 20% of the land. A small amount of Chirpine Forest can also be found in isolated portion of dry valleys. This Dzongkhag contains all the forest types.

Forest Type	Area (Ha)	Percentage
Subtropical Forest	37596.85	15.71%
Warm Broadleaved Forest	115129.64	48.11%
Chir pine Forest	2077.68	0.87%
Cool Broadleaved Forest	40174.53	16.79%
Evergreen Oak Forest	14094.66	5.89%
Blue Pine Forest	3039.63	1.27%
Spruce Forest	410.68	0.17%
Hemlock Forest	3122.74	1.30%
Fir Forest	7614.56	3.18%
Juniper Rhododendron Scrub	1120.90	0.47%
Dry Alpine Scrub	984.50	0.41%



Dzongkhag: Zhemgang



Legend

Dzongkhag	Forest Types	Evergreen Oak Forest	Non Forest
Gewog	Blue Pine Forest	Fir Forest	Spruce Forest
Road	Chirpine Forest	Hemlock Forest	Subtropical Forest
River	Cool Broadleaved Forest	Juniper Rhododendron Scrub	Warm Broadleaved Forest
	Dry Alpine Scrub		

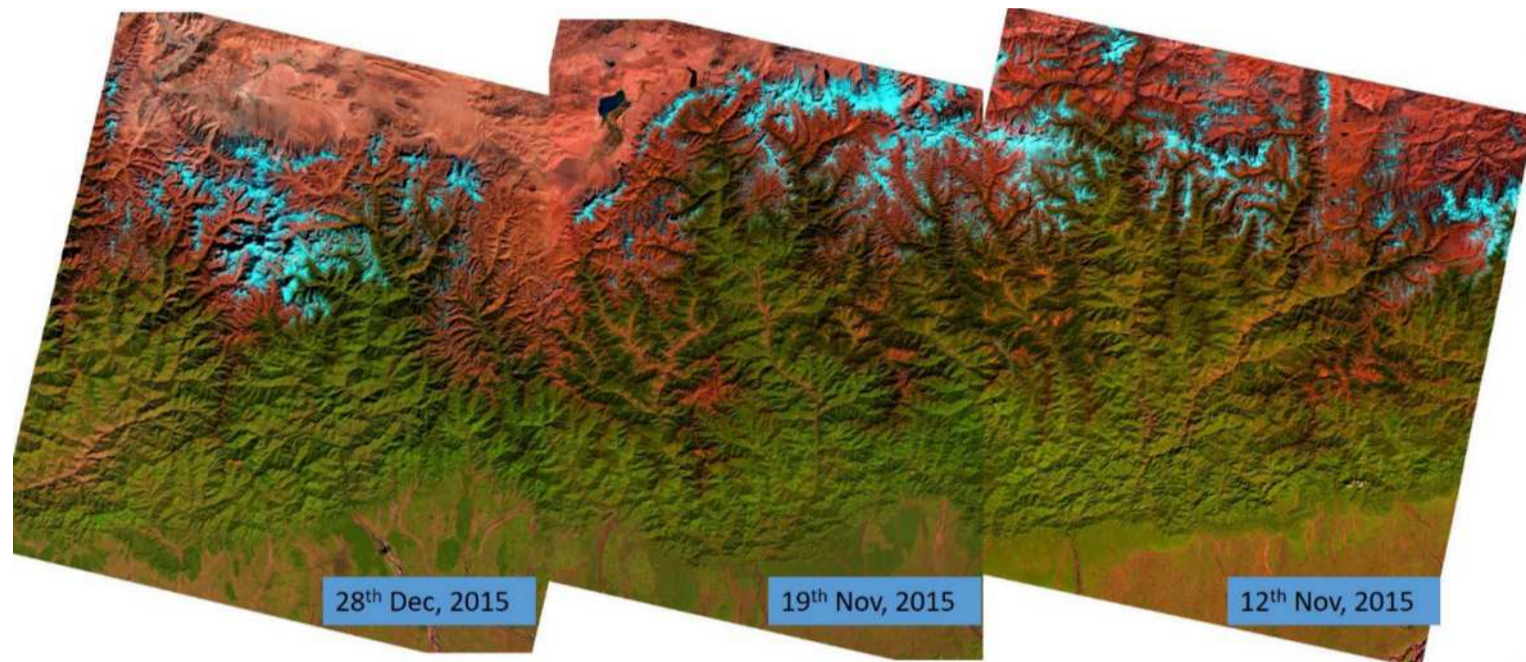
APPENDIX

Material and Methods

Satellite Image

Landsat 8 top of atmosphere (ToA) reflectance of year 2015 was used for the generation of forest type map. According to the path/raw of Landsat Data, Bhutan is fully covered by 3 scenes of Landsat images. Image with the least cloud cover of following dates to respective path/raw was used.

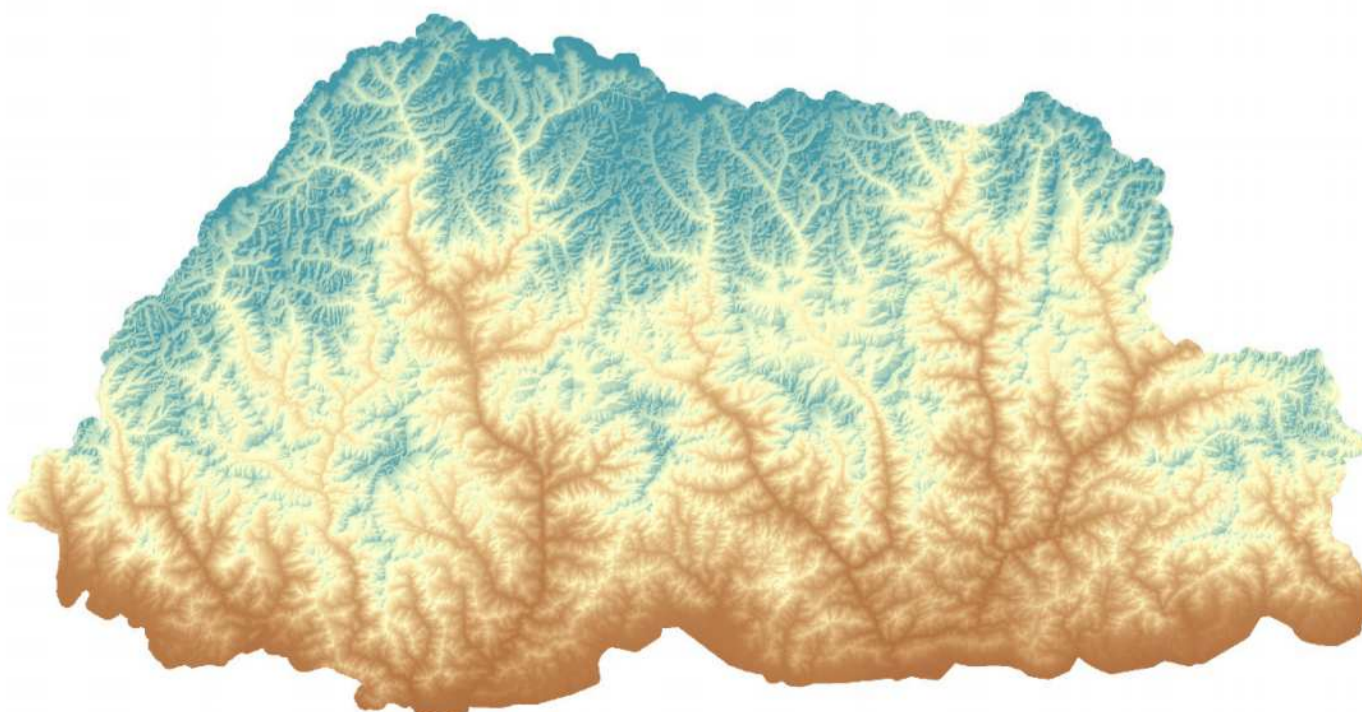
Acquisition Date	Path/Row
12th November, 2015	137/41
19th November, 2015	138/41
28th December, 2015	139/41



Further tasseled cap transformation was carried out using the coefficient developed by Muhamad Hasal Ali et al. (2014).

Landsat 8 band/TCT	Band1	Band2	Band3	Band4	Band5	Band6	Band7
Brightness	0.0000	0.3029	0.2786	0.4733	0.5599	0.5080	0.1872
Greenness	0.0000	-0.2941	-0.2430	-0.5424	0.7276	0.0713	-0.1608
Wetness	0.0000	0.1511	0.1973	0.3283	0.3407	-0.7117	-0.4559
TCT4	0.0000	-0.8239	0.0849	0.4396	-0.0580	0.2013	-0.2773
TCT5	0.0000	-0.3294	0.0557	0.1056	0.1855	-0.4349	0.8085
TCT6	0.0000	0.1079	-0.9023	0.4119	0.0575	-0.0259	0.0252

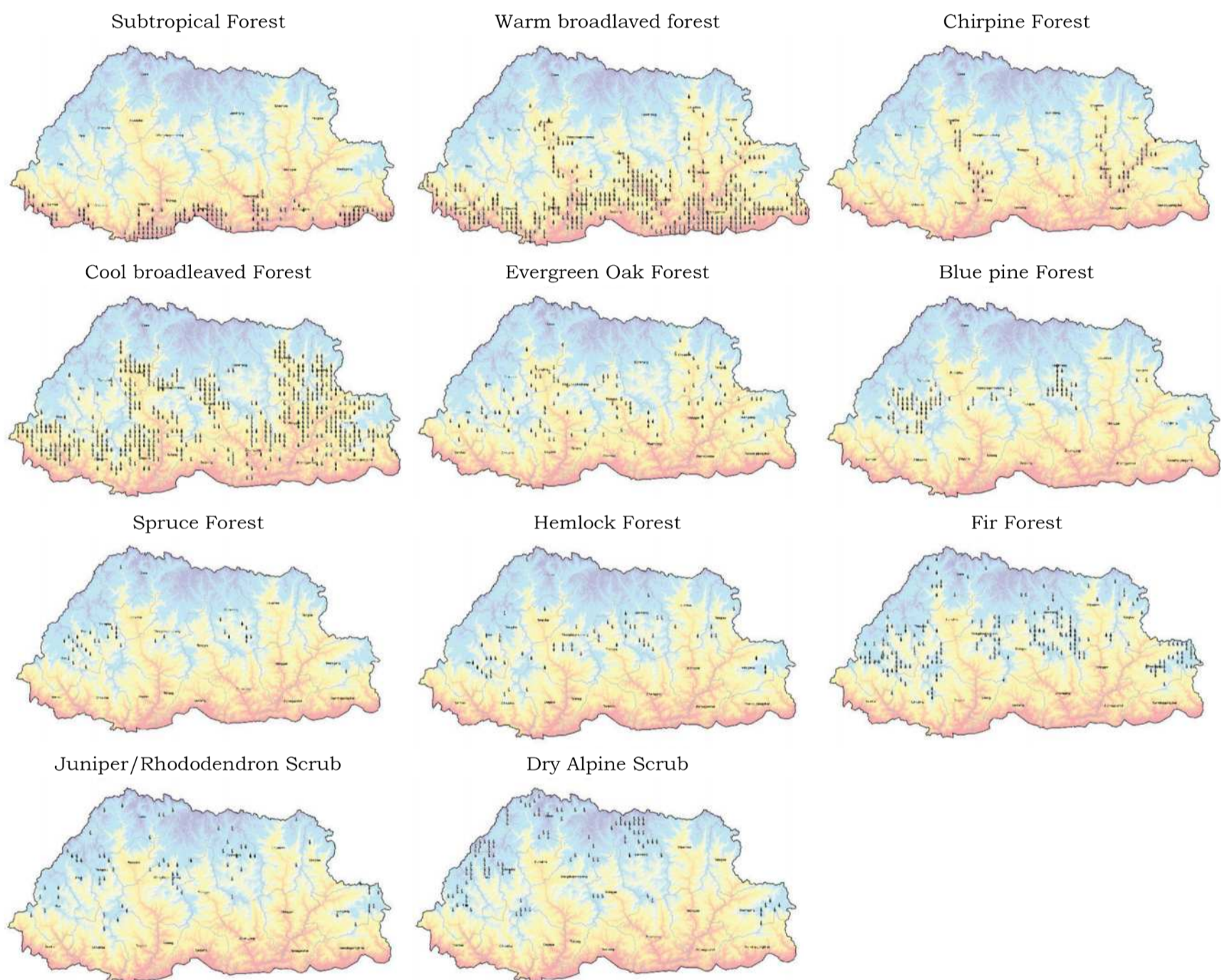
Alos PULSAR Digital Elevation Model (DEM) and aspect derived from DEM was also used for the mapping process.



Training Data

Field plot data from the 1st National Forest Inventory (NFI) was used for model calibration and accuracy assessment of the forest type map. Field data collection for the 1st NFI was carried out during the period of 2012 to 2015. A total of 2424 systematic clustered plots are uniformly spread out across the landscape of Bhutan at 4km x 4km distance. Each cluster plots consists 3 circular subplots with the radius of 12.62m at 50m apart from the central plot towards North and East. From the total of 7272 subplots, around 4689 subplots had the information on the forest type.

Data cleaning was required due to the presence of several errors in the forest type information at the sub plot level. All subplots with missing tree and forest type data were eliminated. During the NFI, the coordinates and properties of each individual tree within the subplots were acquired. The basal area of each individual tree was determined using the diameter. Subplot data were corrected using the species with the maximum basal area and altitude at the subplot level. Following the necessary corrections, a total of 4079 subplot data including forest type information was available for the development of map. Around 80% of the sample was utilized for training the model, while the remaining 20% was used for accuracy assessment.



Landsat 8 (12 bands), six tasseled cap layers, DEM and aspect were used for segmentation. Multiresolution algorithm was applied for image segmentation with the scale parameter of 10. All the layers were assigned equal weight, 0.1 was assigned for shape and 0.9 for compactness. Forest and non-forest were segregated using rule sets. Thereafter Random Forest classifier was applied to classify the different forest types in eCognition 9.3. Random Forest is a new non-parametric ensemble machine-learning algorithm. Random forest classifier algorithms are widely used for generating land use and land cover maps based on satellite imageries.

Accuracy Assessment

Error matrix method was used for assessing the accuracy. This is very effective method as it presents the accuracies in each category with both error of inclusion (commission error) and error of exclusion (omission errors) present in classification. Around 20% of the available sample was used for assessing the accuracy. The overall accuracy of the map was 87%. Both producers and user accuracy were around 86%. The Kappa coefficient of the map is 0.85.

