



## **CROPPING PATTERN VARIABILITY AND AGRICULTURAL TRANSFORMATION IN SIKKIM HIMALAYA**

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### **ABSTRACT**

Agriculture in Sikkim is characterized by diverse cropping patterns shaped by variations in altitude, topography, and climatic conditions. This study examines the spatial and temporal dynamics of cropping systems in Sikkim, highlighting the role of agro-climatic diversity in determining crop combinations and agricultural practices. The findings reveal that cropping patterns vary significantly across altitudinal zones, with mono-cropping dominating higher elevations and multiple cropping systems prevalent in lower and mid-hill regions. Major cropping systems include rice-based, maize-based, potato-based, ginger-based, and millet-based patterns, each associated with specific ecological conditions and seasonal cycles.

The study also identifies a transition from traditional subsistence agriculture to market-oriented cultivation, marked by the increasing importance of cash crops such as ginger, potato, and horticultural produce. Intercropping, relay cropping, and mixed farming systems are widely practiced to maximize productivity under limited land availability and steep terrain. However, the state continues to face challenges such as low productivity, dependence on external food supply, and environmental constraints.

The paper concludes that sustainable agricultural development in Sikkim requires the promotion of climate-resilient cropping systems, improved resource management, and the integration of traditional knowledge with modern agricultural practices to enhance food security and farmers' livelihoods.

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## Introduction

The state of Sikkim has a total area of only 7096 sq. km. and is stretched over 112 km from north to south and 64 km from east to west. It lies in the north-eastern Himalayas between 27 0 00' 46'' to 28 0 07' 48'' North latitude and 88 0 00' 58'' to 88 0 55' 25'' East longitude. Sikkim is known as 'Denjong' and more rarely 'Demojang' or 'Demoshang' which literally means the 'land of rice' or 'valley of rice'. The early European travelers like Samuel Van de putta, Horace Della Penna cited the name 'Bramasojan' for Sikkim. Simultaneously Desideri also called the country 'Bru-me-jong', which means 'the rice country'.

Sikkim is a very small state in the Himalayas with formidable physical features. It is bounded by vast stretches of Tibetan plateaus in the north, the Chumbi valley of Tibet and the kingdom of Bhutan in the east, the kingdom of Nepal in the west and Darjeeling District of West Bengal in the south. Sikkim was known to the Lepchas, the original inhabitants of the state as 'Nye-Ma-el' or heaven. Tibetans called it 'Renjong' or 'Denzong' or 'the valley of rice'.

The state's economy is largely agrarian, based on the terraced farming of rice and the cultivation of crops such as maize, ginger, buckwheat, finger millet, wheat, barley, oranges, tea and cardamom. Agriculture is the primary activity of the people of Sikkim. About 11.13 percent of the total geographical area of the land is dedicated to agriculture. The subsidiary system of livestock rearing is the most predominant livestock rearing system in most rural areas of Sikkim. It is one of the important parts of the mixed farming system in the mid and lower hills of Sikkim in which agriculture, horticulture and agro-forestry form major pillars in the life of farmers. The role of livestock reared under this system is to support the main components. The livestock help to recycle the crop residues and agricultural products effectively.

Even though Sikkim is a small state of India, occupying very little area under cultivation, it embodies a variety of cropping patterns largely due to variations of topography as well as altitude. The cropping pattern varies according to altitude and prevailing climate. The crop with substantial percentage in total sown area in a particular region is taken as the base crop and all other possible substitute crops which are sown in the region either as alternatives as support crop in the same period or as crops that are suitable as rotation in the successive season, are considered in the pattern.

The cropping pattern of a region is determined by a variety of factors, most notably, elevation, topography, precipitation and so on. All kinds of seasonal, off-season and perennial crops can be grown in Sikkim due to climatic variations caused by altitudes. The mixed farming system of agriculture, horticulture and livestock rearing practices are common in Sikkim. The climate of Sikkim is conducive for growing a large number of high value cash crops such as cardamom, potatoes, ginger, variety of fruits, off-season vegetables and numerous other horticultural crops along with agricultural crops and livestock. In general, maize-ginger inter-cropping or maize-urdu are common practices in low and mid elevation dry-fields; paddy-maize/wheat/tori/potato crop rotation at lower elevation; orange-legumes/ginger at mid elevation, cardamom at mid and higher elevation, seed-potato-maize or maize-soybean or seed potato-pea/soybean/temperate fruits at high elevation are common crop rotations. The cropping patterns of the state have undergone metamorphic changes since the merger with India in 1975. These changes are significant indicators of the ongoing process of agricultural transformation from cereal dominated subsistence agriculture to high value cash crop dominated commercial agriculture (Subba, 2008). After 1975, cereal dominated subsistence agriculture slowly started being altered into high value cash crop-based commercial agriculture with increased production of pulses, oilseeds, fruits and vegetables and cultivation of cash crops such as ginger and mandarin orange in more areas.

Though cropping activity goes on all the year round in Sikkim, there are two main seasons in the state are as follows:

1. Kharif Season (May to October) - the crops grown during this season are known as kharif crops e.g. maize, rice, millet etc. and
2. Rabi Season (October to March) - the crops grown during this season are known as rabi crops e.g. wheat, barley, mustard etc.

### Cropping Pattern in Kharif Season

- Pre-kharif: Maize (February- August); in dry field, maize+soybean
- Maize+beans+vegetables
- Kharif: Paddy (May to October-November)
- Kharif: Paddy+soybean/rajma
- Kharif: Rajma+vegetables/potato
- Kharif: Urd (Pehali dal)
- Kharif: Millet (pure crop).

### Cropping Pattern in Rabi Season

- Rabi: In dry field, maize is followed by mustard and buckwheat (September –February).
- Rice is followed by wheat in irrigated field as well as in dry field, to cover fallow land (September – March).
- Large area expansion has been done under buckwheat crop to fill the gap created by low production of wheat during dry season.
- Barley as pure crop in limited area (nfsm.gov.in).

The prevalent cropping systems of Sikkim are the cumulative results of past and present decisions by individual farmers, farming communities of the state, governments and their agencies. These decisions are usually based on experience, tradition, food habit, market facility, expected profit, personal preferences and resources, social and political pressures and so on (Subba, 1984).

**Table 1: Agriculture Crops and Cropping Seasons at Different Agro-Climatic Conditions**

Seasons	Crops/Vegetables	Crops sown	Crops harvested
Winter	Wheat, Buckwheat, Mustard, Radish, Cabbage, Cauliflower, Potatoes, Peas, Tomatoes etc.	December-February	April-May
Summer (Pre-kharif)	Maize	March-April	June-July in lower and August-September in higher altitudes
	Yams, Colocasia, Tapioca	March-April	December-March
	Chayote (Eskush), other climber crops (cucumber, pumpkin, gourds, etc)	March-April	June through March
	Ginger, Turmeric	March-May	Anytime during November through March
Monsoon (Kharif)	Rice, Pulses , Beans	June-July	October-December
	Finger-millet, soybean	August	November-December
Year round	Cabbage, Radish, Carrot, Cauliflower, Brocoli, Beans, Tomatoes etc.	Grown mostly in all the seasons at different altitudes	

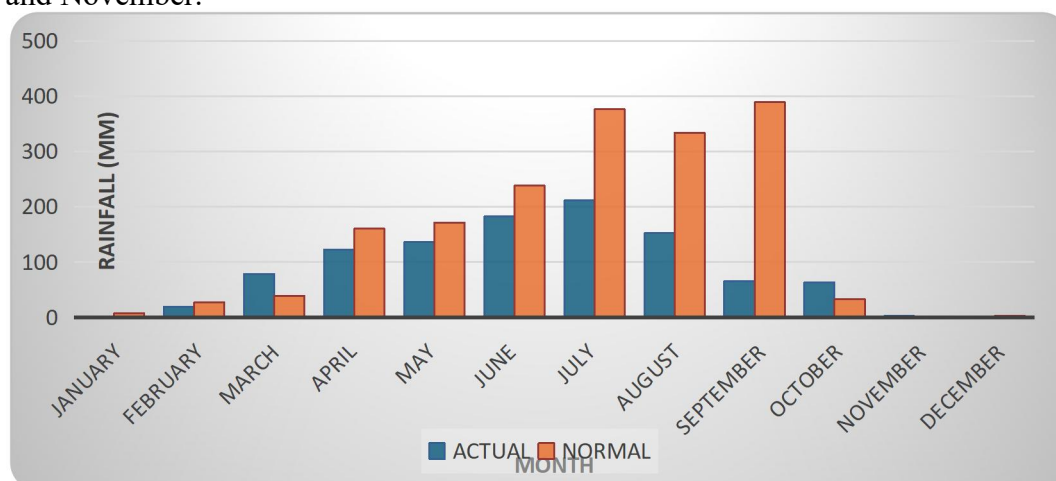
*Source:* Gazetteer of Sikkim, 2013.

To indicate the significance of rainfall and temperature variations on cropping pattern, the rainfall and temperature data of two different places from two districts, namely East and South districts are given below:

**Table 2: Actual and Normal Rainfall (mm) of Namthang (South District)**

Month/Year (2013-14)	Actual	Normal	Situation
January	2.00	7.00	Scanty
February	19.40	27.10	Deficient
March	78.30	38.90	Excess
April	122.20	160.20	Deficient
May	135.80	171.50	Deficient
June	182.20	237.90	Deficient
July	211.20	376.20	Deficient
August	151.90	334.00	Deficient
September	065.60	389.10	Scanty
October	062.80	32.70	Excess
November	002.20	1.70	Excess
December	0.00	2.90	Scanty

As per the table given above, the actual and normal rainfall of Namthang, South district seems to be scanty and deficient. During the time of cultivation, insufficient rainfall leads to non-affluent condition for the agriculture. During 2013-14, rainfall was excessive in three months i.e. March, October and November.

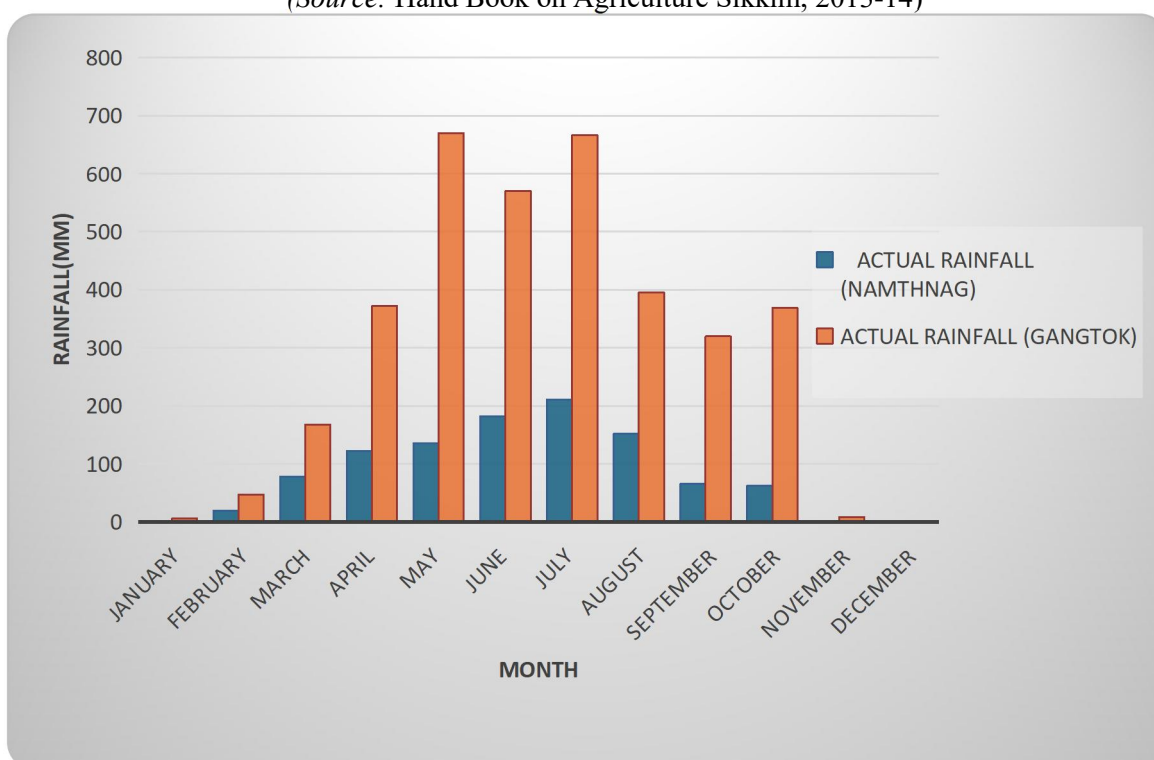


**Figure 1: Rainfall (mm) of Namthang (South District) 2013-14**

**Table 3: Actual Rainfall of Gangtok (East District) and Namthang (South District).**

Month/Year (2013-14)	Actual Rainfall (Namthang)	Actual Rainfall (Gangtok)
January	2.00	6.00
February	19.40	47.30
March	78.30	167.90
April	122.20	372.30
May	135.80	670.20
June	182.20	570.40
July	211.20	666.80
August	151.90	395.70
September	065.60	319.80
October	062.80	368.90
November	002.20	8.80
December	0.00	8.40

(Source: Hand Book on Agriculture Sikkim, 2013-14)



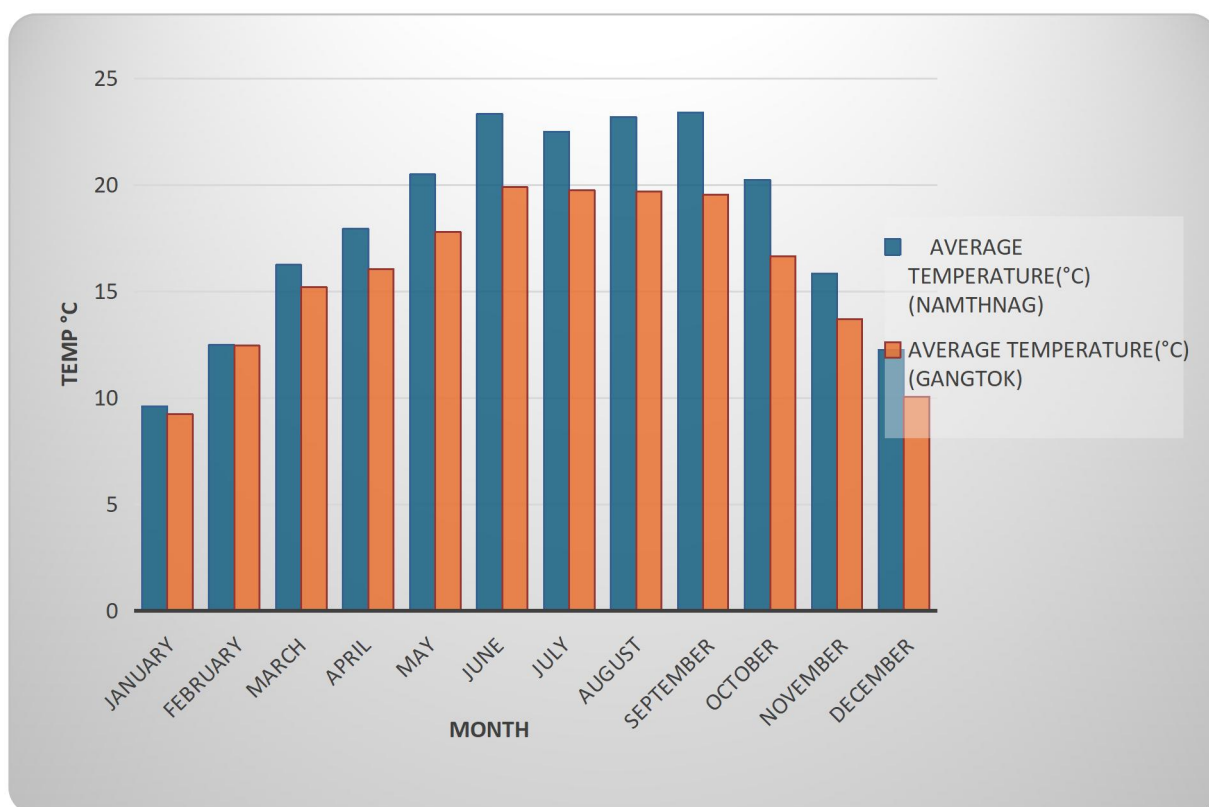
**Figure 2: Actual Rainfall (mm) of Gangtok and Namthang (2013-14)**

From the above figure, it is revealed that the actual rainfall in Gangtok, i.e. the East district and that of Namthang, i.e. South district varies greatly due to topographical aspects of the regions. In almost all the months from January to December, rainfall occurs routinely in East district, but the South district remains dry in winter months. In other months too, rainfall in South district is far too little in comparison with the East district. The South district is considered as drought prone area of Sikkim.

**Table 4: Average Temperature of Gangtok (E. District) and Namthang (S. District)**

Month/Year (2013-14)	Average Temperature(°C) (Namthang)	Average Temperature(°C) (Gangtok)
January	9.60	9.25
February	12.50	12.45
March	16.25	15.20
April	17.95	16.05
May	20.50	17.80
June	23.35	19.90
July	22.50	19.75
August	23.20	19.70
September	23.40	19.55
October	20.25	16.65
November	15.85	13.70
December	12.25	10.05

Source: Hand Book on Agriculture Sikkim, 2013-14.



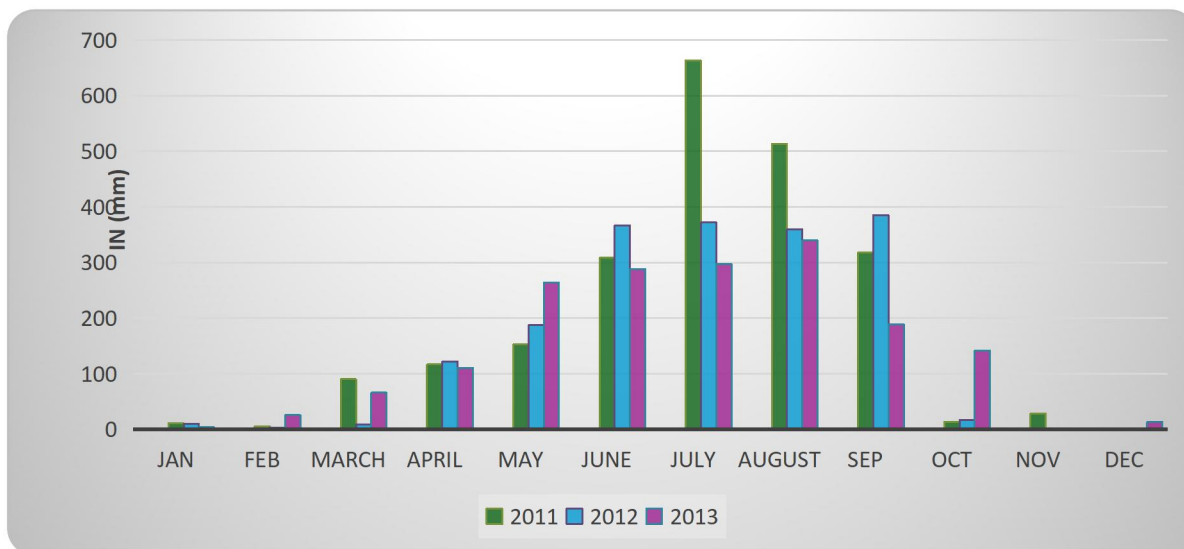
**Figure 3: Average Temperature (°C) of Namthang and Gangtok (2013-14)**

It is evident from the above figure that the average temperature (°C) of Namthang in South district is always higher in comparison with Gangtok in East district. The average monthly temperature in Gangtok normally remains below 20°C, which indicates a salubrious climate, favourable for a variety of crops.

**Table 5: South District Rainfall (mm) for Three Consecutive Years (2011-2013)**

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2011	11.5	5.4	90.4	117	152.7	308.5	663.3	513.4	318.2	13.9	28.6	1.0
2012	10.1	3.6	9.1	122	187.5	367.2	372.1	359.7	385.1	16.9	0.0	0.0
2013	4.0	25.7	66.2	111	263.8	288.4	297.8	339.6	189.2	141.5	2.2	13.5

Source: sikenvis.nic.in.



**Figure 4: South District Rainfall (mm) for Last Three Years (2011-2013)**

From the aforesaid figure which shows the rainfall of South district for three consecutive years i.e. 2011-2013, it is found that the highest rainfall occurs in the month of July. Of the three years from 2011-2013, the highest rainfall recorded was in 2011. In 2012, rainfall has been almost even in the months from June to September. In 2013, rainfall in the month of May was more than the previous years.

Sikkim's diverse ecological condition that arrays from tropical to alpine support the cultivation of a variety of fruits, vegetables, in and out of season, and are also excellent for commercial crops like cardamom, ginger, orange, etc. The present trend towards rapid expansion of horticultural crops will have positive implications for improving food and economic security of the farmers of Sikkim. However, scrutiny of yield data and other parameters like net income per hectare, market demand, peak season of arrivals and price trend in major markets should be kept in mind to regulate the production –marketing chain. Ginger, vegetable farming, seed potato farming in horticulture and also livestock rearing especially dairying has particularly helped small and marginal farmers of Sikkim to come out of poverty trap (Subba, 2008).

Horticulture plays an important role in Sikkim's agriculture and commerce. The vegetable farming extends from the foothills to altitude up to 2000m above sea level. The major vegetables of the state are:

- a) Kharif Vegetables: Brinjal, chili, capsicum, pumpkin, French beans, cowpea, bhindi (okra), cucumber, bottle gourd, sponge gourd, balsam apple, chayote etc.
- b) Rabi Vegetables: Cabbage, cauliflower, broccoli, garden pea, French beans, radish, carrot, turnip, palak (spinach), amaranthus, methi (fenugreek), leafy mustard, lettuce, coriander, leafy onion, garlic, seed potato, colocasia etc.
- c) Off Season Vegetables: Cabbage, cauliflower, broccoli, Brussels sprouts, radish, carrot, tomato, green pea, French beans, palak (spinach), leafy mustard, chayote, cucumber, amaranthus, leafy onion, summer potato, capsicum, asparagus, bamboo shoots, fern shoots, stinging nettles, mushroom etc (Subba, 2008).

### **Cropping and Intercropping System**

Population pressure on the cultivated land is constantly increasing. The per capita availability of net cultivable land in the state during 1981 was 0.31 ha, which decreased to 0.24 ha in 1991, which further decreased to 0.24 ha in 2001.

Most of the land available in state is sloping. Field trials were conducted at ICAR complex to evaluate the role of mono, sequential and intercropping systems on partially terraced and partially contour bounded micro-watershed (Awasthi and Prasad, 1987). The overall results showed the feasibility of increasing total crop yields, carbohydrate, calorie and protein production through crop intensification and diversification. The sloping lands are three to four times less efficient in meeting the food needs of calorie and protein because it can hardly sustain three to four persons per ha per annum against the sustainability of nine to ten persons in a plain land. Continuous available cropping system on steep land even with moderate level of fertilizer beyond two to three years may not be of desirable proportion because of heavy soil erosion. In hill areas like Sikkim terraced farming has been under practice in order to prevent soil erosion.

It is therefore a kind of compulsion to adopt agri-horti-silvi pastoral system as an alternative for such steep sloping land. Sikkim is already deficit in food and vegetables. About half of its population is being fed from outside sources. Hence, it is imperative to augment vegetable production by intensifying vegetable cultivation and increasing the cropping index by multiple cropping programmes. Combining vegetables with several multiple and relay cropping systems in irrigated areas and intercropping systems in rainfed farming systems are relatively new concepts to be explored to benefit the farmers and to increase vegetable production. Multiple cropping and intercropping provide maximum production with available resources per unit area and provides maximum benefit to the farmers from the available land resources. Most of the vegetable crops produced in the state are the products of mixed cropping, relay cropping and intercropping systems. Potato and garden pea are common intercrops at higher hills in Sikkim. French beans, garden pea, tomato, ginger are very common intercrops in the state (Sikkim Study Series, 2004).

### **Cultivation of Seasonal Vegetables**

Cost of production of vegetables in the hilly areas per unit is higher than that of the plains due to low production, wild plant problem, manual means of operation and other climatic factors which play a very important role to determine the fostering of vegetables. As a result, the hill farmers cannot compete with the farmers of the plains in the vegetable market. Therefore, the reason of Kharif and Rabi seasonal vegetable production is the only way to meet both family demand and the local market.

The vegetable growers of the state cannot compete with the outside market in seasonal Kharif and Rabi vegetables. The basic aim of seasonal Kharif and Rabi vegetable production should be to meet the deficit supply of vegetables in the state.

About half of the vegetable requirement of the state is being met from the sources based outside the state. As per the speculative data published in the Sikkim Bihari Jagran Manch post of 7th April, 2018 Sikkim has an eating population of approximately 10.0 Lakhs including tourist and labourers. Sikkim is hypothetically producing 24,710.0 tons of vegetable and consuming 1, 09,500.0 tons of vegetables, thus there is a shortfall of 84,790.0 tons.

### **Cultivation of Off-Season Vegetables**

Most of the vegetables produced in the state are off-season vegetables. Production of vegetables at times other than the normal season is known as off-season vegetables. A wide range of agro-climatic condition of Sikkim with elevation ranges from 270m to 4000m, temperature range of 0°C to 10°C (December to January) to 15°C to 30°C (June to September), well distributed annual rainfall (May to September) 82mm to 3493mm, relative humidity of 70% and above most of the time and sunshine hours of 0.05 to 3.87 hours/day (summer) to 4 to 7 hours/ day (October), provide ample scope for cultivation of various types of local and exotic vegetables all-round the year both for inside and outside markets (Subba, 1998). The most commonly and commercially cultivated off-season vegetables in the state are as follows:

- a. Solanaceous: Summer potato, Summer tomato, capsicum, Akbarey chili (Dale Khursani), tree tomato, green Chili,
- b. Cole Crops: Off-Season cabbage, cauliflower, broccoli, Brussels sprouts,
- c. Roots and Bulbs: Radish, carrot, turnip, beetroot,
- d. Legume Crops: Garden pea, French beans
- e. Cucurbits: Chayote, cucumber, green pumpkin, and
- f. Others: Amaranthus, palak, leafy mustard, leafy onion, leek, bamboo shoots, fern shoots, stinging nettles, mushrooms, buckwheat leaf, etc (Subba, 1998).

Farming of off-season vegetables has its own capacity in the market places as it can compete in both internal and external markets. Himachal Pradesh is a good example in the field of seasonal vegetable production like tomato, capsicum, cabbage and cauliflower. At present, there has been growing production of off-season vegetables in Sikkim. Therefore, it may be a viable means to capture the market.

### **Fruit Crops**

In Sikkim, a large range of fruit crops are grown in diverse climatic conditions. Climate has a significant role in the selection of the right kind of fruit crops that could be effectively grown in the area. Due to monsoonal rainfall from April to September and humidity higher than 70 percent almost throughout the year, the state has enormous possibilities of cultivating fruit crops. Sometimes, high rainfall and humidity, hailstorms create problems of high intensities.

The important fruits grown in the state are mandarin orange, banana, guava, papaya, mango, peach, plum, pears, apple, avocado etc. The state is also rich in native range of minor or wild fruits. Presently mandarin orange is a significant commercial fruit crop of Sikkim. But the productivity of fruit crops is very low. Fruits are grown in different elevations in Sikkim.

**Table 6: Altitude wise Distribution of Cultivated Fruits Crops**

<b>Altitude in meter</b>	<b>Crops</b>
250-1000	Banana, Mango, Papaya, Guava, Litchi, Sapota, Jackfruit, Limes and Lemons, Mosambi
1000-1500	Mandarin Orange, Pomegranate, Avocado, Guava, Banana, Low Chilling Peach, Plum and Pear, Passion Fruits, Strawberries etc.
1500-2000	Peach, Plum, Pear, Low Chilling Apple, Kiwi Fruits, Passion Fruits, Walnut etc.
2000-4000	Apple, Apricot, Plum, Peanut, Walnut, Almond etc.

The above table depicts distribution of cultivated fruit crops according to altitude ranging between 250 to 4000 m. In the bottom up to 1000 m, tropical fruits like banana, mango, papaya, guava, litchi, sapota, jackfruit, limes and mosambi are cultivated. Between 1000 -1500 m of altitude, varieties of sub-tropical fruits such as, mandarin orange, pomegranate, avocado, guava, banana, low chilling peach, plum and pear, passion fruit and strawberries are cultivated. Altitudes between 1500-2000 m are suitable for juicy fruits like peach, plum, pear, low chilling apple, kiwi fruit, passion fruit, walnut etc. In the upper part or top most part ranging between 2000-4000 m, some hard peel (outer coating of fruit) fruits like apple, apricot, plum, peanut, walnut, almond etc. are grown.

According to elevation, different types of crops and fruits found in Sikkim can be classified as follows:

#### **Sub-tropical Zone: Lowlands**

- Elevation: 700 -1500 amsl (ft.)
- Areas: Rangpo, Majitar, Kumrek, Kamling, Singtam, Jorethang, Jitlang, Mamring, Suntaley, Sirwani.
- Cereals and Oilseeds: Rice, Wheat, Soybean, Maize and Mustards.
- Fruit, Vegetables and Floriculture: Mango, Banana, Litchee, Guava, Brinjal, Tomato, Gourds etc.

#### **Temperate Zone Mid Hills**

- Elevation: 1500 to 5000 amsl (ft.)
- Areas: Khamdong, Namthang, Maniram, Sadam, Turuk, Dong, Samatar, Ahoe, Mulukey, Rumtek etc.
- Cereals/Pulses/Oilseeds: Rice, Wheat, Maize, Barley, Baby corn, Sweet corn, Barley, Urd, Millet etc.
- Fruit and Vegetables, Spices, Floriculture: Oranges, Kiwi, Guava, Banana, Passion fruits, Tomato, Chayote, Potato, Ginger/Turmeric etc.

#### **Temperate Zone High Hills**

- Elevation: 5000 ft. to 8500 amsl (ft.)
- Areas: Kabi, Okhrey, Chungthang, Pakyong, Chujachen, Lamaten, Geyzing, Sombaria, Naga, Shipgyar etc.
- Cereals/Pulses/Oilseeds: Rice, Wheat, Maize, Millet, Barley, Rajmah, Beans, Mustard, Soybean etc.
- Fruit and Vegetables: Peach, Plum, Avocado, Tree Tomato, Leafy Vegetables, Seed Potato, Cabbage, Spices, Large Cardamom, Floriculture etc.

#### **Alpine**

- Elevation: 9000 ft to 16000 amsl (ft.)
- Areas: Lachung, Lachen, Hilley, Barsey, Nathang, Tsangu.
- Crops: Cabbage, Apple (till 9000 ft.) (nsfm.gov.in).

The crops cultivated during kharif seasons are maize, rice and millet, while the Rabi crops include wheat, barley, mustard etc. Due to diverse levels of altitude and micro-climatic aspects, the two cropping seasons often overlap. The crops, for instance buckwheat, pre-kharif paddy etc. grown between March and June in the paddy fields of mid- and lower elevation, correspondingly may be categorized as zaid or pre-kharif crops.

In Sikkim, these two seasons are not distinct and overlap each other due to the following factors:

- a. A very wide range of elevation (300 to 1700 meters)
- b. A generally low temperature with occasional fluctuation at the time of precipitation (0° to 27°)
- c. High rate of rainfall and occasional precipitation even during Rabi season.
- d. Occasional hailstorm in March-April at higher elevations.
- e. Occasionally a longer duration dry spell in January-February.
- f. Longer duration of crops.

As a result of these factors Kharif sowing starts in February and harvested by December, while Rabi sowing starts in October and harvested by May depending upon the elevation and other local cropping system of various places of the state (Subba, 1984).

### **Existing Cropping Patterns during Kharif Season**

The main crops during kharif seasons of Sikkim are maize, rice, finger millet, ginger and seed potato.

#### **Maize Based Cropping Patterns**

Maize is the chief cereal crop grown in Sikkim and it is one of the substitute foods of rural group. This is grown even in dry and sloping lands that are not appropriate for the cultivation of rice. It is cultivated in an area of 38,955 hectares, which constitutes the largest area according to progress report 2015-16 of Sikkim. Maize is cultivated in the land ranging from altitude of 300 to 2400 metres above mean sea level. In Sikkim, this crop is cultivated in all four districts, but among them South district covers the largest area (14,000 ha) followed by other districts like West (13,210 ha), East (8,991 ha) and North district (2,754 ha) respectively.

About 12 (twelve) cropping patterns have been identified in the state (Subba, 1984). The maize at the base of irrigated field or dry fields of all places of the state, irrespective of altitude, rainfall and climatic disparity, maize is the base crop. Finger millet, pulses, potato, ginger and vegetables in kharif and wheat, barley, mustard, potato, rabi maize and vegetables in rabi, and wheat in zaid are the main substitute crops of this cropping patterns.

The four districts of Sikkim have alternative crops: in East district the crops are vegetables, barley, mustard, buckwheat, millet, ginger and pulses, while in the West district millet, pulses, vegetable, potato, ginger, wheat, barley, mustard and buckwheat. In the North district the crops are vegetables, potato, wheat, barley, buckwheat, pulses and mustard and lastly in the South district alternative crop are pulses, ginger, vegetable, wheat, barley, mustard, potato, millet and buckwheat are grown. Generally, potato and ginger are inter-cropped, and millet and pulses are relay-cropped (Subba, 1984).

#### **Rice Based Cropping Patterns**

Rice is the staple food crop in Sikkim. The name of Sikkim 'Denzong' means the 'valley of rice' which signifies the cultivation of rice. However, its cultivation is possible only in the irrigated and terraced lands of Sikkim. It can be grown in the areas, which have altitude ranging from 300 to 1700 metres.

The estimated area under rice cultivations according to progress report (2015-16) of Sikkim is 10,669 hectares and most of Sikkim's rice is produced in the East and the West districts. The East district, with an area of 4,813 hectares under rice cultivation, is the largest producer of the crop in the state. The corresponding area in the West district is 3,016 hectares. The South district has only 1,920 hectares of land under rice cultivation and comes after East and West districts.

About nine (9) rice based cropping patterns have been identified in the state (Subba, 1984). The substitute crops in this cropping pattern are maize (between 300 to 900 metres elevation), wheat, buckwheat, mustard, vegetable, potato, pulses on paddy field bunds, fodder and vegetables. But maize and potato are relay cropped in triple cropping at lower altitude especially at Daramdin in West and Majitar in East districts. In East district the significant substitute crops are wheat, mustard, buckwheat, maize and vegetable, while in West district buckwheat, wheat, maize, vegetable, potato, maize fodder and mustard are the main substitutes. In North district, wheat and buckwheat are the only alternatives, but in the South district wheat, mustard, buckwheat, maize and vegetable form the important alternative crops.

#### **Seed Potato Based Cropping Patterns**

In Sikkim, potato is considered as a horticultural crop. The total area under potato cultivation in Sikkim is 3,550 ha (2001). The areas located within 1700m above mean sea level are best suited for the cultivation of seed potato. Seed potato occupies about 65 percent of the total area under potato cultivation. It is an important crop in the West and North districts of Sikkim (Choudhury, 2004). The estimated area under potato has been increased to 188 percent i.e. 10,246 ha (2015-16) as compared to 3,550 ha in 2001. According to the 2015-16 report, West district has 4,401 ha, East has 2,738 ha, South having 2,503 ha and North district has only 604 ha.

Moreover, potato is one of the major cash crops particularly in high attitude area of Sikkim, where potato is grown as seed potato. Potato is grown as kharif potato (i.e. summer potato) which is sown in January-February and harvested in July-August. Likewise, rabi potato (i.e. winter potato) is sown in September-October and harvested during February-March.

Farmers prepare the compost by using collected forest litter and animal bedding along with animal excreta in pits. The compost is applied at the time of seed planting on furrows or pits. Pea is intercropped

giving the space of 4-5 furrows between each row to avoid the shading effect and harvesting of pods is done in May-June for vegetable purpose. In some areas, farmers burn the residues openly on the entire field and then mix with the soil by ploughing. At higher elevation above 2500 m it is mono-cropped and at lower elevation crop sequences of maize-potato, maize-rice-potato, rice-potato, and maize-ricebean-potato are most common (Subba, 2009).

Sikkim has different places where seed potato is considered as base crop, e.g. in Ribdi, Okharey, Bharang, Hattabon, Sepreynagi, Thambong, Buriakhop, Sribadam, Upper Bermiok, Hee Patal, Sankhu, Uttarey and Yoksum in the West and Ravangla in South, Pademchen and Zaluk in the East and Lachung and Lachen in the North district. West district covers the maximum area under potato cultivation. The important alternate crops in this cropping pattern are maize, pea, wheat, cabbage, barley and radish. Pea is cultivated as mixed crop especially in West district. Maize is sown as mixed crop in other areas of the state. About six (6) cropping patterns are selected in seed potato-based cropping pattern in the state

### **Ginger Based Cropping Patterns**

Ginger is considered as one of the cash Crops of Sikkim in the group of spices. The estimated area under ginger cultivation occupies 10,115 ha (2015-16). The main areas of ginger growing are Rhenock, Rongli, Rorathang and Pendam of East district; Chakung, Zoom, Takuthang and Chuchen in the West Sikkim. But in South district, Turuk, Sumbuk, Payong, Tarku, Kalikhola, Namchi and Tokal Bermiok are appropriate places whereas in North district, cultivation of ginger is very rare.

The important substitute crops in this cropping pattern are maize and paddy. Only three cropping patterns has been identified under this cropping pattern i.e. one as pure crop and other mixed crop with maize and the third in rotational cropping with paddy crop.

### **Millet Based Cropping Patterns**

The finger millet crop comes under cereal crop in Sikkim and is cultivated in an area of 2,853 ha (2015-16). It is grown in the marginal lands ranging in elevation between 1300m to 1800m above mean sea level. This is considered as a pure crop and is cultivated during May to August.

Millet based cropping is identifiable only in the case of "Bhadaurey" crop that is a crop transplanted during May and harvested in "Bhadhau" (August). The alternative crops of this cropping pattern are wheat and barley. Three cropping patterns are identifiable under millet based cropping patterns in Sikkim. The land is kept fallow during Rabi Season or alternated with wheat or barley crops (Subba, 1984).

### **Existing Cropping Patterns during Rabi Season**

The important crops grown in rabi season are wheat, barley and buckwheat.

### **Wheat and Barley Based Cropping Patterns**

Wheat and barley are grown in areas above 1400 meters above mean sea level. The area covered by wheat and barley is 7,530 hectares. The agro-climatic factors for the cultivation of these two crops are identical. These two base crops are grown on marginal lands in East, West and North districts. The crops are sown in September and harvested in May. The crops associated with wheat and barley are soybean, pulses and potato. The land is kept fallow from June to August (Choudhury, 2004). As per above information it is found that two crops i.e. wheat and barley are not seen in South district.

### **Buckwheat Based Cropping Pattern**

Buckwheat is cultivated in sloping marginal lands located usually above 1200 meters. The crop is grown as pure crop, sometimes they are alternatively cropped with maize. During kharif season the land is kept as fallow. Among other crops, the oilseeds, especially mustard, rapeseed and soybean are grown quite extensively in Sikkim. The estimated area under various oilseeds is 9990 hectares and together they rank third in the state as far as area under crop is concerned (Choudhury, 2004).

The state is estimated to have about 38,955 ha of area under maize, 10,669 ha under rice, 323 ha under wheat, 5,670 ha under various pulses, 2,853 ha under finger millets, 3,570 ha under buckwheat and 447 ha under barley (2015-16). The area under wheat is most extensive in the East and North Districts, while pulses are grown mostly in the South and West districts. The East district too has considerably large area under pulses (i.e. 760 ha) but the North District has less i.e. 267 ha only. Finger millets and buckwheat are grown in all four districts.

### **Plantation and Other Commercial Crops**

Crops under this group include cardamom, horticultural crops such as orange, apple, other temperate

fruits, guava, banana and tea. All these plants under this category are persistent crops. In general, the areas occupied by horticultural crops are limited as compared to food and other crops. Most of them need explicit environmental conditions and they are either concentrated in some particular area or spread throughout the state. Orange is spread throughout the state ranging from elevation between 800 to 1500 meters. Apple is available at Lachung, Lachen, Yoksum and Hilley area of North and West districts. Tea is confined only at Temi and other fruits are grown in limited area. Large cardamom is cultivated throughout the state, occupying a total area of 17,549 hectares, and constitutes 23.84 percent of the total horticultural crops cultivated area. Out of the total area, North district has 31.39 percent, followed by East district 28.53 percent, West district 20.22 percent and South district 19.86 percent. It is a semi-irrigated crop and requires canopy.

Cropping intensity in the state is closely linked with altitudinal variations. At lower altitudes below (1000m) it is possible to do multiple cropping (pre-kharif, kharif and rabi), but with increasing altitudes, cropping intensity declines. Double cropping (kharif and rabi) can be practiced in mid altitudes (below 2000m) but in high altitude areas (2000m-3000m) only mono-cropping is possible. Due to steep gradient and rugged terrain, agriculture is a very hard and labour-consuming task. Most of the cultivated land is terraced and are unfit for the use of modern machinery. The per unit area in case of food grain is not as remunerative as in the plains (Choudhury, 2004).

The cropping pattern in Dhankheti (paddy field) terrace rice lands are: rice-wheat, rice-mustard, rice-potato, rice-fallow, maize-rice-mustard (below 800m), and maize-rice-fallow at higher hills. Sukhabari (dry land) includes terraced, partially terraced, un-terraced fields and crops are raised under rainfed conditions. The common practice of sowing the crop is by broadcast. Yield is very poor and often crops are harvested leaving 0.5m stalk in the field. The following crop sequences are common in Sikkim depending upon the elevation: maize-fallow, maize-soybean-mustard, maize-finger millet, maize-finger millet-fallow, maize-soybean-mustard, maize-rice bean-fallow, maize-rice bean/urdf/field beans, maize-potato, maize-buckwheat, maize-barley, maize-black gram (urd), maize-vegetables, maize-ginger, maize-cassava, maize-beans (Subba, 2009).

### **Ginger + Maize Cropping System**

Ginger locally called as “Adua” is an important spice/cash crop which is grown in Sikkim since time immemorial. The crop is a good income source for small and marginal farmers and is grown up to an altitude of 1500m above mean sea level. It occupies an area of about 10,115 ha (2015-16) and cultivated extensively for the market as green ginger and it is popular in South district.

Ginger is cultivated in raised beds; field is divided into beds of 60-80 cm and width of 15-20 cm high with a spacing of 30-40 cm between the beds and gentle slope outwards to drain the rain water. The seed rhizomes 40-60 q/ha are planted in pits and covered with organic manure (30-40t/ha) maintaining 30-45 cm distance between rows and 15-20 cm between rhizomes in the last week of February to March. Maize seeds are sown either around the periphery of beds or in the space made for draining the water between two beds. The beds are covered with leaves and twigs of various forest trees, weeds and grasses available around fields, animal breeding and surplus rice straw as the mulch keeps the soil shaded and warm, prevents the weed infestation, minimizes soil erosion and protects the young plants from heavy rain. After decomposition, manure and mulch enrich soil nutrients and meets the nutritional needs of the growing plants. Ginger is harvested twice, first during May/June when only mother rhizomes are harvested. It is known as Mau and is of inferior quality. The second harvesting is done after 7-8 months of planting and is also decided by market demands. Farmers harvest around 150-250 q/ha rhizomes, provided crop is not affected by rhizomes rot diseases (Subba, 2009).

### **Zero-Tillage Cultivation of Cabbage**

In Sikkim, cabbage is an important vegetable and commercially cultivated in almost all the areas. Cabbage can be grown in large range of soils but it is suitable in the cool moist climate areas. The cabbage seedling transplanting time in mid-hills is September-November, in high hills March-April i.e. off-season, and in very high hills February-March i.e. off-season. Farming of cabbage is done at higher hills as off-season vegetable. In the month of April-May growers cut the grasses, weeds and stubbles with sickles on sloping lands and after drying, burn the same on entire field. The cabbage seedlings are raised on separate seedbeds prepared with organic manure. The field preparation is done by simple shallow digging of the field. Seedlings are now planted without any other input. No inter-culture

operation is done. The cabbage is harvested and marketed in the month of June-August (Subba, 2009).

### **Vegetable Fostering**

All categories of vegetable crops like cabbage, cauliflower, broccoli, knolkhol in cole crops; tomato, brinjal, chili, capsicum, tree tomato in solanaceous; pea, beans, cowpea, French bean, in leguminous; radish, carrot turnip in roots, cucumber, pumpkin, bottle gourd, sponge gourd, ridge gourd, snake gourd, bitter gourd, sweet gourd, balsum apple, iskus (chayote) in cucurbitaceous; palak, amaranthus, methi, leafy mustard, celery, coriander, mint in leafy vegetables; onion, garlic, leek in bulbs; potato, sweet potato, cassava, colocasia, dioscorea, ginger, turmeric, in tuber and rhizomatous vegetables and okra are cultivated based on organic manuring in Sikkim. Organic compost is useful in channel or plant basis to get utmost output with minimum loss by erosion.

### **Relay Cropping of Rice bean, Urd bean, French bean, Pea, Tomato and Soybean with Maize**

Both the rice bean and urd bean are grown as relay crops with maize only at lower elevations whereas soybean is usually cultivated in all places. The three vegetables such as peas, tomato and French bean are intercropped in tiny area near the houses for off- season crop. Similarly, rice bean and soybean are intercropped in May-June in the footing of maize field at the time of inter culture. When maize becomes mature, crops are harvested leaving the stalks in the field for maintaining the intercrops, but in case of soybean only half stalk is left.

### **Legume Crops in Rotation**

When the harvesting of maize is over, the rice bean and urd bean are cultivated on rotation basis everywhere in the mid and low hills of Sikkim. Rice bean is a type of legume, which makes the soil superior by adding large amount of leafage and nitrogen fixation compared to other legumes. Urd bean is broadly cultivated after maize crop at lower and mid hills of dry areas of Sikkim for harvesting the remaining moisture in soil.

### **Kothebari (Homestead Gardening)**

Kothebari system includes the house, animal shed, tiny fruit trees, food crops, vegetables and different trees adjoining the house. There exists a large disparity in the combination of aforesaid mechanism from individual house-to-house based on availability of area and existing agro-ecosystems. The compound of trees as well as annual crops allows the continuous use of land around the house round the year. Recycling of nutrients is very important for giving the same input to other lands and farmers have to hold the inputs on head loads to particular distance. These processes not only beautify the landscape milieu but also directly benefit the crops with which they are associated.

A great variation has been witnessed in farmers' approach towards cultivation from the past till the present. In the past, farmers used to follow the traditional way of farming in every sector related to agriculture. In the earlier days, farmers used to depend on natural phenomena like the monsoon and rainfall. They simply used to cultivate their lands with the help of manual mechanism. To fulfill the shortage of labourers, farmers used to practice the 'Parma System' (exchange of agricultural labourers) from one family to other family during the time of cultivation. However, 'Parma System' has slowly disappeared due to decrease in the number of family members, individual involvements in various other vocations, and the onset of compulsory education policies of the government.

In the current scenario, the view towards cultivation has changed and the new concept has emerged. With the advancement of science and technology agricultural equipments also have evolved for the betterment of agriculture. Farmers are aware of the financial implications which could be materialized through agriculture. The Government of Sikkim through the concerned Department has been taking concerted initiatives to explore the possibilities of agricultural perspectives. The farmers are being trained from time to time and also given agricultural aids like green houses, hybridism, roof rainwater harvesting, plastic storage of water (dug pond), power tiller, organic fertilizer etc. as some of the major components in today's advanced agricultural approaches. Farmers are also made aware on the benefits of cash crops and relay cropping. Through these collective means, the approach towards agriculture has been changing and the socio-economic scenarios of the cultivators have also changed to certain extent.

### **Conclusion**

The study of cropping patterns in Sikkim reveals a highly diversified and dynamic agricultural system shaped by complex interactions of altitude, climate, topography, and socio-economic factors. The

variation in agro-climatic conditions across different elevations enables the cultivation of a wide range of crops, from cereals and pulses to high-value horticultural and cash crops. This diversity not only enhances agricultural resilience but also provides opportunities for income generation among farmers. Over time, Sikkim has witnessed a significant transformation from traditional subsistence agriculture to a more market-oriented system characterized by the expansion of cash crops such as ginger, cardamom, and off-season vegetables. This transition reflects the adaptive strategies of farmers in response to changing economic conditions, government policies, and market demands. However, challenges such as uneven rainfall distribution, limited cultivable land, soil erosion, and dependence on external markets continue to affect agricultural productivity and sustainability.

The analysis further highlights the importance of adopting integrated farming systems, including intercropping, multiple cropping, and agri-horti-livestock practices, to optimize resource use and enhance productivity in the fragile hill ecosystem. Additionally, the promotion of off-season vegetable cultivation and horticulture presents a viable pathway for improving food security and rural livelihoods. In conclusion, sustainable agricultural development in Sikkim requires a balanced approach that integrates traditional knowledge with modern agricultural practices, supported by effective policy interventions, improved infrastructure, and climate-resilient strategies. Such efforts will not only strengthen the agricultural economy but also ensure ecological stability in the Himalayan region.

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