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A study on cultivation prospects of millets in Northeast India with special reference to plains and hills

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Abstract
Context: Millets often referred as 'nurticereals' have been listed in the traditional food culture of Indian society long back. Millets also known for its high nutritional value accelerate a huge impact on agricultural economy of the country. References of millets can be seen in Vedic texts showing as "staff of life" during that period. The impact of climatic variation has a substantial impact on the production of these nutri-cereals.
Objective: Northeast India comprising of both hilly and plain areas, with substantial variation in weather pattern, demonstrating a significant difference in its millet's category and also in the agro-climatic suitability for its cultivation. Given the priority on millets the present study explores the suitability of millet varieties location-wise across the Northeastern states in line with the climatic suitability on factors like rainfall, temperature and soil type to recommend a few suitable varieties for commercial cultivation.
Method/Approach: With the objective of analyzing the varietal difference of millets in the hilly and non-hilly areas of Northeast India the study adopts a qualitative research approach using content analysis. The study relies entirely on Secondary data like Journal articles, Government and agricultural reports and research organizations. A thematic content analysis was used to examine the collected literature and make a comparative analysis.
Result: The climate, soil type, rainfall and also the farming pattern have a huge impact on the production of different varieties of millets both in the hilly and non-hilly areas. Even after the adoption of tradition farming methods the production of millets is more in hilly areas compared to the non-hilly areas with their mechanized from of farming methods.
Conclusion: Agro-climatic conditions strongly influence millet production, with hilly areas demonstrating better suitability for diverse millet varieties and higher yields than non-hilly regions.
Significance: The study highlights the importance of location-specific varietal recommendations for millet cultivation in Northeast India. Such insights can help improve productivity, promote sustainable agricultural practices, and support rural livelihoods.

Keywords: Agro-climatic suitability, millets, nurti cereal, nutritional value, varietal diversity

Introduction

Millets as an ancient cereal grain has a flourishing past in the history of India. The historical and cultural significance and nutritional worth of millets could be traced to texts like the Veda, Purana, and Samhita. These grains are characterized by their remarkable ability to excel in detrimental environmental conditions, making them a dependable choice for cultivation. As mentioned in the Kautilya's Arthashastra, millet has been one of the primary crops cultivated during the Mauryan empire, emphasizing the significance in the agricultural framework of the era. Moreover, millets held a prominent place in Ayurveda, describing their health benefits and therapeutic properties (Veerabadhran *et al*., 2023) [17]. Millets, evident at Harappan sites, were among India's earliest cultivated crops. Archaeological data indicate Kashmir as a millet exchange hub in South and Central Asia (3000–2000 BC)(Ankita & Seth, 2025) [1].References to foxtail millet (priyangava), proso millet (aanava) and Barnyard millet (shyaamaka) could be traced to the scripts of Indian Sanskrit Yajurveda's verses indicating the practice of millet consumption, dating to the Indian Bronze Age (1,500BC)(Bhadkariyaa & Khana, n.d.).Millets were traditionally grown as rain-fed crops and were well-suited to the dry climate of the Deccan Plateau in southern India (Tripathi, 201 C.E.) [16]. For centuries, millets were staple foods in various regions, particularly in semi-arid and drought-prone areas due to their resilience and low water requirements (Seetharam *et al*., 1990) [13]. Post independence of India, the Green Revolution in the 1960s further shifted the focus away from millets in favor of high-yielding varieties of rice and wheat. This shift led to a significant reduction in millet cultivation, despite their nutritional superiority and suitability for rain fed agriculture. Later recognizing their importance in ensuring food security and addressing malnutrition, the Government of India took steps to revive millet cultivation. In 2018, millets were reclassified as "nutri-cereals" and were promoted extensively during the National Year of Millets (The Story of Millets, n.d.) and the then Agriculture minister had proposed to the United Nations Food and Agriculture Organization to declare the year 2023 as International year of millets.

Millets are highly nutritional and known for the high anti-oxidant activity. Millets are beneficial in reducing the risk of diabetes and other related diseases due to higher viscosity and water holding capacity. They have high fiber content which aid in relieving constipation and lowers cholesterol. Presence of high amount of lecithin, millets are an excellent cereal in strengthening the nervous system and also easy to digest (Y. Das *et al*., n.d.). Millets are the cheapest source of energy and contain high digestive fibre (15-20%), protein (7-12%), 2-5% of fat (2-5%) along with vitamins and minerals (Chapke, Prabhakar, Prasad, Das &Tonapi, 2018). Millets are a potential antidote to gluten related disorders

more common in North and West India due to consumption of wheat-based products. The coarse grains, pearl millet and sorghum are gluten free and can be used to substitute wheat for such disorders (Shivay, 2021).

Table 1: Proximate Composition and Dietary Fibre of Millets (per 100 g)

Millets and Cereals	Moisture (g)	Protein (g)	Ash (g)	Total Fat (g)	Dietary Fiber (g)			Carbo hydrates (g)	Energy (KJ)
					Total	Insoluble	Soluble		
Bajra (*Pennisetumtyphoideum)*	08.97 ± 0.60	10.96 ± 0.26	1.37 ± 0.17	5.43 ± 0.64	11.49 ± 0.62	9.14 ± 0.58	2.34 ± 0.42	61.78 ± 0.85	1456 ± 18
Sorghum (*Sorghum vulgare)*	09.01 ± 0.77	09.97 ± 0.43	1.39 ± 0.34	1.73±0.31	10.22± 0.49	8.49 ± 0.40	1.73 ± 0.40	67.68 ± 1.03	1398 ± 13
Ragi (*Eleusine coracana)*	10.89 ± 0.61	07.16 ± 0.63	2.04 ± 0.34	1.92 ± 0.14	11.18 ± 1.14	9.51 ± 0.65	1.67 ± 0.55	66.82 ± 0.73	1342 ± 10
Little Millet (*Panicummiliare)*	14.23 ± 0.45	08.92 ± 1.09	1.72 ± 0.27	2.55± 0.13	06.39 ± 0.60	5.45 ± 0.48	2.27 ± 0.52	65.55 ± 1.29	1449 ± 19
Kodo Millet (*Setariaitalica)*	14.23 ± 0.45	08.92 ± 1.09	1.72 ± 0.27	2.55 ± 0.13	06.39 ± 0.60	4.29 ± 0.82	2.11 ± 0.34	66.19 ± 1.19	1388 ± 10
Foxtail Millet *	-	12.30	-	4.30	-	-	-	60.09	331
Barnyard Millet *	-	06.20	-	2.20	-	-	-	65.55	307
Proso Millet *	-	12.50	-	1.10	-	-	-	70.04	341

(**Source:** Indian Food Composition Tables, NIN-2017and *Nutritive value of Indian Foods, NIN-2007) (Longvah *et al*., 2017) [8]

Table 1, illustrates Millets being a staple food with a balanced combination of protein, fiber, carbohydrates, and essential minerals. They have a moderate moisture content, which help in cell expansion and nutrient uptake. The protein content varies though yet is a valuable source of amino acids, including methionine and cysteine. The ash in millets with the rich mineral composition of calcium, phosphorus, magnesium manganese, zinc and iron contribute to overall health of human beings. In terms of protein content, Proso Millet (12.50 g) and Foxtail Millet (12.30 g) have the highest values. On the other hand, Barnyard Millet (6.20 g) and Ragi (7.16 g) have the lowest protein content. Bajra (10.96 g) and Sorghum (9.97 g) also contain a good amount of protein. The fiber content varies significantly, with Bajra (11.49 g) and Ragi (11.18 g) having the highest fiber levels. In contrast, Little Millet and Kodo Millet (6.39 g each) have lower fiber contents. Regarding carbohydrates, Proso Millet (70.04 g) contains the highest amount, making it a high-energy grain. Sorghum (67.68 g), Ragi (66.82 g), and Kodo Millet (66.19 g) also provide significant carbohydrate content. Foxtail Millet (60.09 g) has the lowest carbohydrate value. In fat content, Bajra (5.43 g) and Foxtail Millet (4.30 g) have the highest fat values, while Proso Millet (1.10 g) and Sorghum (1.73 g) contain the least. In terms of energy values, Bajra (1456 KJ) and Little Millet (1449 KJ) offer the highest energy per 100g, making them excellent for endurance and physical activity. Barnyard Millet (307 KJ) and Foxtail Millet (331 KJ) provide the lowest energy values. Proso millet is a rich source of phosphorus, Calcium, Potassium, Sodium, Magnesium and many others along with amino acids. It is low in glycemic acid values when compared with rice wheat and barley and corn (Das *et al*., 2019) [5].

- **Prospects of millets:** The robustness in cultivation of millets is in the resilience to varied and extreme weather conditions of rainfall and temperature (Bandyopadhyay *et al*., 2017) [3]. The suitability makes it adaptable to extreme conditions and thereby cultivable worldwide substantiating the suitability to grow easily given the nutritional worth and cultivation with little fertilizer interventions (Kheya *et al*., 2023; Yadav *et al*., 2024) [7, 18]. Millets are suited for inventoriability and being least prone to damages on storage. The wide variety of millets available makes it more apt for growth across the geographies and affordability across the masses that can cater to SDG2 of UN of achieving zero hunger. The versatility in the composition of the various millets can serve the clarion call of hunger elimination more specific to the third world countries. Devoid of a rigmarole cultivation process and requiring minimal interventions, millets also have large prospects of value-added products to cater to the urban population besides, fulfilling nutritional requirements. Fortification as in salt and popular rice products, millets can be a popularized as a breakfast item and as snacks. Consumption of millets can be instrumental in creating demand for millets and hence necessitate the cultivation of millets on large scale (Yadav *et al*., 2024) [18]. In the context of the deliberation so far, millets can be a suitable crop for cultivation in the North East region of the country.

- **Varieties of Millets across India and their Nutritional Values:** Millet, a grain family of the Poaceae family, varies in color, texture, appearance, grain size and species. These grains are divided into two categories based on grain size: one is large or major millets, the second one is small or minor millets, and the third is pseudo millet (The Millets of India, n.d.). Sorghum Millet, Pearl Millet and Finger Millet are categorized under large or major millets having ability to grow well in semi-arid and arid environment with

diverse nutritional value. Minor millets like Foxtail, Barnyard Millet, Proso Millet, Little Millet, Kodo Millet and Brown top Millet are segregated under the head of Minor Millets. Their reference as "minor" is directed by global production and consumption. These millets are mostly seen in local environmental conditions and they also have high nutritional value. Moreover, The Pseudo Millets such as Buckwheat Millet and Amaranth Millet are marked as gluten free grains. Despite India being the largest producer of millets in the world, there exists a variation in the categories cultivated state-wise. While Rajasthan, Karnataka and Maharashtra top the list of the production of millets in India, there exists ample potential across all other states.

There exist multiple references to Government of India schemes in popularizing and promoting millet production. The National Food Security Mission (NFSM) aims to increase the production of coarse cereals, including millets, through various interventions such as improved seed distribution, demonstrations, and training (National Food Security Mission, 2025). To complement NFSM is the Rashtriya Krishi Vikas Yojana (RKVY) which focuses on increasing the production and productivity of millets and other coarse cereals. This includes promoting improved varieties, providing credit support, and creating awareness among farmers (Rashtriya Krishi Vikas Yojana. Pradhan Mantri Krishi Sinchai Yojana (PMKSY), 2019 is a scheme that aims to improvise water use efficiency and promotes drought-resistant crops, including millets, in rain fed areas. The National Mission for Sustainable Agriculture (NMSA), 2019scheme supports the promotion of millets through various measures, including adopting conservation agriculture practices and integrated farming systems**.** The National Mission on Food Processing (NFPM), 2017supports the food processing industry, including the processing of millets into value-added products. This enhances the marketability of millets and provides income opportunities for farmer. For the well-being of farmers associated with millet cultivation is the *Pradhan Mantri Annadata Aay Sanrakshan Abhiyan* (PM-AASHA), 2019 which ensures a minimum support price (MSP) for millets and other crops, providing farmers with a safety net. Moreover, State Governments of Northeast India have different schemes on millet promotion. As the like, Assam launched "Assam Millets Mission, 2022" for a period of 7 years to increase millet's productivity, to contribute to crop diversification, raising the nutrition quotient and doubling the income of farmers. Arunachal Pradesh launched Millet Cultivation Project, 2020 in Siang District run by Indian Institute of Millet Research (IIMR) in Hyderabad, with the objective to increase millet production in the North Eastern region. Mizoram Government has taken initiatives in the promotion of millets and its cultivation along with rice (paddy). To promote the indigenous crop, Central government accepted the proposal from Nagaland to add Foxtail millet to its state level Price Stabilization (PSF). In Tripura the scheme of cluster demonstration on millets under 'National Food Security Mission – Nutri Cereals' is being implemented for last few years with financial support of Rs. 6,000/- per ha to the farmers for cultivation of millets. Further, Value Chain on Millet is being developed under Mission Organic Value Chain Development for North Eastern Region.

Table 2: Millets in Different states of the Country

Types of Millet	Scientific name	Local Names	Cultivation states
Major Millets			
Sorghum Millet	Sorghum bicolor	Jowar	Maharashtra, Karnataka, Telangana, Andhra Pradesh, Tamil Nadu, Madhya Pradesh
Pearl Millet	Pennisetum Glaucum	Bajra	Rajasthan, Haryana, Gujarat, Maharashtra, Uttar Pradesh, Punjab
Finger Millet	Eleusine coracana	Ragi	Karnataka, Tamil Nadu, AndhraPradesh, Telangana, Kerala
Minor Millets			
Foxtail Millet	Setariaitalica	Kangni/Motki	Tamil Nadu, AndhraPradesh, Karnataka, Odisha, Maharashtra, Madhya Pradesh
Barnyard Millet	Echinochloa Esculenta	Sanwa	Uttar Pradesh, Rajasthan, Madhya Pradesh, Gujarat, Karnataka, Tamil Nadu

(**Source:** WII-EIACP Publication, The Millets of India) (The Millets of India, n.d.)

Millets are cultivated in different parts of country based on their topography. Sorghum, the major millet which is commonly known as "Jowar Millet" are mostly cultivated in the areas like Maharashtra, Karnataka, Telengana, Andhra Pradesh, Tamil Nadu and Madhya Pradesh. The Pearl millet is seen in the states of Rajasthan, Haryana, Gujarat, Maharashtra, Uttar Pradesh and Punjab. While Finger millet famous as "Ragi" is cultivated in the areas of Karnataka, Tamil Nadu, Andhra Pradesh, Telengana, and Kerala. In the minor section, Foxtail millet is farmed in Tamil Nadu, Andhra Pradesh, Karnataka, Odisha, Maharashtra and Madhya Pradesh. While Barnyard millet i.e. Sanwa is mostly cultivated in Uttar Pradesh, Rajasthan, Madhya Pradesh, Gujarat, Karnataka and Tamil Nadu.

Objectives of the study

- To examine the nutritional importance of millets as a sustainable alternative to staple crops like rice and wheat.
- To analyze the suitability of millet cultivation in Northeast India based on its diverse agro-climatic conditions.
- To identify region-specific millet varieties (foxtail, finger, barnyard, and little millet) best suited for the Northeastern states.

Methods

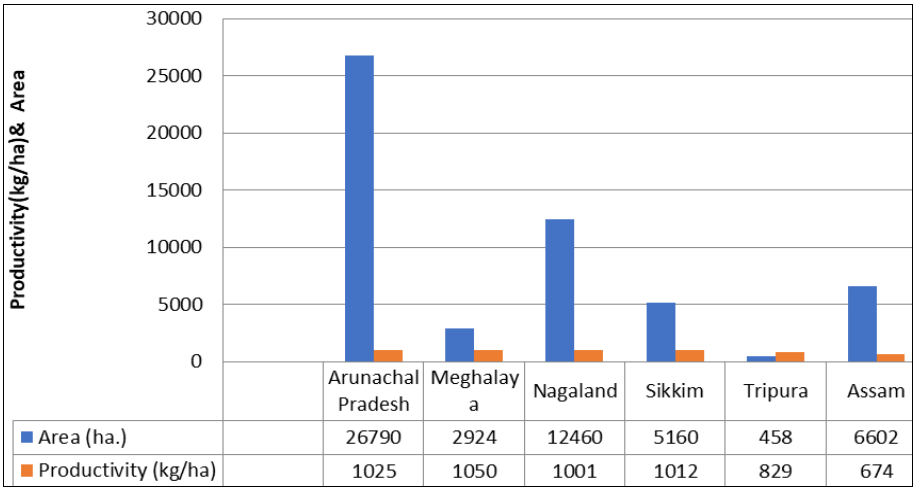
The present study is a descriptive qualitative study conducted in the eight states of North East India to account for the cultivation and production of millets in the context of varieties and availability across the geographies of stated states of India. A secondary exploratory study is conducted to elaborate on the prospects of cultivation. The study aims to establish the geographical association of the millet varieties to the states to further indicate future growth prospects on the varieties for an economic viability. The same is explored in the context of cultural practices and historical references of the varieties of millets geography-wise to establish a possible linkage to proceed with promotion and cultivation of specific varieties for better yield syncing with the natural production cycle. The same is

expected to be win-win for the region and the country in general.

Millets in Northeast India: With the importance of millets in India's agricultural landscape, the northeastern states, particularly Arunachal Pradesh, Assam, Meghalaya, and Nagaland, show adaptation towards millet cultivation with their traditional jhum farming systems. The different agro-climatic conditions of Northeastern states of India also aid towards maintaining heterogeneity in millet cultivation. Based on APEDA 2023 report, there is a diversity in the growth possibility of the millet varieties so far cultivation in NE states is concerned. While foxtail millet is potentially suitable for cultivation in all the states of NE India there exists a little variability in the potential of the other varieties of millets in the backdrop of research. For Arunachal Pradesh, Nagaland, Assam, Tripura and Manipur finger millet is a potential variety. In addition, pearl millet, job tears, sorghum is suitable except in Sikkim. Sikkim is a potentially suitable location for buckwheat millet.

Source: Self report of Researchers (Chaliha P.2025)

Fig 1: Geographical distribution of Millets in the hilly and non-hilly areas of Northeastern India



Source: Area, production and productivity of millets in North Eastern states of India", APEDA, (Aribam *et al*., 2024) [2]

Fig 2: Production area and productivity of millets in tones- State wise

Figure 2 above depicts the millet cultivation in North Eastern States of India, highlighting the area under cultivation and productivity per hectare. Arunachal Pradesh has the largest cultivation area and highest production in 27460 metric ton with the productivity of 1,025 kg per hectare. In contrast, Tripura implying challenges in agricultural output evince lower production area with lower productivity of 674 kg per hectare.

Millet cultivation in Northeast India exhibits significant varietal diversity between the hilly and non-hilly areas, influenced by differences in topography, climate, and traditional agricultural practices.

The hilly areas of the northeastern India which include states like Arunachal Pradesh, Nagaland, Meghalaya, Mizoram, hill districts of Manipur, Sikkim, is characterized with cool, humid and heavy rain fall with distinct microclimatic variations. In contrast, millet cultivation in the plains, such as the plains of Assam, Tripura, the valley regions of Manipur, and the lower parts of Arunachal Pradesh, benefits from a warmer, subtropical climate. The varietal difference of Millets with the agro climatic conditions of the states of hilly and non-hilly areas has been described with the help the following tables 3 through 10.

Table 3: State- Arunachal Pradesh and climate

Millet types with local names	Climate	Temperature range	Average annual rainfall	Soil type
▪ Finger Millet (Mipu Sarsee, Rube Sarsee) ▪ Foxtail Millet (Konidhan) ▪ Little Millet (Kutki) ▪ Proso Millet (Chena) ▪ Kodo Millet (Kodoh)	The low-altitude (<3500 m) ranges have a sticky subtropical climate. High-altitude zones (3,500–5,500 m) have a subtropical climate and snowcapped climate. Arunachal Pradesh gets a normal of 2782 mm of precipitation annually with 70%–80% May and October.	The minimum winter temperature falls below 0°C in winter in the higher altitudes and rises to 35°C during summer months in the plain areas in the eastern districts.	The average rainfall varies from 1,492 mm (in upper Subansiri district) to 4,442 mm (in the lower Dibang Valley). About 64% of rainfall occurs during the monsoon from June to September.	Entisols (35.6 %) Inceptisols (37.3 %) Alfisols (0.3 %) Ultisols (14.2 %) Mollisols (0%)

Source: (NEC Year Book 2024, n.d.) [11]

Table 4: State- Mizoram and climate

Millet types with local names	Climate	Temperature range	Average annual rainfall	Soil type
▪ Sorghum (Faisa or Faibar)	Climate is relatively cooler in summer ranging 20°C to 29 °C & continuously hotter temperatures crossing 30 °C and winter temperatures extending from 7 to 22 °C. The region is affected by heavy rainfall from May to September with small rain within the cold season. The climate design is wet tropical to wet sub-tropical, with normal state precipitation 1881 mm per annum.	The mean winter temperature varies between 21°C and 27°C, while the annual mean temperature is 20°C.	The average annual rainfall in the state is 2,483mm due to the direct influence of monsoon winds from the Bay of Bengal. About 67% of the annual rainfall takes place during the monsoon months (June-September). Most of the districts have similar levels of rainfall, as the driest Chamhai district receives almost 80% of the rainfall of Kolasib, which is the wettest of the state's districts.	Entisols (21.5 %) Inceptisols (37.3 %) Alfisols (2.6 %) Ultisols (0%) Mollisols (38.6 %)

Source:(NEC Year Book 2024, n.d.)

Table 5: State- Sikkim and climate

Millet types with local names	Climate	Temperature range	Average annual rainfall	Soil type
▪ Finger Millet (Kodo) ▪ LittleMillet (Kutki)	Sikkim's climate ranges from sub-tropical to tundra. Most of the districts encounter a calm climate, with temperatures rarely surpassing 28 °C in summer. The normal yearly temperature for most of Sikkim is around 18°C with average normal precipitation of 2739 mm per annum.	The annual temperature ranges from 16.75°C(62.15°F) and a low of 9.41°C (48.94°F)	The mean rainfall is 2,548 mm approx. 64% falling in the monsoon months of June to September. July is the wettest month with an average rainfall of 476mm (about 19% of the annual rainfall). The variation of rainfall amongst the districts is not very marked in Sikkim, as the rainfall of the driest East Sikkim being about 75% of the wettest South Sikkim district.	Entisols (43 %) Inceptisols (33 %) Alfisols (0 %) Ultisols (0%) Mollisols (23.6 %)

Source: (NEC Year Book 2024, n.d.) [11]

Table 6: State- Nagaland and climate

Millet types with local names	Climate	Temperature range	Average annual rainfall	Soil type
▪ Finger Millet (MipuSarsee, Rube Sarsee) ▪ Foxtail Millet (Konidhan) ▪ Little Millet (Kutki) ▪ Proso Millet (Chena) ▪ Kodo Millet (Kodoh)	The state incorporates to a great extent storm climate with tall stickiness levels. Annual average precipitation is around 1881 mm, concentrated in the months of May to September. Temperatures vary from 21 to 40 °C. Winter temperatures rarely drop below 4 °C yetsnowfalls at high altitudes. Summer is brief. Temperature in summer varies between 16 and 31 °C. Winter normally arrives early, with cold and dry climate.	The temperature varies 0°C in winter to 40°C in summer.	The state has comparatively lower rainfall with average of 1,664.6mm. Over 67% of the state's rainfall occurs during the monsoon period (June-September).	Entisols (4 %) Inceptisols (76 %) Alfisols (4.8 %) Ultisols (17.2%) Mollisols (0 %)

Source: (NEC Year Book 2024, n.d.) [11]

Table 7: State- Meghalaya and climate

Millet types with local names	Climate	Temperature range	Average annual rainfall	Soil type
▪ Finger Millet (Ragi) ▪ Foxtail Millet (Kangni) ▪ Little Millet (Kutki) ▪ Proso Millet (Chena or Barri) ▪ Kodo Millet (Kodrah) ▪ Barnyard millet (Sawa) ▪ Pearl Millet (Bajra)	The western portion has low temperatures for most of the year. The most extreme temperature once in a while goes past 28 °C, while sub-zero winter temperatures are common.	The mean summer temperature of the state is 26°C, while the mean winter temperature is just 9°C.	The climate of Meghalaya is per-humid with average rainfall between 2,000 and 4,000 mm, with the state's average being 3,784 mm. Over 70% of the annual rainfall takes place during the monsoon months of June to September.	Entisols (10.7 %) Inceptisols (45.7%) Alfisols (3.6 %) Ultisols (40%) Mollisols (0 %)

Source: (NEC Year Book 2024, n.d.) [11]

Table 8: State- Assam (Non-Hilly) and climate

Millet names with local names	Climate	Temperature range	Average annual rainfall	Soil type
▪ Finger Millet (Ragi) ▪ Foxtail Millet (Kakum) ▪ Little Millet (Kutki) ▪ Pearl Millet (Bajra)	With the tropical storm climate, Assam is mild (summer max. at 35–38 °C and winter min. at 6–8 °C) and encounters overwhelming precipitation and tall mugginess. The climate is characterized by overwhelming rainstorm storms with a 2818 mm precipitation lessening summer temperatures and influencing foggy evenings and misty mornings in winters. Assam's horticulture ordinarily depends on the south-west storm downpours.	The annual high temperature is 30.16°C(86.29°F) and annual low temperature is 19.68°C (64.42°F)	less rainfall is received during the pre-monsoon period (April and May) and the post-monsoon period (after September). The average annual rainfall is 2,135 mm and average annual	Entisols (34 %) Inceptisols (41%) Alfisols (11 %) Ultisols (4%) Mollisols (0

	Singh, R. L. (1993), *India, A Regional Geography*, Varanasi, India: National Geographical Society of India		temperature is about 24°C.	%)

Source: (NEC Year Book 2024, n.d.) [11]

Table 9: State- Tripura (Non-Hilly) and climate

Millet names with local names	Climate	Temperature range	Average annual rainfall	Soil type
▪ Kodo Millet (Kodon) ▪ Barnyard Millet (Sanwa) ▪ Sorghum Millet (Jowar)	The state incorporates a tropical climate and four primary seasons i.e. winter, pre-monsoon or summer, monsoon, and post-monsoon. The normal yearly precipitation is 1881 mm. Amid winter, temperatures range from 13 to 27 °C, whereas within the summer they drop between 24 and 36 °C.	The mean winter temperature is 16°C in winter, while the summer temperature is 28.2°C.	The average rainfall is about 2,400mm, with over 60% of it falling in the months from June to September.	Entisols (8 %) Inceptisols (80%) Alfisols (50 %) Ultisols (7%) Mollisols (0 %)

Source: (NEC Year Book 2024, n.d.) [11]

Table 10: State- Valley regions of Manipur and climate

Millet names with local name	Climate	Temperature range	Average annual rainfall	Soil type
▪ Finger Millet (Ragi) ▪ Pearl Millet (Bajra) ▪ Foxtail Millet (Kakum) ▪ Little Millet (Kutki)	Manipur is wedged among slopes on all sides. The greatest temperature within the summer months is 32 °C. The coldest month is January, and the hottest is July. The state gets a normal yearly rainfall of 1881 mm.	The summer temperature is around 29°C, which drops to 0-12°C in the winter season.	The western ranges receive from 2,000 to 2,65omm of rainfall on an average.	Entisols (23.1 %) [1] Inceptisols (38.4%) [2] Alfisols (0.2 %) [3] Ultisols (36.4%) [4] Mollisols (0 %) [5]

Source: (NEC Year Book 2024, n.d.) [11]

Analysis of the Study

Tables 3 through 10 have been carefully studied to explore and understand the millet varieties state wise and based on soil types in the Northeastern region. This is to identify and sort for a recommendable variety in general for the entire region both hills and plains. A compilation made in Table 11 below explicates the millet types based on elevation of the regions. As apparent a few varieties of millets do grow and flourish and are robust to sustain variations of temperature, rainfall and hence are cultivable across the region. It is interesting to note that the productivity is higher in the hills than the plains possibly attributable to the mechanization in agricultural methods employed coupled with traditionally successful agricultural practices followed since ages.

Table 11: Comparison of millet varieties in the hilly and plainsof Northeast, India

Aspect	Hills	Plains
Millet Varieties	Major Millet: Finger Millet, Foxtail Millet, Proso Millet, Kodo Millet	Major Millet: Finger Millet, Foxtail Millet, Pearl Millet
	Minor Millet: Barnyard millet, Little millet	Minor Millet: Barnyard millet, Little millet.
Climatic condition with Rainfall	Relatively Cooler, Moderate summers (16°C-28°C) and cold winters (0°C-15°C)	High humidity. Hotter summers (30°C-38°C) and mild winters (6°C-20°C).
	Heavy rainfall (1,800mm-12,000mm)	Heavy monsoon rainfall (1,800mm-2,800mm)
Soil Type	Inceptisols, Ultisols, Entisols, and Alfisols.	Inceptisols and Entisols.
Area	47,334 total area of Millet cultivation (including Arunachal Pradesh, Meghalaya, Nagaland, Sikkim)	7,060 total area of Millet cultivation (including Assam and Tripura)
Production	47,923 metric tonnes in total (including Arunachal Pradesh, Meghalaya, Nagaland, Sikkim)	4,827 metric tonnes in total (including Assam and Tripura)
Productivity	Higher Productivity (above 1,000kg/ha)	Lower Productivity (below 1,000kg/ha)
Farming Methods	Traditional, organic-based, rain-fed farming, terraced fields, and jhum cultivation.	Mechanized farming, a mix of irrigated and rain-fed systems.

Source: Comparison conducted by the Researchers

Results

The major millets like Finger millets, Foxtail millets, Prosco Millets, Kodo millets and in minor category Barnyard millet and little millet are generally seen in the hilly areas of the region. Whereas Finger millet and Pearl millet as the major millets and Barnyard and little millets as minor millets are seen in the plains of the region. The availability of these different varieties of millets in the hilly and plains are basically due to climatic conditions, soil type and water availability. As is evident, the climate in the hilly areas is relatively cooler and with frequent and heavy rainfall (1,800mm-12,000mm). Such regions have moderate summers (16°C-28°C) and cold winters (0°C-15°C). The soil types like Inceptisols, Ulisols, Entisols and Alfisols are seen in the hilly regions. In contrast, in the plains the humidity is high with heavy monsoon rainfall (1,800mm-2,800mm). The summers (30°C-38°C) are hot and winters (6°C-20°C) mild. The soil types where cultivation of millets is evident belong to Inceptisols and Entisols types. Hilly regions show higher productivity (above 1,000kg/ha) compared to plains (below 1,000 kg/ha). The farming methods adopted for the yield of millets are generally

traditional, organic based, rain fed farming, terraced fields and concentrates on jhum cultivation, whereas non-hilly areas focused on mechanized farming, irrigated and rain fed mix. As is evident from Table 11, finger millet, foxtail millet and of major type and Barnyard and Little millet of minor types are grown in both hills and plains with evidences of growing in Assam and Manipur and robust to be cultivated irrespective of rainfall levels, temperature and soil types. Mizoram stands an exception with cultivation of Sorghum only. Inference can be made to the context that inceptisol and entisols are conducive for these varieties. There is a consistency in the millet types in the plains *viz*., finger, pearl, foxtail and little. As per Indian Institute of Millets Research, pearl and barnyard contain high iron contents 15.8 mg and 15.2 mg along with protein of 10.6mg and 11.2 mg per 100 grams which can be a panacea for the region to aid iron and protein deficiencies of the region. Poor protein intake has been established to profoundly impact children, adults and pregnant women (Minocha *et al*., 2017) [9]. Of all the millets grown in the region foxtail millet contains the highest protein content of 12.3 mg per 100 grams. The widespread cultivation of foxtail millet can aid in addressing the protein shortages in the masses when mixed with other grain mix (Minocha *et al*., 2017) [9]. While millet is a prospective crop for attaining nutritional sufficiency, the North East India represents a parallel dimension in the paradigm of the delicacies derived from millets on festivals and special ceremonies as engrained in the culture and traditions. Though pearl millet is a popular grain in west of India, cultivation in northeastern region can add to the national produce total. Bangui, a steamed dish of foxtail millet is traditional to Tripura. Misi pita is traditional resemblance to round golden brown sweet fried cakes made of sorghum flour consumed in Garo Hills of Meghalaya. While millet chicken soup is a delicacy among the Assam Meghalaya bordering region of Meghalaya, foxtail millet is consumed as Suthu Maho Tonya, a porridge popular with the Chakesang tribe of Nagaland and as AwanSokrang a similar savory porridge in Tripura (Mohanty *et al*., 2024) [10]. Besides, a number of local wines are prepared and consumed in the states such as MaduaApong, Rakshi, Themsing from finger millets in Arunachal Pradesh, KodakaJannr in Sikkim and Tongba in Sikkim from pearl millets (Pohtam, 2024) [12]. Nevertheless, engrained in cultural practices millet can be a suitable ingredient for production and branding of locally prepared wines.

Conclusion

Millets, renowned for their exceptional nutritional profile, stand out as a superior dietary choice, promoting both health and sustainability. Their nutritional value is comparable to that of staple crops like rice and wheat. Rich in protein, energy, healthy fats, calcium, dietary fiber, and essential minerals, millets have been an integral part of India's coarse grain agriculture since the Vedic period.

The Northeastern states of India are blessed with its capacity for the production of millets with favorable weather condition and soil type. The study elucidates the suitability of Northeastern India for millet cultivation given the diversity agronomy both hills and plains. The study further rules out the preference to foxtail, finger, barnyard and little varieties as suitable for the region. Improved agronomic practices of higher yield seeds can enhance the production leading to large scale production of millets aiding the national initiatives of the Government in the direction.

Nevertheless, to understand their prospects, an integrated approach involving research and development, marketing strategies, and consumer awareness is of vital importance. Undoubtedly, cultivation of millets can be instrumental in aiding the rural economies of the country. Thus, holding the promise of a healthier diet, production of millets can not only take a decisive step toward achieving nutritional security but also the increase demand of millet-based food products in the global market. Moreover, the resurgence of millets through different government schemes can make a pathway to more equitable and nourishing world.

This study highlights the significance of millets as a nutritious and sustainable food source comparable to staple crops like rice and wheat. By focusing on Northeast India, the study identifies location-specific millet varieties such as foxtail, finger, barnyard, and little millet, which are most suitable for the region's diverse agro-climatic conditions which improve the productivity, promote sustainable agricultural practices, and ensure better crop adaptation. The study also narrates the importance of improved agronomic methods and the use of high-yielding seeds to enhance millet production. Increased cultivation can strengthen rural economies, provide livelihood opportunities for farmers, and contribute to the government's national initiatives for millet promotion.

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19. Entisols are soils that develop in areas with newly deposited parent materials or where erosion and deposition occur faster than soil formation, such as dunes, steep slopes, and floodplains.
20. Inceptisols are found in semiarid to humid environments and show only moderate soil development and weathering. They occur across diverse climatic conditions.
21. Alfisols are soils found in semiarid to moist regions, typically formed under forest or mixed vegetation. They are highly productive and suitable for most crops.
22. Ultisolsare acidic soils found in humid areas, with most nutrients concentrated in the upper layers. They have a relatively low ability to retain added lime and fertilizers
23. Mollisols are fertile soils with a dark surface horizon rich in organic matter. They have a high base content, making them highly productive.
24. Source: https://soilsensor.com/articles/soil-orders-and-taxonomy/