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Spatio-temporal analysis of crop diversification in Manipur: A district-level assessment (2000-2021)

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Abstract
Agricultural diversification is a critical strategy for promoting sustainable land use, ensuring food security, and enhancing rural livelihoods. In the context of Manipur, a predominantly agrarian state with diverse physiographic and climatic conditions crop diversification has emerged as a key indicator of changing agricultural practices. This study investigates the spatio-temporal patterns of crop diversification across the districts of Manipur from 2000-01 to 2020-21 using secondary data. The analysis employs the Gibbs-Martin Crop Diversification Index (CDI) to quantify diversification levels and assess shifts in cropping patterns over time.

Findings reveal a clear trend of increasing diversification at the state level, with the CDI rising from 0.360 in 2000-01 to 0.538 in 2020-21, reflecting a gradual move away from paddy-dominated monoculture towards the inclusion of crops such as maize, pulses, oilseeds, and potatoes. District-level analysis shows significant inter-regional variation: while districts like Chandel (0.722), Ukhrul (0.707), and Senapati (0.699) exhibit high diversification, others such as Imphal West (0.371) and Imphal East (0.399) remain relatively specialized. Tamenglong recorded the highest percentage increase in CDI (+121.03%) over the study period.

This research underscores the importance of targeted policy interventions promoting crop diversification in regions with lower index values. Enhancing irrigation infrastructure, market access, and agricultural extension services is essential to support this transition. The study provides a valuable empirical foundation for planners and policymakers seeking to promote sustainable agriculture and improve rural resilience in Manipur.

Keywords: Crop diversification, sustainable agriculture, Manipur

Introduction
Agriculture remains the foundation of rural livelihoods and is crucial in ensuring food security, economic stability, and sustainable land use in India. In recent decades, crop diversification has emerged as a strategic imperative, particularly in regions heavily dependent on monoculture systems (Guin *et al*., 2023) [2]. Diversifying crop production not only mitigates the risks associated with climate variability and market fluctuations but also enhances soil health and contributes to economic resilience (Jaworski *et al*., 2023) [3]. This study focuses on analyzing spatio-temporal shifts in crop diversification in the state of Manipur, a region where agriculture is integral to both the economy and the socio-cultural fabric (Singh *et al*., 2021) [1]. Manipur, one of the seven northeastern states of India, offers a distinctive agro-ecological setting characterized by its predominantly hilly terrain with concentrated valley regions (Sharma & Roy, 2020) [4]. Covering an area of 22,327 square kilometers roughly 0.7% of India's total land area the state is marked by its diverse topography and climate (Government of Manipur, 2021) [5]. Over 90% of its land comprises hills, while the central valley, which constitutes only 7.41% of the total area, is home to nearly 67% of the state's population and 52% of its agricultural land (Statistical Handbook of Manipur, 2022). This pronounced disparity in land use highlights the critical need to assess agricultural practices within both the ecologically diverse hill and valley regions.

Historically, paddy cultivation has dominated Manipur's cropping pattern, particularly in the valley regions where flat and fertile land is available (Devi *et al*., 2019) [7]. However, over the past two decades (2000-01 to 2020-21), there has been a discernible shift towards diversification with increasing attention to crops such as maize, pulses, oilseeds, and potatoes (Singh & Singh, 2022) [8]. These changes have been largely driven by improvements in irrigation and mechanization, the adoption of high-yielding seed varieties, and evolving market dynamics coupled with supportive government policies (GoI, 2020; ICAR, 2021) [9, 10].

Quantifying these transitions is essential for developing targeted interventions that enhance the sustainability of the state's agricultural practices.

To capture the nuances of this transformation, the present study employs the Gibbs-Martin Crop Diversification Index (GMI), a widely accepted index for measuring crop diversity that accounts for both the number of crops and the evenness of their distribution (Joshi *et al*., 2006) [11]. By applying the index to detailed secondary data collected for the years 2000-01, 2010-11, and 2020-21, the study provides a rigorous, district-wise analysis of the evolving cropping patterns in Manipur. Geographic Information System (GIS) tools and statistical software have been utilized to map and quantify spatial variations across districts, offering insights into areas where diversification is either flourishing or lagging (Kumar *et al*., 2023) [13].

The objectives of this study are threefold

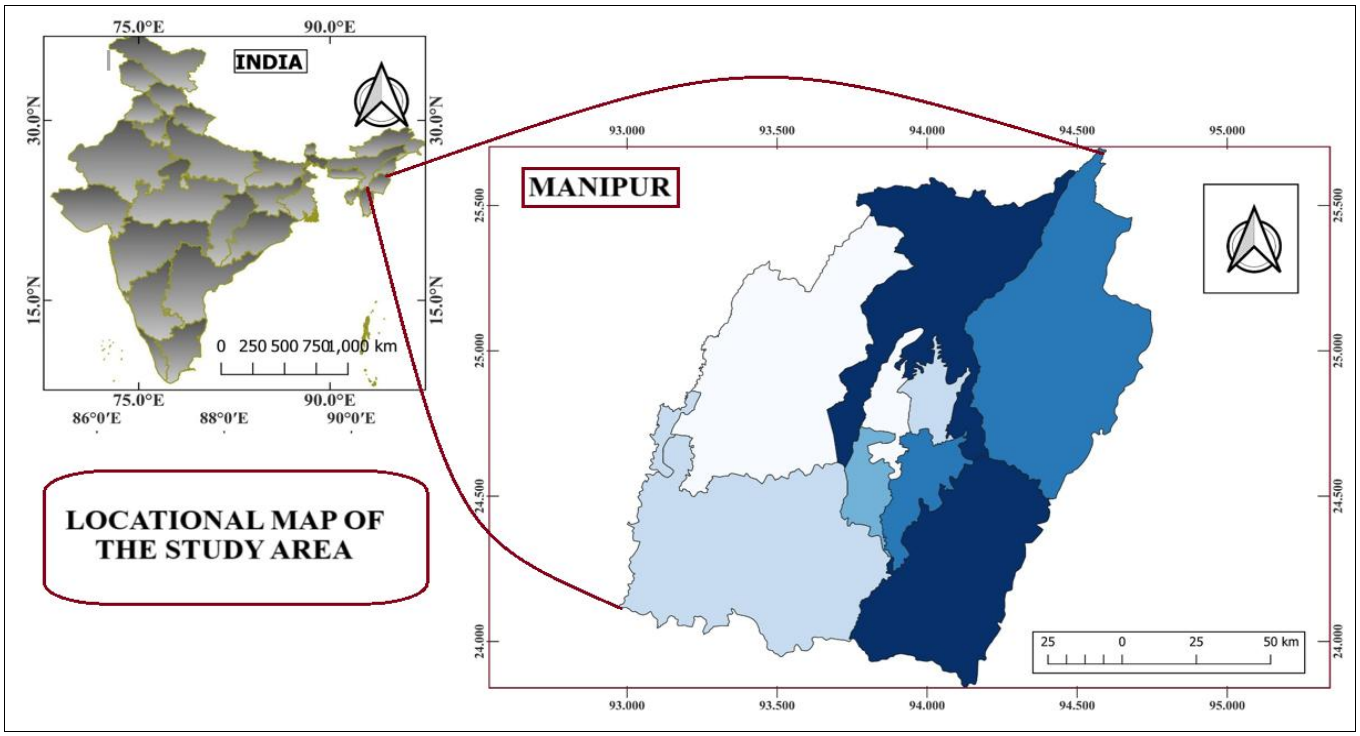
To understand the spatio-temporal changes in crop diversification across Manipur, documenting the extent to which cropping patterns have transitioned from a paddy-centric system to a more diversified agricultural landscape.

To assess the spatial variability of these patterns at the district level, thereby identifying regions with significant diversification and those that remain highly specialized.

To inform policy decisions aimed at promoting sustainable agricultural practices, improve irrigation and infrastructure, and ultimately safeguard the economic and environmental interests of rural communities.

Study Area

One of the seven northeastern states of India, Manipur-dubbed the "jewels of India" by Jawaharlal Nehru nestle deep within a lush green corner between 93°03°E and 94°78°E longitudes and 23°83°N and 25°68°N latitudes, as depicted in the image below. The state's geographic size is 22,327 square kilometres or roughly 0.7% of the nation's total land area. Manipur shares 352 kilometres of the whole international land border with Myanmar. In addition, Nagaland shares borders with Mizoram in the south, Assam in the west, and Nagaland in the north. About 90% of the entire land area is made up of hills on practically all sides at an elevation above 790 metres, with the remaining 10% situated in the centre of the state, which is comparable to a football stadium. The state's agricultural land makes up only 7.41 percent of its overall land area. Fifty-two percent of the entire agricultural area is located within the valley. As a result, agriculture occupies half of the valley's entire land, which is home to 67% of its inhabitants.



The state has a mild climate, with geography playing a major role in determining experiences that range from subtropical to sub-temperate. The mountain ranges block cyclonic storms from the Bay of Bengal and keep chilly winds from the north from reaching the valley. While summer temperatures might reach up to 32 degrees, winter temperatures are still frigid. The average rainfall is 1500 mm, with variations ranging from 1000 mm to 3500 mm. With its tributaries, the Irang, Maku, and Tuivai, the Barak River is the biggest river in Manipur.

The Manipur, Imphal, Iril, Nambul, Sekmai, Chakpi, Thoubal, and Khuga are the other significant rivers in the Manipur River basins. The state's primary soil types are alluvial soils in the valley areas and mountain soils in the high areas.

According to the 2011 census, there are 27,21,756 people living in the state, with a density of 103 people per square kilometre. Of them, about 70.79 percent live in rural areas and are mostly dependent on agriculture. The primary industry of Manipur, accounting for a significant portion of the state's GDP and employing about 22.13 percent of all workers, is agriculture.

Materials and Methods

The study employs a quantitative analytical framework to investigate the spatio-temporal dynamics of crop

diversification in Manipur over the periods 2000-01, 2010-11, and 2020-21 by integrating secondary data analysis with spatial mapping and statistical computation for a comprehensive district-wise assessment of changing cropping patterns (Singh & Singh, 2022; Kumar *et al*., 2023) [8, 13]. Secondary data were obtained from the Directorate of Economics & Statistics and the Department of Agriculture, Government of Manipur, focusing on three discrete intervals that offer a longitudinal perspective on diversification trends (Government of Manipur, 2021) [5]. The data include the area (in thousand hectares) and percentage share under major crops paddy, maize, wheat, pulses, oilseeds, sugarcane, and potatoes and the gross cropped area, representing the total cultivated area during each period (Statistical Handbook of Manipur, 2022). Manipur, located in Northeast India, is characterized by a distinct agro-ecological landscape, covering 22,327 square kilometers, with more than 90% hilly terrain and only 7.41% valley land, which supports nearly 67% of the population and comprises 52% of the agricultural area (Sharma & Roy, 2020; ICAR, 2021) [4, 10]. The state also shares an international border with Myanmar and spans subtropical to sub-temperate zones, shaping its cropping patterns and diversification strategies (Devi *et al*., 2019) [7]. To quantify diversification, the study employs the Gibbs-Martin Index (GMI), a recognized measure for analyzing the degree of crop diversification or specialization (Joshi *et al*., 2006) [11]. The index is calculated as:

$$\mathrm{CDI} = 1 - \left(\frac{\sum X^2}{(\sum X)^2} \right)$$

Where;

X = Percentage share of the total cropped area occupied by each individual crop.

This index is adept at capturing both the number of crop types and the evenness of their distribution, thus providing a robust measure of diversification that facilitates comparability across different regions and scales regardless of the absolute values of cropped area. The analytical procedure involves consolidating and validating the raw data for consistency, with percentage shares calculated to standardize the analysis for effective comparisons between districts and time intervals. The Gibbs-Martin Index is computed for each district to quantify crop diversification, and comparative analysis is performed to detect shifts in cropping patterns over the three decades, with percentage changes in GMI values calculated to assess diversification evolution at both state and district levels. Spatial analysis is carried out using Geographic Information System (GIS) tools, particularly ArcGIS, to visualize the spatial distribution of the Gibbs-Martin Index across districts and generate maps that highlight regions with high and low diversification, thereby providing insights into spatial trends in agricultural practices. Microsoft Office Excel is used for data tabulation, preliminary calculations, and statistical analyses, while ArcGIS supports the mapping of district-level variations and spatial analysis of cropping patterns. It is acknowledged that, as the study relies on secondary data, any discrepancies or limitations in the original data collection by the Government of Manipur may affect the outcomes. Additionally, the use of discrete time intervals provides snapshots rather than a continuous record of trends, and while the study focuses on major crops central to Manipur's agrarian economy, emerging trends in minor crops may not be fully captured. Nonetheless, this methodical approach highlights the temporal shifts in cropping patterns and offers a spatial framework for identifying regional disparities, thereby informing future policies and agricultural practices aimed at enhancing crop diversification and promoting sustainable land use in Manipur.

Results and Discussions

Spatial and temporal change in cropping pattern of Manipur

Table 1 displays the share of land under different crops in the state of Manipur from 2000-01 to 2020-21. A close observation shows there has been a shift in cropping pattern during the study period, showing the temporal change in cropping pattern in the state**.**

Table 1: Change in cropping pattern of Manipur from 2000-01 to 2020-21

Name of crops	2000-01		2010-11		2020-21	
	Area	Percentage	Area	Percentage	Area	Percentage
Paddy	212.4	74.27	212.68	67.00	225.77	65.84
Maize	16.5	5.77	22.32	7.03	25.53	7.44
Wheat	1	0.35	2.1	0.66	2.3	0.67
Pulses	22.18	7.76	26.97	8.50	31.11	9.07
Oilseeds	22.75	7.96	34.5	10.87	37.86	11.04
Sugarcane	3.63	1.27	5.2	1.64	4.94	1.44
Potato	7.52	2.63	13.65	4.30	15.41	4.49
Gross cropped area	285.98	100	317.42	100	342.92	100

***Source*:** Computed by researcher

It is evident that the total gross cropped area increases from 285.98 ('000 hectares) in 2000-01 to 342.92 ('000 hectares) in 2020-21, showing an expansion of gross cropped area in the state in the last two decades. This expansion is likely due to improved irrigation, mechanization, improved variety of seeds, government policies.

During the initial of the study period i.e. 2020-21, paddy cultivation occupied 212.4 ('000 hectares) which is 74.27 percent of total gross cropped area of the state. Of the total gross cropped area, maize pulses and oilseeds accounted for 16.5, 22.18, and 22.75 thousand hectares, contributing 5.77%, 7.76%, and 7.96%, respectively. This demonstrated unequivocally that food crop farming predominated in Manipur. The production of potatoes and sugarcane

accounts for 2.63% and 1.27% of the total. With about 0.35 percent of the state's total gross planted area, wheat is the least grown crop in Manipur.

In 2010-11, the state's gross cultivated area increased to 317.42 ('000 hectares). Although paddy contributes 67% of the total cropped area, there is decrease trend of paddy cultivation with a total area of only 212.68 thousand hectares. The expansion of the land planted to various crops is the cause of the area growth. Twenty-two thousand hectares, or 7.03% of the total gross area, are planted to maize. Oilseeds, pulses, sugarcane, and potatoes all exhibit an upward tendency, taking up 13.65, 5.2, 34.5, and 26.97 thousand hectares, respectively. The smallest area under wheat is 2.1 ('000 hectares), or 0.66% of the total area under crop cultivation.

The state's gross cropped area continues to exhibit an upward trend in 2020-21 with a total of 342.92 thousand hectares. Among the crops, sugarcane and paddy exhibit a declining trend, with respective areas of 4.94 and 225.77 thousand hectares. About 65.84 percent of the land is planted to paddy, and 1.44 percent is planted to sugar. The remaining crops are trending upwards. The area under maize covers 25.53 ('000 hectares), wheat covers 2.3 ('000 hectares), pulses cover 31.11 ('000 hectares), oilseed covers 37.86 ('000 hectares), and potatoes cover 15.41 ('000 hectares), with overall percentages of 7.44%, 0.67%, 9.07%, 11.04%, and 4.49% respectively.

The state's paddy area is steadily declining, according to the spatio-temporal analysis of the state under different crops during the two-decade period 2000-01 to 2020-21. Except for potatoes, which exhibit a fluctuating pattern, the other crops show an increasing trend.

Measures of crop diversification

Table 2: Decadal Crop Diversification Index (CDI)

Year	Paddy (%)	Maize (%)	Wheat (%)	Pulses (%)	Oilseeds (%)	Sugarcane (%)	Potato (%)	CDI
2000-01	74.27	5.77	0.35	7.76	7.96	1.27	2.63	0.4318
2010-11	67.00	7.03	0.66	8.50	10.87	1.64	4.30	0.5250
2020-21	65.84	7.44	0.67	9.07	11.04	1.44	4.49	0.5383

***Source*:** computed by researcher

Over the last two decades, Manipur has witnessed a notable shift in cropping patterns, as reflected by the rise in the Crop Diversification Index (CDI) from 0.4318 in 2000-01 to 0.5383 in 2020-21. Paddy, once accounting for 74.27% of the total cropped area, declined to 65.84%, indicating a gradual but steady departure from mono-cropping. In contrast, crops such as maize increased from 5.77% to 7.44%, pulses from 7.76% to 9.07%, and oilseeds from 7.96% to 11.04%. Notably, potato cultivation surged by approximately 71%, from 2.63% to 4.49%. These transitions signal an adaptive agricultural strategy shaped by market dynamics, improved inputs, and policy support. While paddy still dominates, the increasing CDI values reflect a slow but meaningful transition toward a resilient and economically viable crop mix.

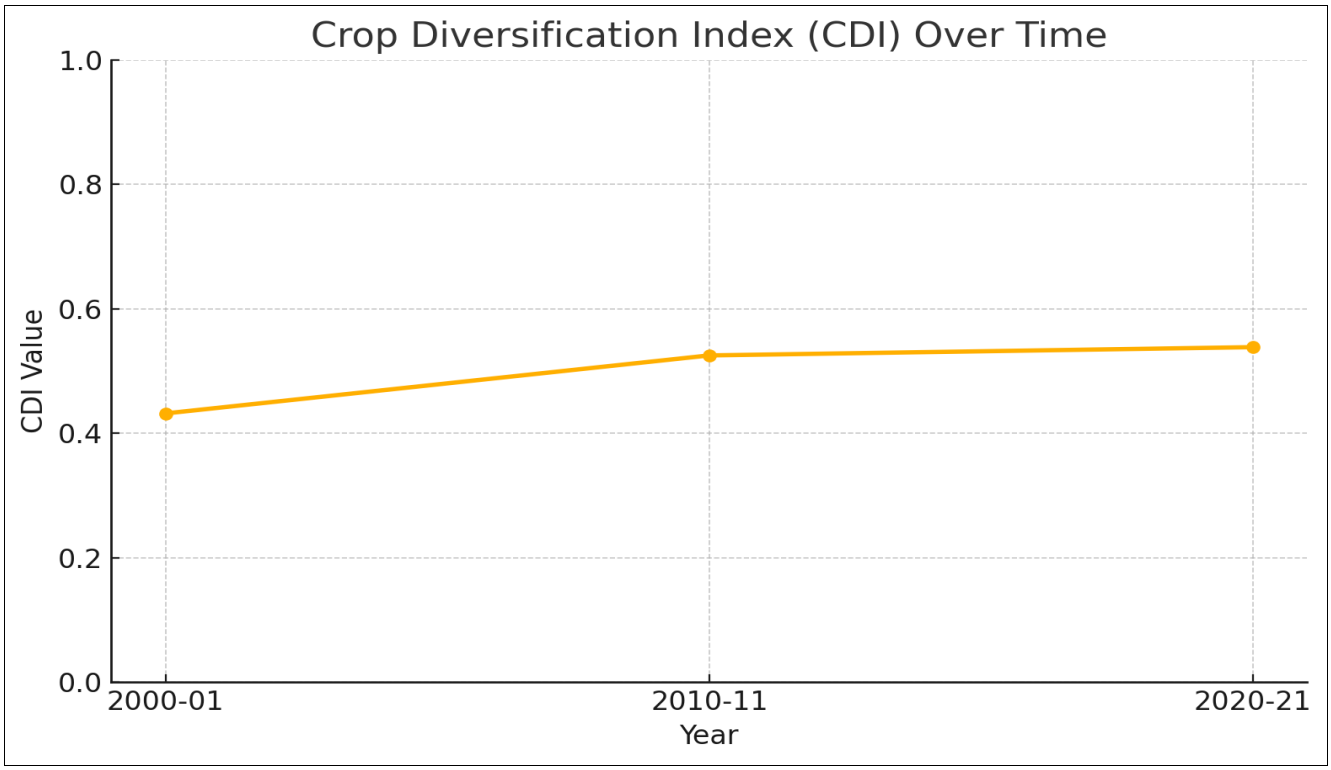
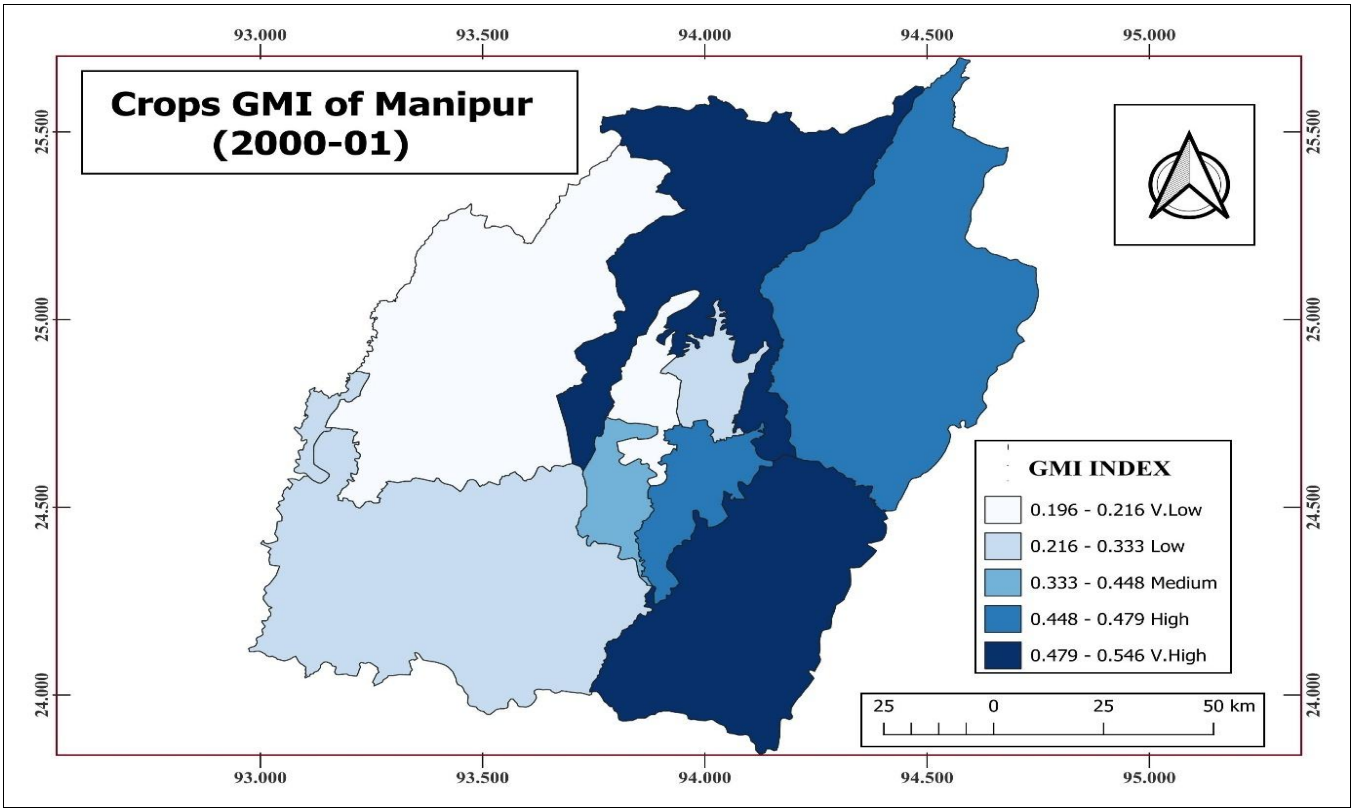


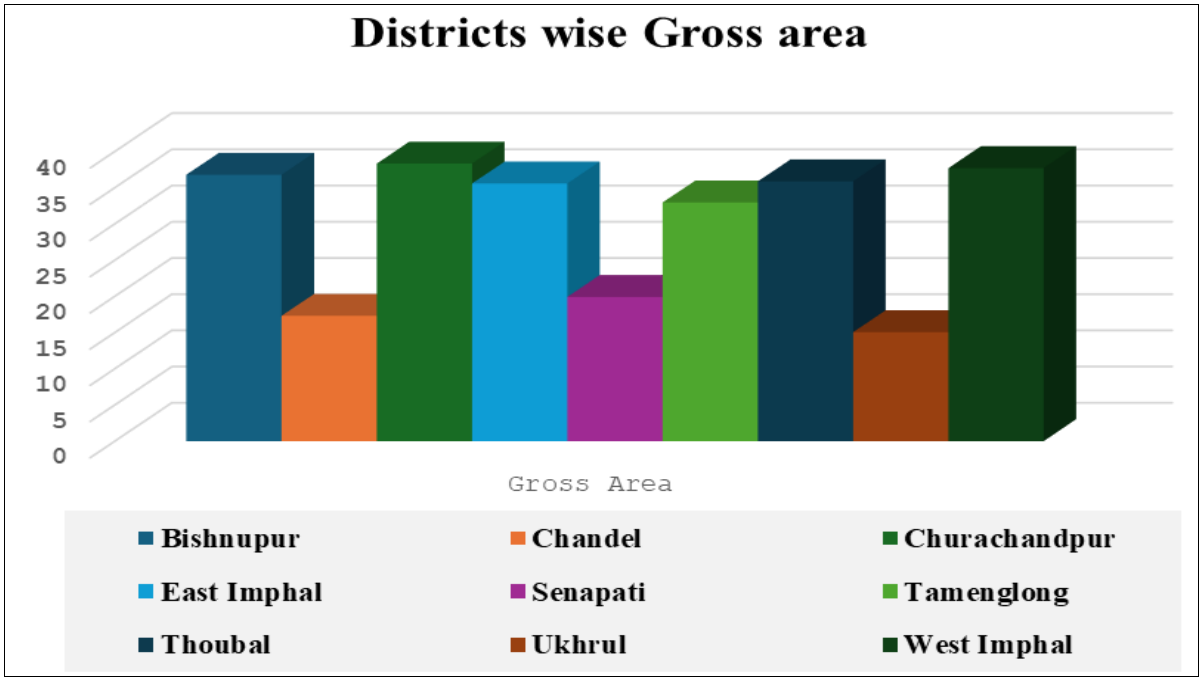
Table 3: District-wise area under different crops GMI of Manipur (2000-01)

Districts	Paddy	Maize	Wheat	Pulses	Oilseed	Sugarcane	Potato	Gross area	GMI
Imphal east	31.4	0.45	0.14	1.65	1.34	0.22	0.83	35.58	0.217
Imphal west	33.74	0.47	0.09	1.7	0.98	0.44	0.75	37.7	0.196
Thoubal	25.66	1.5	0.2	2.81	5.07	0.91	1.22	35.87	0.459
Bishnupur	26.86	0.72	0.16	2.79	4.76	1.07	1.17	36.78	0.442
Chandel	10.89	1.54	0	2.98	2.36	0.7	0.37	17.3	0.546
Churachandpur	31.18	5.19	0.15	2.57	3.77	0.11	0.55	38.33	0.306
Tamenglong	29.01	2.15	0	2.45	0.78	0.06	0.65	32.95	0.214
Senapati	13.06	2.8	0.26	2.39	3.05	0.1	1.06	19.92	0.510
Ukhrul	10.6	1.68	0	2.84	0.64	0.05	0.92	15.05	0.450
State total	212.4	16.5	1	22.18	22.75	3.63	7.52	269.48	0.360

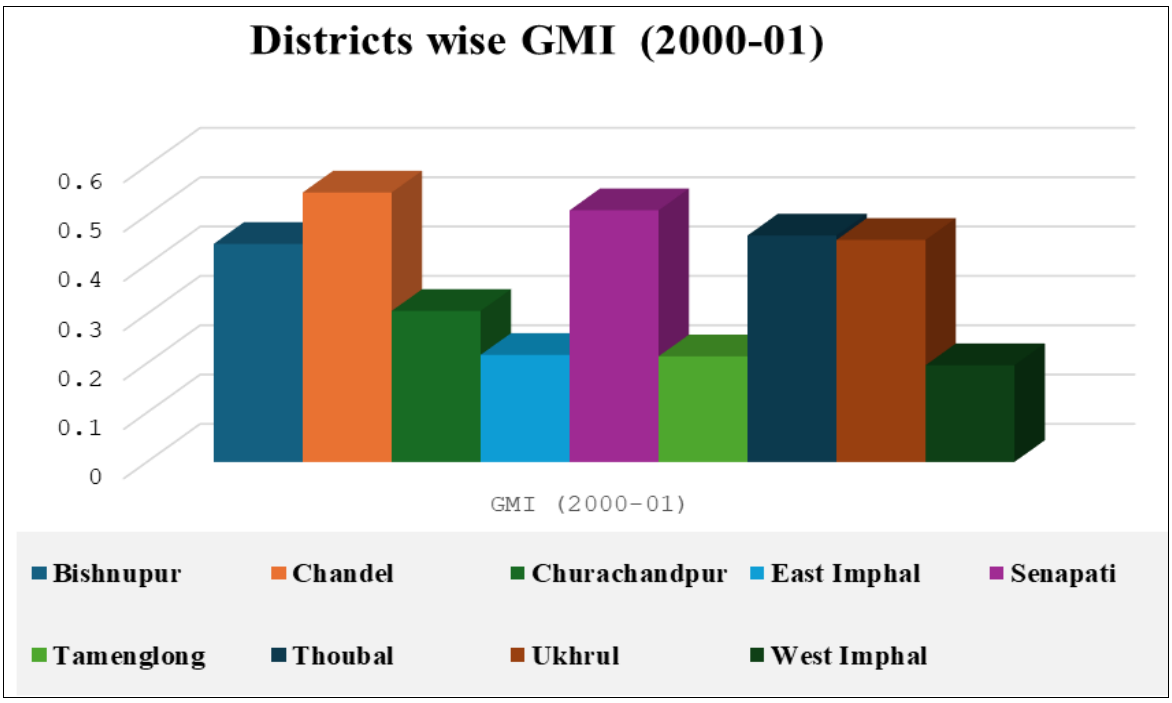
***Source*:** Department of Agriculture, Government of Manipur, and computation of Index values

In 2000-01, paddy dominated cropping patterns across all districts of Manipur, especially in Imphal West (33.74) and Imphal East (31.4). These valley districts showed minimal cultivation of other crops like maize, wheat, and pulses. Chandel district demonstrated better diversification, with notable areas under maize (1.54), pulses (2.98), and oilseeds (2.36). Senapati also exhibited a diverse mix with lower paddy area (13.06) and higher shares of pulses, oilseeds, and potatoes. Thoubal and Bishnupur showed moderately mixed cropping with significant areas under oilseeds (5.07 and 4.76, respectively). Churachandpur had a sizable area under maize (5.19) but remained paddy dominant. Tamenglong was heavily paddy-dependent (29.01) with low diversification. Ukhrul had less paddy (10.6) and meaningful shares of pulses (2.84) and potatoes (0.92). Most hill districts practiced mixed farming, while valley areas focused on rice monoculture. This reflects spatial variation in cropping shaped by geography, infrastructure, and farming practices.





The highest gross cropped area was recorded in Churachandpur with 38.33 thousand hectares, reflecting its agrarian expanse and crop variety. Imphal West (37.7) and Bishnupur (36.78) followed closely, indicating intensive cultivation in the central valley region. Thoubal and Imphal East had similar cropped areas at 35.87 and 35.58 thousand hectares, respectively. These valley districts together contributed a major share of the state's total cropped area. Among hill districts, Tamenglong had a significant gross area of 32.95, despite being less diversified. Senapati and Chandel, with 19.92 and 17.3 thousand hectares, respectively, showed lower total cultivated land but more diversity. Ukhrul had the lowest gross cropped area at 15.05, likely due to terrain and accessibility. The state's total gross cropped area in 2000-01 stood at 269.48 thousand hectares. The data reflect both geographic disparities and infrastructural limitations across districts. Higher cropped areas in valley districts highlight their fertility, irrigation access, and intensive paddy cultivation.



Imphal West (GMI: 0.196) and Imphal East (0.217) recorded the lowest crop diversification, indicating a strong dependence on paddy. Tamenglong also had a low GMI (0.214), suggesting limited variety in cropping despite a large gross area. Churachandpur and Ukhrul showed slightly better diversity with GMI values of 0.306 and 0.450, respectively. Bishnupur (0.442) and Thoubal (0.459) had moderate diversification, aided by oilseeds and pulses. Chandel recorded the highest GMI (0.546), showing a well-balanced cropping structure across several crop types. Senapati followed closely with a GMI of 0.510, reflecting significant diversification despite a smaller cropped area.

These figures highlight a distinct spatial pattern, with hill districts generally more diversified than the valley. The state average GMI was 0.360, indicating an overall moderate level of diversification in 2000-01. The data underline the need for targeted interventions in low-GMI regions like Imphal Valley. This baseline assessment provides a reference point for evaluating decadal changes in crop diversification.

Table 4: District-wise area under different crops GMI of Manipur (2010-11)

Districts	Paddy	Maize	Wheat	Pulse	Oilseed	Sugarcane	Potato	Gross area	GMI
Imphal east	33.34	0.91	0.24	3.04	3.74	0.52	0.93	42.72	0.377
Imphal west	35.75	0.91	0.24	2.97	3.39	0.79	1.04	45.09	0.360
Thoubal	28.26	1.78	0.38	3.72	4.52	1.37	2.13	42.16	0.526
Bishnupur	26.51	1.21	0.27	4.75	6.08	1.66	2.23	42.71	0.577
Chandel	10.03	3.31	0	2.42	2.93	0.21	1.59	20.49	0.694
Churachandpur	29.12	5.13	0.43	2.32	3.09	0.19	1.69	41.97	0.493
Tamenglong	27.45	2.53	0	2.48	3.16	0.16	1.98	37.76	0.453
Senapati	12.1	4.49	0.54	2.29	3.17	0.18	1.09	23.86	0.678
Ukhrul	10.12	2.1	0	2.98	4.42	0.12	0.97	20.71	0.683
State total	212.68	22.37	2.1	26.97	34.5	5.2	13.65	317.47	0.525

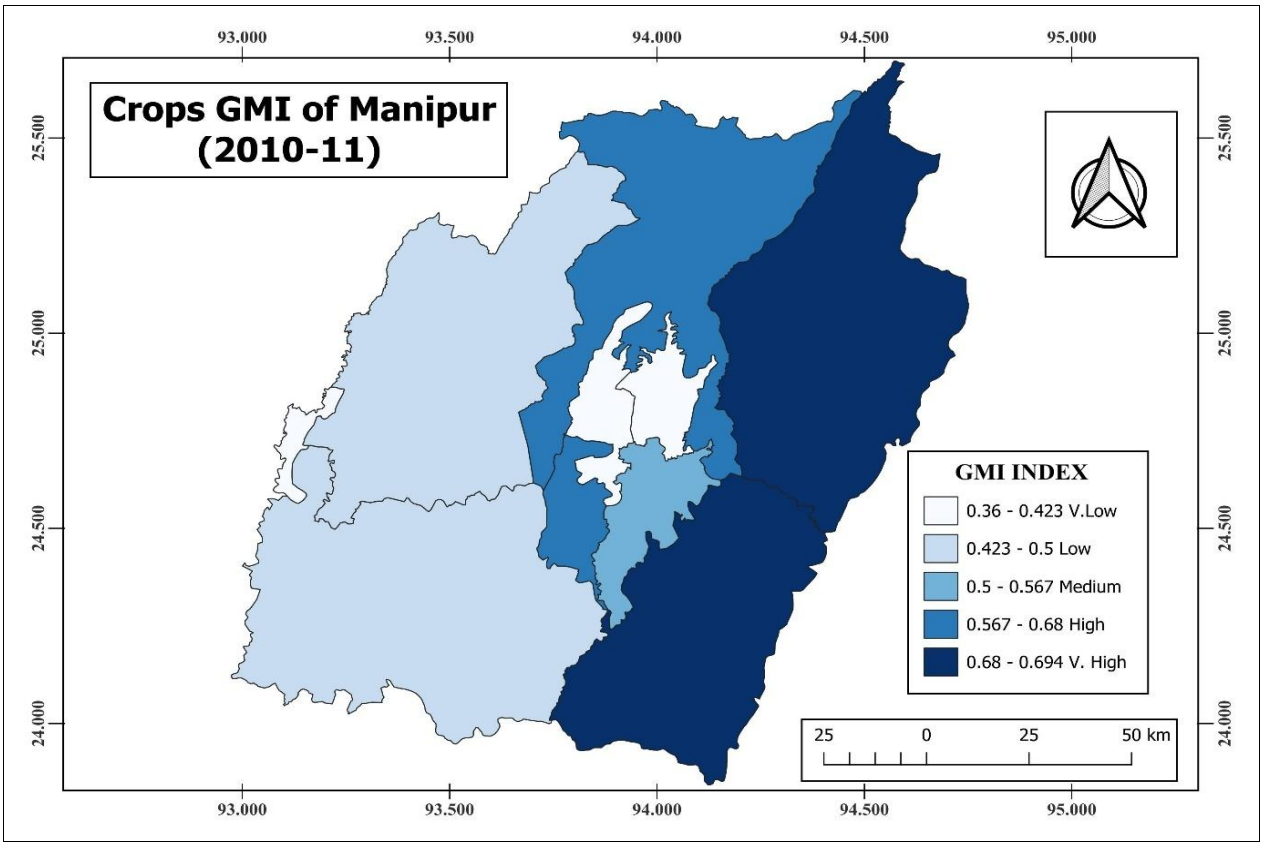
***Source*:** Department of Agriculture, Government of Manipur and computation of index values

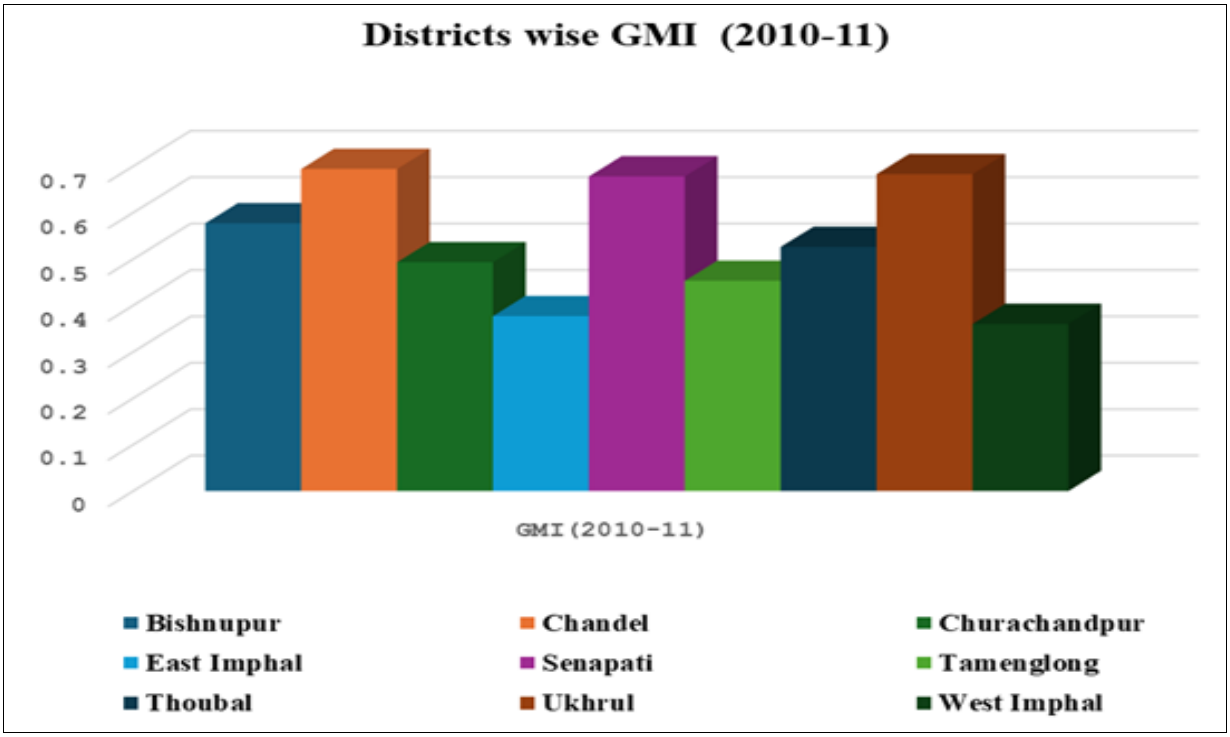
In 2010-11, Imphal West and Imphal East remained predominantly paddy-growing districts, with over 33 thousand hectares each under paddy and limited area under other crops.

Despite modest increases in pulses and oilseeds (around 3-4 thousand hectares), these valley districts showed limited diversification. Thoubal and Bishnupur demonstrated better crop mixes Thoubal with high pulses (3.72), oilseeds (4.52), and potatoes (2.13), and Bishnupur with oilseeds (6.08) and pulses (4.75). Chandel shifted further toward diversification with significant maize (3.31), oilseeds (2.93), and pulses (2.42) along with low paddy (10.03).

Churachandpur had the highest maize cultivation (5.13) among all districts, indicating adaptation to coarse grains. Tamenglong continued to favor paddy (27.45) but diversified moderately with oilseeds (3.16) and potatoes (1.98). Senapati showed strong presence of maize (4.49), pulses (2.29), and oilseeds (3.17), with relatively low paddy area.

Ukhrul cultivated more oilseeds (4.42) and pulses (2.98) than paddy (10.12), suggesting balanced cropping practices. The hill districts overall demonstrated a clear move toward diversification, reducing reliance on paddy. These patterns reflect improved input access, changing crop preferences, and region-specific adaptations.





In 2010-11, the state-level GMI rose to 0.525, indicating a noticeable improvement in overall crop diversification compared to 2000-01. Bishnupur emerged as the most diversified valley district with a GMI of 0.577, driven by a balanced distribution of pulses, oilseeds, and potatoes.

Thoubal also showed strong diversification (GMI: 0.526) due to increased non-paddy cropping. Chandel (0.694) and Ukhrul (0.683) registered the highest GMI values, reflecting substantial diversification in hill regions. Senapati followed closely with a GMI of 0.678, supported by maize, oilseed, and pulse cultivation. Churachandpur (0.493) and Tamenglong (0.453) showed moderate diversification, improving from earlier levels.

Imphal East (0.377) and Imphal West (0.360) remained the least diversified, still dominated by paddy. The data highlights a clear spatial trend: hill districts diversify faster than valley regions. This improvement suggests the impact of policy interventions, enhanced input access, and shifting farmer preferences. Overall, the decade saw a positive transition toward more resilient and diverse cropping systems in Manipur.

Table 5: District-wise area under different crops GMI of Manipur (2020-2021)

Districts	Paddy	Maize	Wheat	Pulse	Oilseed	Sugarcane	Potato	Gross area	GMI
Imphal east	37.61	1.38	0.27	3.77	4.29	0.62	1.21	49.15	0.399
Imphal west	39.83	1.3	0.28	3.74	3.72	0.53	1.31	50.71	0.371
Thoubal	30.15	1.88	0.41	4.44	5.17	1.45	2.4	45.9	0.541
Bishnupur	29.36	1.33	0.3	4.18	6.49	1	2.47	45.13	0.543
Chandel	10.03	3.84	0.02	3.14	3.32	0.3	1.74	22.39	0.722
Churachandpur	29.12	5.87	0.46	2.8	3.33	0.28	1.83	43.69	0.526
Tamenglong	27.45	2.39	0.01	2.92	3.42	0.25	2.11	38.55	0.473
Senapati	12.1	4.81	0.54	2.73	3.49	0.3	1.24	25.21	0.699
Ukhrul	10.12	2.73	0.01	3.39	4.63	0.21	1.1	22.19	0.707
State total	225.77	25.53	2.3	31.11	37.86	4.94	15.41	342.92	0.538

***Source*:** Department of Agriculture, Government of Manipur and computation of Index values

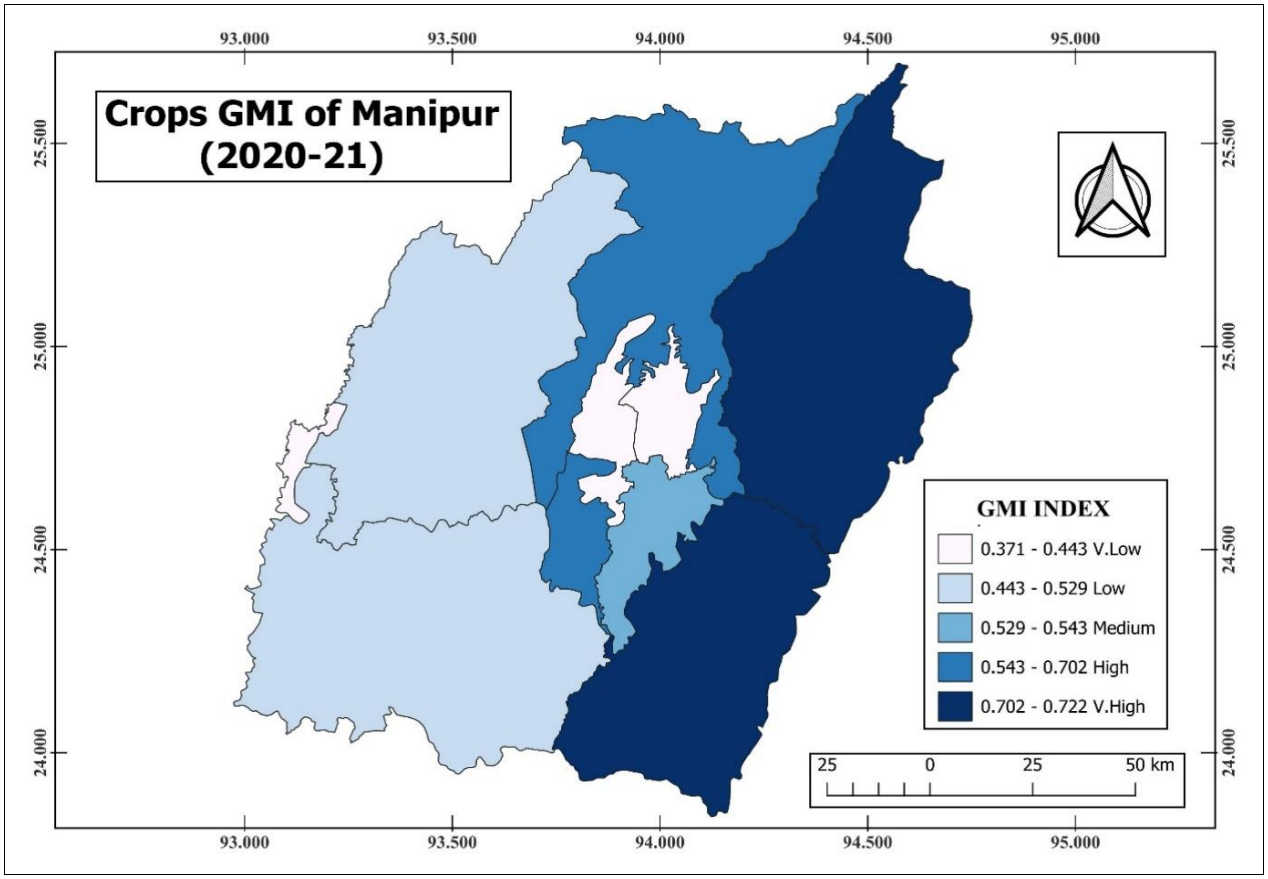
In 2020-21, Imphal West and Imphal East remained the most paddy-reliant districts, with over 39 and 37 thousand hectares, respectively, under paddy cultivation.

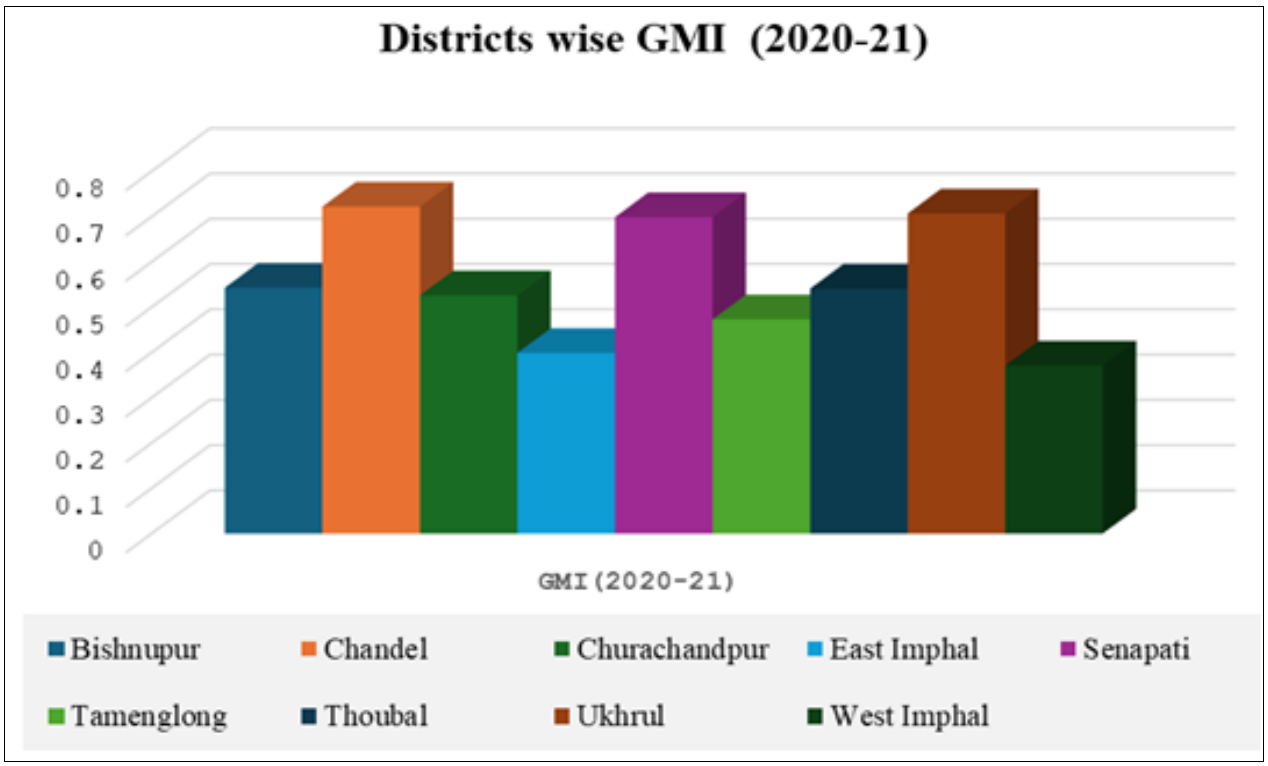
These districts also recorded modest areas under pulses (around 3.7) and oilseeds (about 3.7-4.3), but other crops remained minimal. Thoubal and Bishnupur reflected more balanced cropping, each with significant areas under pulses (4.44 and 4.18) and oilseeds (5.17 and 6.49).

Chandel led in diversification among hill districts, cultivating high levels of maize (3.84), pulses (3.14), and oilseeds (3.32) alongside minimal paddy. Churachandpur had the highest maize cultivation (5.87), indicating a trend toward coarse grains in hill farming.

Tamenglong showed similar cropping to past trends, with high paddy (27.45) and increasing potato (2.11) and pulse cultivation (2.92). Senapati featured a well-balanced cropping mix with maize (4.81), oilseeds (3.49), and pulses (2.73), supporting dietary and economic diversity.

Ukhrul cultivated nearly equal proportions of pulses (3.39) and oilseeds (4.63) relative to its low paddy area (10.12), indicating sustainable diversification. Potato cultivation expanded across all districts, with higher values in Tamenglong (2.11), Bishnupur (2.47), and Churachandpur (1.83). Overall, crop distribution data reveal continued diversification in hill districts, while valley regions show gradual but slower transition from paddy dependency.





In 2020-21, the state-level GMI reached 0.538, indicating continued improvement in crop diversification from previous decades. Chandel (GMI: 0.722) emerged as the most diversified district, reflecting a balanced mix of cereals, pulses, and oilseeds. Ukhrul (0.707) and Senapati (0.699) also showed high diversification, suggesting that hill districts are leading in mixed cropping systems. Churachandpur (0.526) and Tamenglong (0.473) maintained moderate diversification, continuing trends seen in the previous decade. Thoubal (0.541) and Bishnupur (0.543) represented the most diversified among valley districts, benefiting from increased non-paddy crop areas. Imphal East (0.399) and Imphal West (0.371) again recorded the lowest GMI values, signaling persistent crop concentration around paddy. The GMI distribution shows a clear spatial pattern diversification is stronger in hill regions than in the valley.

Districts with higher maize, oilseed, and pulse shares had

consistently higher GMI values.

These trends reflect the positive impact of targeted interventions, input access, and adaptive farming in hill zones. Overall, the decade concluded with an encouraging shift toward resilient, diversified agriculture, particularly outside the central valley.

Districts	Gross Area	GMI (2000-01)	GMI (2010-11)	GMI (2020-21)
Bishnupur	36.78	0.442	0.577	0.543
Chandel	17.3	0.546	0.694	0.722
Churachandpur	38.33	0.306	0.493	0.526
East Imphal	35.58	0.217	0.377	0.399
Senapati	19.92	0.51	0.678	0.699
Tamenglong	32.95	0.214	0.453	0.473
Thoubal	35.87	0.459	0.526	0.541
Ukhrul	15.05	0.45	0.683	0.707
West Imphal	37.7	0.196	0.36	0.371

The GMI values across districts indicate an overall average increase of approximately 0.18 from 2000-01 (mean ≈0.403) to 2020-21 (mean ≈0.547), evidencing a significant upward shift over two decades. Districts like Chandel and Ukhrul exhibited robust growth, with respective increases of 0.176 and 0.257, positioning them as high performing and statistically above the overall mean. In contrast, West Imphal, despite a relative improvement of 0.175, remains at the lower tail of the distribution with a 2020-21 value of only 0.371, highlighting persistent disparities. The standard deviations for each period would likely reflect greater variance in the earlier period that narrows slightly over time as performance improves across more districts. These statistics suggest that focused policy interventions might have contributed to the convergence in GMI values, though significant district-level variations persist.

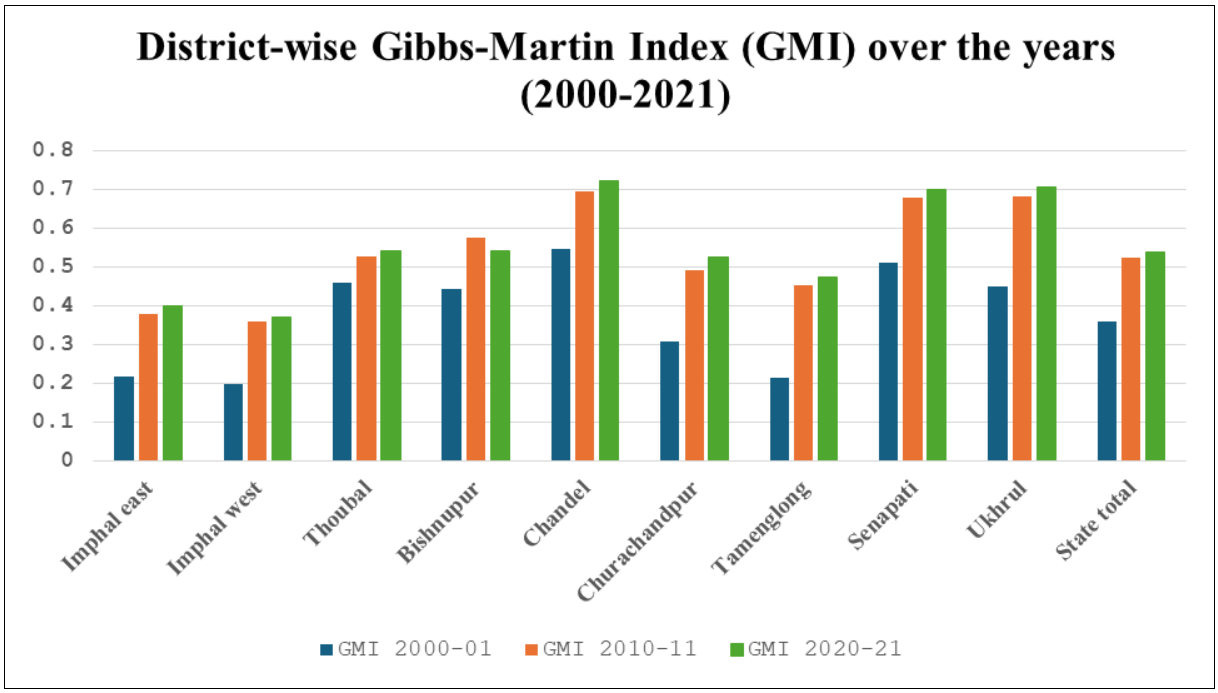


Fig 1: GMI Index, District-wise, Manipur (2000-01, 2010-11 and 2020-21)

Table 6: District-wise variations in the GMI Index in Manipur for the year 2000-01 and 2020-21

Districts	GMI (2000-01)	GMI (2020-21)	Change in magnitude	% change value
Imphal east	0.217	0.399	0.182	83.87
Imphal west	0.196	0.371	0.175	89.87
Thoubal	0.459	0.541	0.082	17.87
Bishnupur	0.442	0.543	0.101	22.85
Chandel	0.546	0.722	0.176	32.24
Churachandpur	0.306	0.526	0.220	71.90
Tamenglong	0.214	0.473	0.259	121.03
Senapati	0.510	0.699	0.189	37.06
Ukhrul	0.450	0.707	0.257	57.11
State total	0.360	0.538	0.178	49.44

***Sources*:** Department of Agriculture, Government of Manipur and computation of Index values

From 2000-01 to 2020-21, all districts in Manipur recorded an increase in GMI, indicating a clear shift toward crop diversification. Chandel maintained the highest GMI across all decades, rising from 0.546 to 0.722, demonstrating

consistent diversification leadership.

Ukhrul and Senapati followed closely, reaching 0.707 and 0.699 in 2020-21, reflecting strong improvements in crop diversity. Churachandpur saw significant growth, with GMI rising from 0.306 to 0.526, indicating a substantial reduction in monocropping. Tamenglong also improved from 0.214 to 0.473, though it remained in the moderately diversified category. Valley districts like Bishnupur, Thoubal, and East Imphal showed steady improvement, with GMI values exceeding 0.5 in 2020-21. West Imphal, despite a slight increase from 0.196 to 0.371, continued to have the lowest diversification among all districts. The highest absolute GMI gain was seen in Ukhrul (+0.257) and Senapati (+0.189), showing remarkable diversification. Valley districts still lag behind hill districts, highlighting geographic disparities in crop variety and adoption of alternate crops. This trend emphasizes the need for targeted diversification strategies in low-performing districts and support for sustaining gains in high-performing areas.

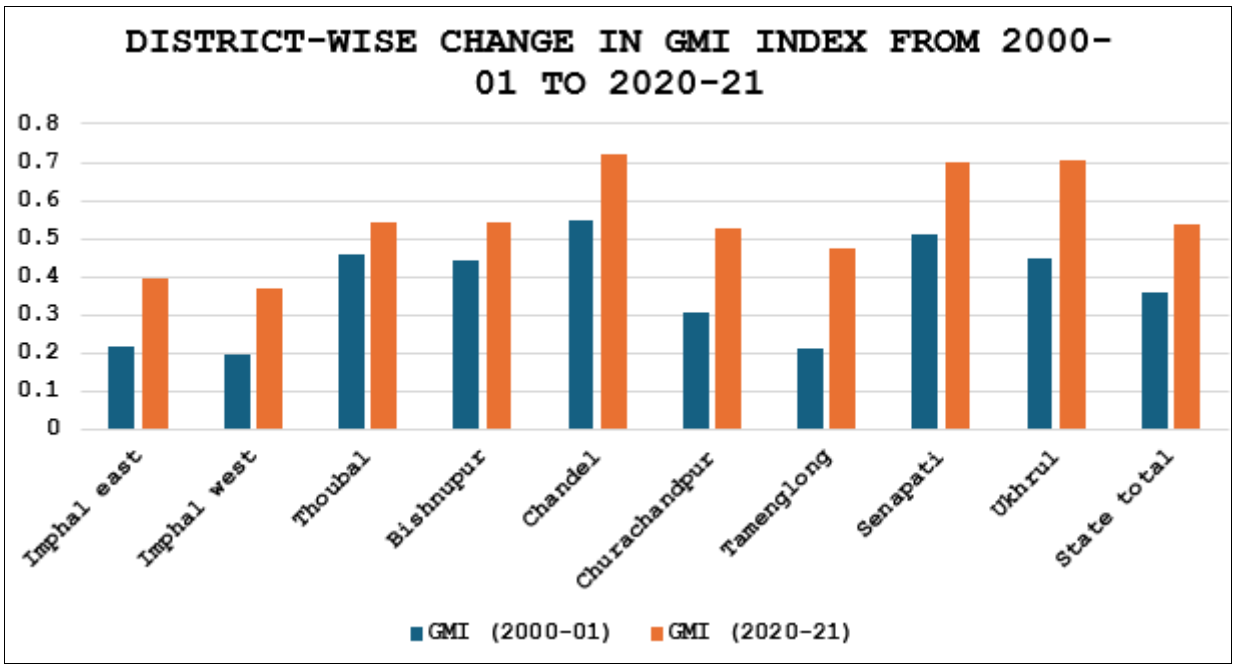


Fig 2: District-wise change in gmi index from 2000-01 TO 2020-21

Concluding Remarks

This study comprehensively analyzed the spatio-temporal changes in crop diversification across the districts of Manipur over a two-decade period (2000-01 to 2020-21) using the Gibbs-Martin Index (GMI). The results reveal a consistent and positive trend toward agricultural diversification at both the state and district levels. The state-level GMI increased from 0.360 in 2000-01 to 0.538 in 2020-21, reflecting a gradual but meaningful transition away from paddy monoculture toward a more balanced and sustainable crop portfolio.

While paddy continues to dominate the cropping pattern, particularly in the valley districts such as Imphal East and Imphal West, there has been a measurable increase in the cultivation of maize, pulses, oilseeds, and potatoes. Hill districts such as Chandel, Ukhrul, and Senapati emerged as the most diversified, registering GMI values above 0.69 in 2020-21, owing to greater reliance on mixed cropping systems. On the other hand, some valley districts still exhibit lower diversification levels, indicating the need for region-specific interventions.

Improvements have influenced the increase in gross cropped area and diversification in irrigation infrastructure, input availability, policy support, and changing market dynamics. Notably, the highest percentage increase in GMI was observed in Tamenglong (+121.03%), highlighting the district's remarkable shift in cropping behavior. Despite the overall progress, regional disparities remain prominent. Therefore, promoting crop diversification in relatively specialized districts through targeted policy initiatives, technological support, market access, and capacity building remains imperative. Strengthening these efforts can contribute to agricultural sustainability, food security, rural livelihood enhancement, and climate resilience in Manipur.

Suggestions

Based on the findings of this study, several actionable suggestions can be proposed to enhance crop diversification in Manipur. Firstly, there is a need to implement region-specific diversification strategies, especially in low-diversification districts such as Imphal East and West, where paddy still dominates. These areas require targeted interventions promoting the adoption of high-value, less water-intensive, and climate-resilient crops. In contrast, hill districts like Chandel, Ukhrul, and Senapati, though already diversified, would benefit further from strengthened irrigation infrastructure, rural road connectivity, storage, and market access, which are often limited due to terrain.

The promotion of improved agricultural inputs and technologies, including high-yielding and stress-tolerant crop varieties, should be prioritized across all districts to support the transition from traditional monocultures to diversified systems. Additionally, establishing strong market linkages and ensuring fair pricing mechanisms, such as minimum support prices (MSP) for pulses, oilseeds, and maize, can incentivize diversification beyond paddy cultivation. Awareness campaigns and agricultural extension services should be expanded to educate farmers

on the benefits of crop rotation, intercropping, and integrated nutrient management (Samanta *et al*. 2024) [12].

Moreover, crop diversification should be integrated into climate adaptation strategies, as diverse cropping systems are inherently more resilient to climatic shocks. The development of local food processing units can further encourage diversification by adding value to surplus produce and generating local employment. Financial incentives, including credit facilities and crop insurance schemes, should be extended to farmers practicing diversified agriculture to reduce production risks and improve income stability.

Finally, the use of spatial tools such as GIS and remote sensing can help in identifying underperforming areas and planning spatially targeted interventions. Continuous monitoring of crop diversification through indices like the Gibbs-Martin Index should be institutionalized for evidence-based policy formulation and evaluation. These measures, if effectively implemented, can lead to more sustainable, economically viable, and climate-resilient agricultural systems in Manipur.

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