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Analyzing spatio-temporal pattern in area of crops under Shivamogga district of Karnataka

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Abstract

Crop diversification is a crucial strategy for building resilient agricultural systems in India. This study analyzes the spatio-temporal patterns of crop diversification in Shivamogga district, Karnataka, over a 20-year period (2003-04 to 2022-23) using the Entropy Index (EI) and Herfindahl Index (HI). The results reveal significant spatial heterogeneity, with a clear polarization among taluks. While taluks like Bhadravathi and Shivamogga are increasingly specializing in fewer crops, others such as Soraba, Sagara, and Hosanagara have successfully diversified their crop base. Temporally, the analysis identifies three distinct phases of stability, volatility, and divergence, culminating in a recent and concerning trend of re-specialization across several taluks after 2020-21. The findings indicate that diversification in the district is a dynamic and non-linear process, with recent gains appearing fragile. This underscores the need for decentralized, context-specific agricultural policies tailored to the divergent trajectories of individual taluks, rather than a uniform district-wide strategy.

Keywords: Crop diversification, spatio-temporal analysis, entropy index, herfindahl index, Shivamogga, agricultural policy

Introduction

Agriculture remains the backbone of rural livelihoods and socio-economic stability, particularly in developing economies such as India, where nearly 42 per cent of the workforce is engaged in the sector (Economic Survey, 2023-24). However, Indian agriculture is increasingly facing challenges such as land degradation, groundwater depletion, monoculture dependence, and climate-induced risks of droughts and floods (FAO, 2021; Chand *et al.*, 2007) ^[1, 4]. In response, crop diversification has emerged as a critical strategy to enhance productivity, ensure ecological balance, and build resilience against risks associated with monocropping (Joshi *et al.*, 2004; Pingali, 2012) ^[8, 15].

At the regional scale, spatio-temporal analysis of cropping patterns provides insights into how agricultural systems adapt to ecological, market and policy dynamics. Studies across India and beyond highlight that diversification has increasingly moved away from subsistence cereals toward high-value crops such as fruits, vegetables, pulses and oilseeds (Kumar & Gupta, 2015; Nagpure *et al.*, 2017; Mithiya *et al.*, 2018) ^[11, 13, 14]. Empirical analyses also demonstrate wide inter-regional variations: for instance, Gadag district of Karnataka recorded higher diversification in vegetables and pulses compared to cereals and oilseeds (Basavaraj *et al.*, 2016) ^[3], while Kota in Rajasthan exhibited complete diversification over three decades, unlike Jaisalmer which showed initial specialization (Meena *et al.*, 2016) ^[12]. Similar findings from Andhra Pradesh (Suseela & Chandrasekaran, 2016) ^[20], Telangana (Kamraju *et al.*, 2017) ^[9], and Himachal Pradesh (Sharma, 2019;

Sharma & Kumar, 2019) ^[18] underscore the role of local agro-ecological conditions and infrastructural support in shaping cropping patterns.

In Karnataka, crop diversification has shown a positive trend at the state level, though regional disparities persist. Districts such as Belagavi and Dharwad rank high in diversification, while Shivamogga remains among the low-diversity districts (Felix & Ramappa, 2023) ^[7]. Yet, the district holds significant agricultural importance due to its unique mix of Malnad and semi-Malnad zones, perennial rivers like the Tunga and Bhadra, and varied soil types supporting a wide range of crops (Directorate of Economics and Statistics, 2022) ^[5]. Historically dominated by paddy, Shivamogga has in recent decades witnessed a gradual shift toward commercial and horticultural crops such as arecanut, maize, sugarcane, fruits and vegetables, driven by better market opportunities, climatic adaptability, and supportive state initiatives.

Therefore, analyzing the spatio-temporal patterns in the area under crops in Shivamogga district is essential to trace agricultural transitions, assess the drivers behind diversification and evaluate implications for food security, income stability and sustainable land use. This study builds upon the existing body of literature on crop diversification in India (Khorajiya *et al.*, 2015; Eswaran & Murugan, 2019; Tiwari *et al.*, 2024) ^[10, 6, 24] while situating the analysis within the specific agro-climatic and socio-economic context of Shivamogga.

Methodology

The study was conducted in Shivamogga district, located in

the Malnad region of Karnataka, India. The district comprises seven taluks: Bhadravathi, Hosanagara, Sagara, Shikaripura, Shivamogga, Soraba, and Tirthahalli. To analyze the spatio-temporal patterns of crop diversification, secondary time-series data on the area under major crops was collected for each taluk. The data spans a 20-year period from 2003-04 to 2022-23 and was sourced from the district statistical office, Shivamogga.

The collected data was analyzed using diversification indices and visualization techniques to assess both spatial and temporal trends.

1. Crop Diversification Indices

Two widely recognized indices were employed to quantify the extent of crop diversification:

Entropy index (EI)

The Entropy index is a direct measure of diversification having a logarithmic character.

$$EI = \sum_{i=1}^N P_i^2 * \log (1/P_i)$$

Where, P_i represents acreage proportion of the i^{th} crop in total cropped area

The Entropy index increases with an increase in diversification. The Entropy index approaches zero when the farm is specialized and there is perfect specialization, i.e., P_i equals to one and takes a maximum value when there is perfect diversification. The upper limit of the Entropy Index is determined by the base chosen for taking logarithms and the number of crops. The upper value of the index can exceed one, when the number of total crops is higher than the value of the logarithm's base, and it is less than one when the number of crops is lower than the base of logarithm.

Herfindahl Index (HI)

It was for the first time used by Theil (1967)^[22]. Herfindahl index (HI) is the sum of square of the acreage proportion of each crop in the total cropped area.

$$HI = \sum_{i=1}^N P_i^2$$

Where, P_i represents acreage proportion of the i^{th} crop in total cropped area

With an increase in diversification, the sum of square of the proportion of activities decreases, so also the indices (HI). The Herfindahl index takes a value of one when there is complete specialization and approaches zero as N gets large, i.e. if diversification is perfect.

2. Spatio-temporal Visualization

- Heatmaps were used to provide a clear and intuitive visualization of the spatial patterns of crop diversification. The heatmaps display the values of the Entropy and Herfindahl indices across all seven taluks for the entire time period, using a color gradient to represent the intensity of diversification or concentration. This allows for an immediate comparison of diversification levels between taluks and

highlights spatial clusters of high or low diversity at different points in time.

- Line graphs were generated to visualize the trends of the EI and HI for each taluk over the 20-year study period. This helps illustrate the dynamic changes, volatility, and long-term trajectory of diversification over time.

Results and Discussion

Spatial variation in crop diversification

The analysis of the Entropy Index (EI) and Herfindahl Index (HI) over two decades (2003-04 to 2022-23) reveals significant spatial heterogeneity in crop diversification across Shivamogga district. The findings show a clear divergence, with some taluks rapidly specializing while others successfully diversified. The Table 3 illustrate this spatial variation over the two-decade period.

1. Taluks shifting towards crop specialization

Bhadravathi and Shivamogga taluks, despite historically high diversity, show a clear trend towards specialization, indicating a contraction of their crop portfolios. Bhadravathi recorded the most dramatic shift, with the Entropy Index (EI) dropping significantly (from 1.57 to 1.29) and the Herfindahl Index (HI) rising sharply (from 0.27 to 0.38). The detailed data confirms the steepest decline in diversity (−0.79 change in EI). Shivamogga followed a similar, though less severe, trajectory, with the EI declining (from 1.69 to 1.57) and the HI increasing (from 0.26 to 0.27).

This trend toward crop concentration in these two taluks aligns with observations in other specialized agricultural regions. Tiwari *et al.* (2024) reported a decline in diversification and rising HI in Chhattisgarh's Northern Hills, suggesting that concentration in fewer crops reduces system resilience. Similarly, Khorajiya *et al.* (2015)^[10] highlighted that the dominance of one or two staple crops (like maize in their study region) constrains overall diversification. The high concentration, especially in Bhadravathi, may be attributed to the expansion of highly remunerative cash or perennial crops (e.g., arecanut), echoing the overall finding by Felix and Ramappa (2023)^[17] that Shivamogga is a low-diversity district within Karnataka.

2. Taluks shifting towards crop diversification

Soraba, Sagara, and Hosanagara all recorded robust shifts toward diversification, demonstrating a widening of their crop base and an increase in crop mix complexity. Soraba emerged as a standout performer, with the EI increasing substantially (from 1.36 to 1.50) and the HI decreasing significantly (from 0.40 to 0.31). The detailed data indicates it reached one of the highest EI values in the district in recent decade (1.72 in 2020-21) as shown in Figure 3. Sagara and Hosanagara also showed consistent gains in diversity, with their EI values increasing and HI values decreasing, reflecting a positive shift in their cropping patterns.

This positive diversification trajectory is likely fueled by the adoption of high-value crops. The findings parallel those of Basavaraj *et al.* (2016)^[3] in Gadag district, where higher growth rates in fruits, vegetables, and pulses (7%-11%) contributed significantly to diversification. The reduction in

the Herfindahl Index (HI) in these taluks indicates a move away from the dominance of a few crops, similar to the trend observed by Nagpure *et al.* (2017) ^[14] in Western Vidarbha, where declining cereal areas were replaced by high-value alternatives like soybean and sugarcane. The results of Soraba's significant diversification align with the general trend noted by Kumar and Gupta (2015) ^[11] of increasing Simpson Index values nationwide, indicating a shift toward commercial and high-value agriculture.

3. Taluks with stable or constrained diversification

Shikaripura and Thirthahalli show relatively stable or only marginal changes in their indices, suggesting that structural factors may be constraining significant shifts in cropping patterns. Thirthahalli consistently recorded the lowest EI values (1.02 to 1.10) and relatively high HI values (0.46 to

0.41). This indicates a persistent high level of specialization. Shikaripura experienced only a moderate reduction in concentration (HI change of -0.05).

The persistent high concentration (low diversification) in Thirthahalli, despite marginal improvements, reflects situations noted by Suseela and Chandrasekaran (2016) ^[20] in Andhra Pradesh, where diversification remained limited due to the continued dominance of major crops like paddy and groundnut. Similarly, Sharma and Kumar (2019) ^[18] found that cereal-based farming systems exhibited the least diversification, suggesting that Thirthahalli's structure is heavily constrained by the dominance of traditional or perennial staples. The stability observed in Shikaripura is consistent with the finding that regional disparities in India persist, with some zones stagnating while others diversify rapidly (Barik and Bedamatta, 2024) ^[2].

Table 1: Taluk wise estimation of extent of crop diversification in Shivamogga district

Taluks	2003-04 to 2012-13		2013-14 to 2022-23	
	Entropy index	Herfindahl index	Entropy index	Herfindahl index
Bhadravathi	1.57	0.27	1.29	0.38
Hosanagara	1.24	0.45	1.33	0.36
Sagara	1.34	0.40	1.48	0.33
Shikaripura	1.41	0.35	1.47	0.32
Shivamogga	1.69	0.26	1.57	0.27
Soraba	1.36	0.40	1.50	0.31
Thirthahalli	1.02	0.46	1.10	0.41

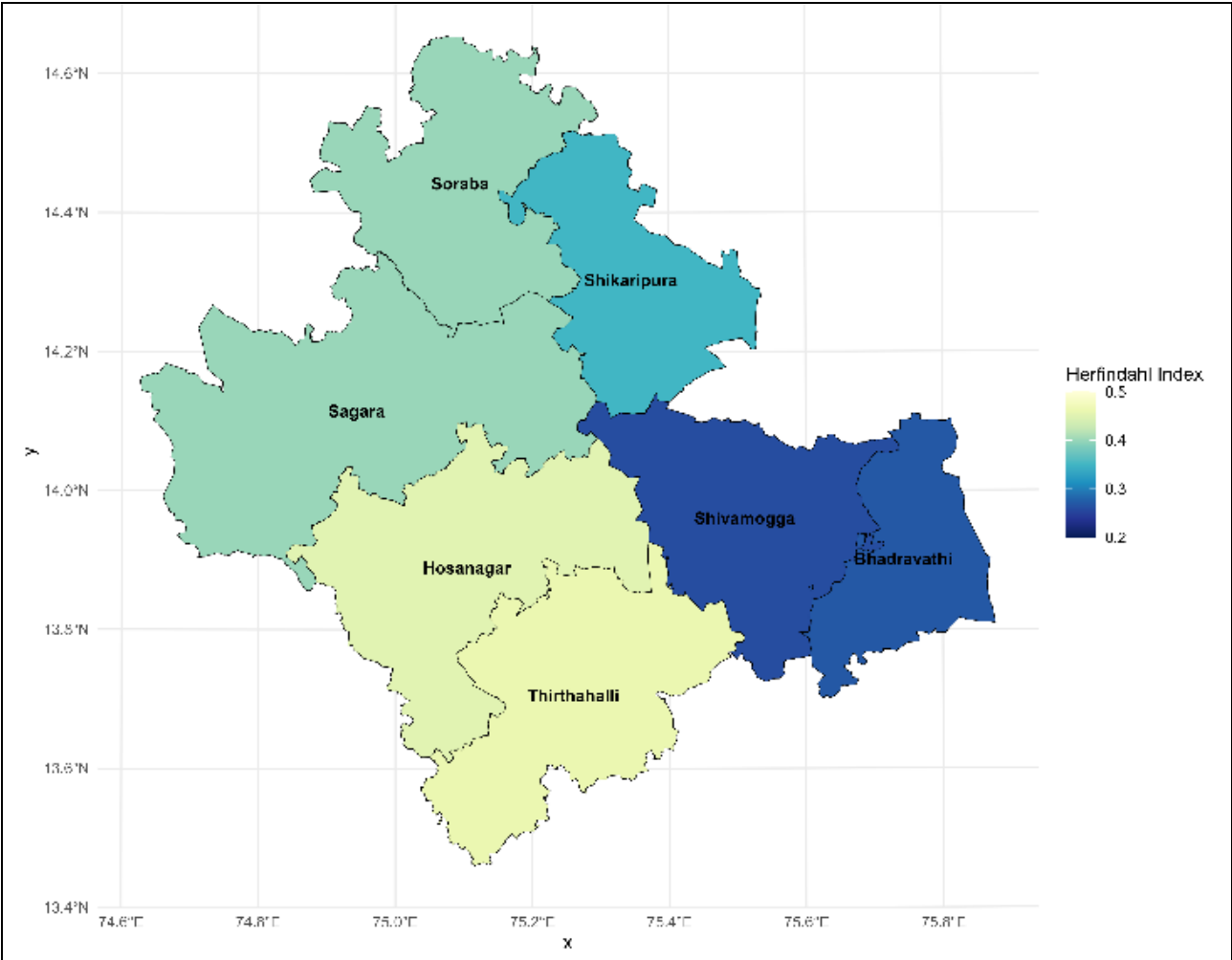


Fig 1: Spatial Variation in Crop Diversification across Taluks (2003-04 to 2012-13)

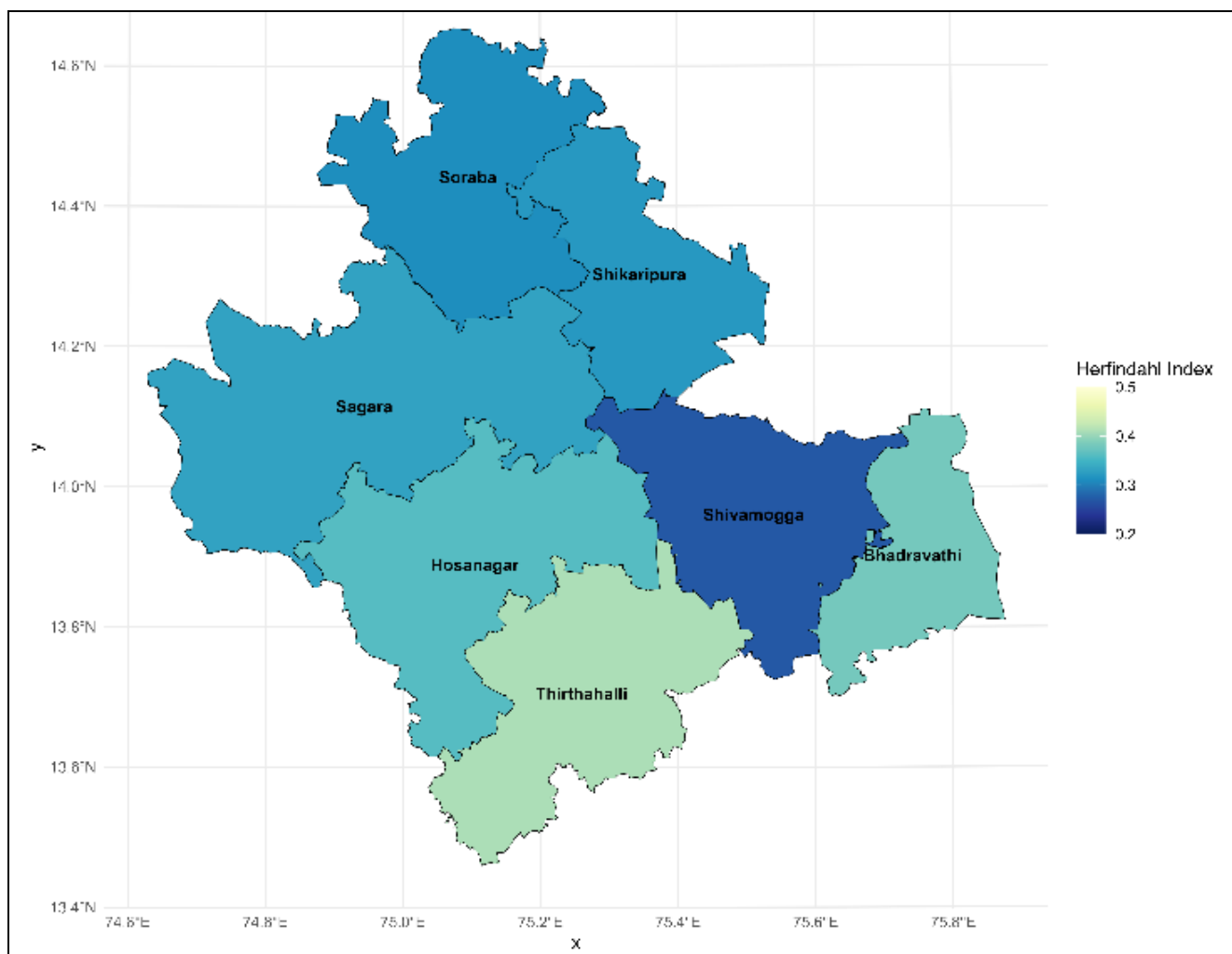


Fig 2: Spatial Variation in Crop Diversification across Taluks (2013-14 to 2022-23)

Temporal variation in crop diversification

The temporal analysis of the Entropy Index (EI) and Herfindahl Index (HI) from 2003-04 to 2022-23 reveals that the district's diversification trajectory was not linear.

Instead, it was characterized by distinct phases of stability, volatility, and recent re-specialization. The line graphs (Figure 1 and Figure 2) illustrate these dynamic shifts over the two-decade period.

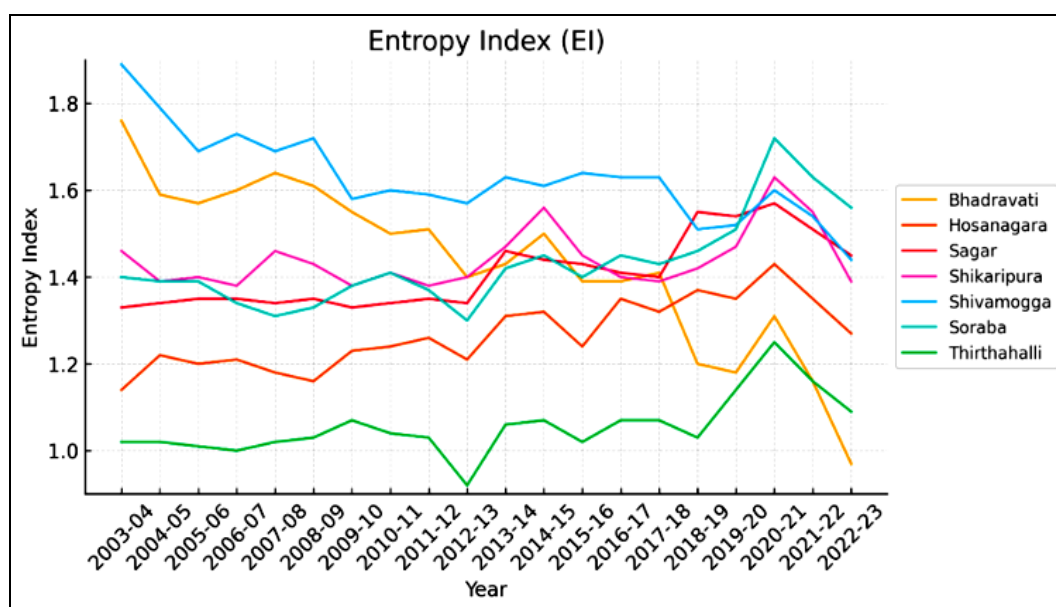


Fig 3: Trends in Entropy Index (EI) of crop diversification across taluks of Shivamogga district, 2003-04 to 2022-23

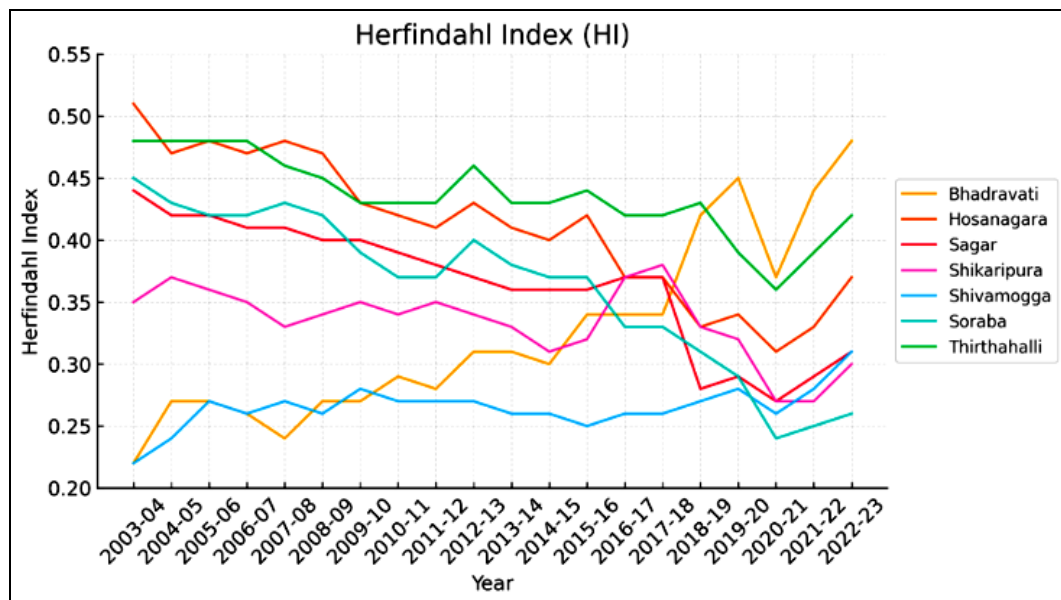


Fig 4: Trends in Herfindahl Index (HI) of crop diversification across taluks of Shivamogga district, 2003-04 to 2022-23

1. Initial period (2003-04 to 2011-12): relative stability and early divergence

The first decade of the study period was marked by relative stability in cropping patterns for most taluks. At the outset, Shivamogga (EI ~1.78) and Bhadravathi (EI ~1.76) exhibited the highest levels of crop diversity in the district. However, they both began a gradual but steady decline in diversification (increase in HI) during this phase. In contrast, Thirthahalli, Soraba and Hosanagara started with low diversification (high HI values around 0.45-0.50) and maintained this specialized structure with minor fluctuations. This initial phase established the baseline from which more dramatic shifts would later occur, with some taluks already on a path toward concentration while others maintained their specialized agricultural systems.

This early stability in specialized taluks like Thirthahalli reflects patterns observed in regions dominated by staple or perennial crops, where change is often slow. The gradual trend towards specialization in initially diverse taluks like Shivamogga and Bhadravathi could signify an early response to market signals favouring specific remunerative crops, a precursor to the nationwide shifts toward high-value agriculture noted by Kumar and Gupta (2015)^[11].

2. Mid-period (2012-13 to 2019-20): a period of high volatility and divergence

This period was the most dynamic, characterized by significant fluctuations and a clear divergence in the diversification pathways of different taluks. Soraba demonstrated a remarkable surge in diversification, with its EI climbing steadily and peaking around 2020-21, while its HI correspondingly dropped to its lowest point. This indicates a successful broadening of its crop base. Sagara and Hosanagara also showed a consistent, positive trend toward diversification during these years. Conversely, Bhadravathi experienced extreme volatility, with its HI value swinging sharply, indicating rapid shifts between diversification and specialization. Shivamogga's diversity continued its steady decline. This divergence suggests that taluks were responding differently to external drivers. Some

successfully adopted a wider variety of crops, while others either intensified their focus on fewer crops or struggled to find a stable cropping pattern.

The pronounced diversification in Soraba, Sagara, and Hosanagara aligns with findings from Nagpure *et al.* (2017)^[14] and Sharma (2019)^[18], who documented shifts from traditional cereals to a mix of high-value crops driven by profitability. The volatility seen in Bhadravathi could be attributed to factors like price fluctuations in commercial crops and water availability, which Sathyapriya and Asokhan (2019)^[17] identified as key influencers forcing farmers to frequently alter their cropping choices.

3. Recent period (2020-21 to 2022-23): an emerging trend towards re-specialization

The final years of the study reveal a concerning trend: a reversal towards specialization in several taluks that had previously been diversifying. After reaching peak diversity around 2020-21, taluks like Soraba, Sagara, and Hosanagara show a distinct downturn in their EI values and an uptick in their HI values in the last two years. Bhadravathi and Shivamogga continued their long-term trend toward specialization, with Bhadravathi recording its lowest diversity (highest HI) in the final year. Only Thirthahalli showed a marginal improvement, moving away slightly from its highly specialized base, but it remained the least diversified taluk overall.

This recent trend towards re-specialization across multiple taluks is a critical finding and resonates with the research by Tiwari *et al.* (2024)^[24], who observed a gradual but consistent decline in crop diversification in Chhattisgarh, indicating a growing concentration on fewer crops. This pattern suggests that despite earlier gains, regional agriculture may be consolidating around a few highly profitable or resilient crops, potentially increasing vulnerability to market or climate shocks. It also reflects the regional imbalances noted by Barik and Bedamatta (2024)^[2], where certain areas trend towards specialization even amidst national diversification efforts.

Conclusion

This study undertook a spatio-temporal analysis of crop diversification in Shivamogga district from 2003-04 to 2022-23, utilizing the Entropy Index (EI) and Herfindahl Index (HI) to map the changing agricultural landscape. The findings reveal that crop diversification in the district is not a uniform or linear process but a highly dynamic and spatially heterogeneous phenomenon, marked by divergent pathways across its taluks and distinct temporal phases. Spatially, the analysis highlights a clear polarization. Taluks like Bhadravathi and Shivamogga are trending towards crop specialization, driven likely by the expansion of remunerative commercial crops. In sharp contrast, taluks such as Soraba, Sagara, and Hosanagara have successfully embraced diversification, broadening their crop portfolios. Meanwhile, Thirthahalli remains locked in a state of high specialization, indicating the presence of structural constraints that limit agricultural change.

Temporally, the two-decade period was characterized by three distinct phases: an initial period of relative stability, followed by a mid-period of high volatility and divergence, and culminating in a recent, concerning trend of re-specialization across several taluks in the last few years. This recent reversal suggests that the gains from diversification may be fragile and susceptible to prevailing market or environmental pressures, potentially increasing the vulnerability of the district's farming systems.

The implications of these findings are significant for regional agricultural planning. The wide disparity between taluks underscores the need for decentralized and context-specific policy interventions rather than a "one-size-fits-all" approach. For specializing taluks, policies should focus on sustainable intensification and risk management, while for diversifying taluks, strengthening market linkages and post-harvest infrastructure for high-value crops is crucial. Future research should focus on identifying the specific socio-economic and agro-ecological drivers behind these observed patterns through primary data collection and examining the long-term impacts of these cropping system shifts on farm income, food security, and environmental sustainability.

References

1. Anonymous. The state of food and agriculture—making agrifood systems more resilient to shocks and stresses. Rome (Italy): FAO; 2021. p. 182.
2. Barik P, Bedamatta R. Crop diversification in India (1990-2016): implications for the Eastern and Northeastern States. *Asia-Pac J Rural Dev*. 2024;34(1):53-76.
3. Basavaraj ND, Gajanana TM, Satishkumar M. Crop diversification in Gadag district of Karnataka. *Agric Econ Res Rev*. 2016;29(1):151-158.
4. Chand R, Raju SS, Pandey LM. Growth crisis in agriculture: severity and options at national and state levels. *Econ Political Wkly*. 2007;42:2528-2533.
5. Directorate of Economics and Statistics, Government of Karnataka. Reports. <https://des.karnataka.gov.in/29/reports/en> (accessed 2025 Aug 04).
6. Eswaran S, Murugan A. Extent of diversification in Western Zone of Tamil Nadu. *Int J Agric Sci Res*. 2019;9(3):121-126.
7. Felix KT, Ramappa KB. An economic analysis of crop diversification and dynamics of cropping pattern in Karnataka, India. *Humanit Soc Sci Commun*. 2023;10(1):1-9.
8. Joshi PK, Gulati A, Birthal PS, Tewari L. Agriculture diversification in South Asia: patterns, determinants and policy implications. *Econ Political Wkly*. 2004;39:2457-2467.
9. Kamraju M, Vani M, Anuradha T. Crop diversification pattern: a case study of Telangana state. *Int J Innov Sci Res Technol*. 2017;2(5):366-371.
10. Khorajiya MH, Jadav KS, Chaudhari V. Resource efficiency under maize-based farming system in the tribal area of central Gujarat. *Trends Biosci*. 2015;8(5):1325-1330.
11. Kumar S, Gupta S. Crop diversification towards high-value crops in India: a state level empirical analysis. *Agric Econ Res Rev*. 2015;28(2):339-350.
12. Meena LK, Sen C, Kushwaha S. Implications of the methods of crop diversification: a comparative study. *Int J Environ Ecol Family Urban Stud*. 2016;6(1):95-102.
13. Mithiya D, Mandal K, Datta L. Trend pattern and determinants of crop diversification of smallholders in West Bengal: a district-wise panel data analysis. *J Dev Agric Econ*. 2018;10(4):110-119.
14. Nagpure S, Deshmukh RG, Sharma PK, Ingole DN. Pattern of crop concentration and crop diversification: an economic analysis. *Maharashtra J Agril Econ*. 2017;20(2):128-132.
15. Pingali PL. Green revolution: impacts, limits and the path ahead. *Proc Natl Acad Sci U S A*. 2012;109(31):12302-12308.
16. Sajjad S, Dar KH. Extent and determinants of crop diversification: empirical evidence from Kashmir Valley. *Indian J Agric Econ*. 2024;79(3):430-440.
17. Sathyapriya E, Asokhan M. Extent of diversification in Western Zone of Tamil Nadu. *J Agric Sci Res*. 2019;9(3):121-126.
18. Sharma D, Kumar V. Extent of diversification and constraints in adoption of different farming systems in Chamba district of Himachal Pradesh. *J Krishi Vigyan*. 2019;8(1):122-127.
19. Sharma S. Crop diversification in Himachal Pradesh: a temporal analysis. *Indian J Econ Dev*. 2019;7(7):1-4.
20. Suseela K, Chandrasekaran M. Crop diversification in Andhra Pradesh: regional and state level analysis. *Int J Agric Sci Res*. 2016;6(3):187-194.
21. Tiwari A, Choudhary VK, Shrey R. Nature and extent of crop diversification during Kharif season in Northern Hills of Chhattisgarh. *Int J Agric Biochem Res*. 2024;8(5):398-402.
22. Theil H. Economics and information theory. Amsterdam: North-Holland Publishing Company; 1967