**Trends and Patterns of Crop Diversification** **across North-Eastern Agro-Climatic Zones of Karnataka, India**

**ABSTRACT**

The present study was conducted to examine the trends and patterns of crop diversification in the North Eastern Transition Zone (NETZ) and North Eastern Dry Zone (NEDZ) of Karnataka. The results revealed that the growth rate in area for Aurad taluk (rainfed) of NETZ was negative for cereals and millets, pulses and commercial crops over the years. Whereas, oilseeds, fruits and vegetables have registered positive growth, but instability was in a higher range. Similarly, Humnabad taluk (irrigated) of the same zone registered a negative growth in area for cereals and millets and commercial crops over the years. The growth in area for Sedam taluk (rainfed) of NETZ was found negative for cereals and millets, oilseeds and fruits. Whereas, pulses, vegetables and commercial crops have registered a positive growth over the years. The instability was higher in the case of pulses, vegetables and commercial crops. Similarly, Devdurga taluk (irrigated) of the same zone registered a negative growth in area for cereals and millets, oilseeds and fruits, whereas a positive trend was observed in the case of pulses, vegetables and commercial crops, with higher instability found in vegetables and commercial crops. Thus, the moderate extent of crop diversification in both zones was observed.

**Keywords:** Crop diversification, Growth, Instability, Vegetables

**Introduction**

Crop diversification represents the growing of a variety of crops that are commercially viable and locally acceptable (Akash *et. al.,* 2024). It means moving away from growing a single crop to a number of crops. Crop diversification is intended to give a wider choice in the production of a variety of crops in a given area so as to expand production related activities on various crops, lessen the risk and also know the extent of competition among the crops in the area. Crop diversification in India is generally viewed as a shift from traditionally grown less remunerative crops to more remunerative crops (Gupta & Tewari, 1985).

Crop diversification is a strategic mechanism designed to optimize the utilization of land, water and other agricultural resources, contributing to comprehensive agricultural development. It offers farmers the flexibility to grow a diverse range of crops, thereby mitigating risks and uncertainties associated with climatic and biological variability. To fully comprehend crop diversification, it is essential to conduct a detailed analysis of growth trajectories, instability and shifting cropping patterns within a given region. For a nuanced understanding of crop diversification in north-eastern agro climatic zones of Karnataka, an examination of spatial and temporal trends in growth, instability and diversification has been undertaken.

**Methodology**

**Study area and sources of data**

The present study used secondary data related to area under different crops from District Statistical Offices (DSOs). The study was carried out in the North Eastern Transition Zone (NETZ) and North Eastern Dry Zone (NEDZ) of Karnataka. The time series data related to area under different crop groups from 2001-02 to 2023-24 were collected for the study. Two taluks, representing one irrigated and one rainfed taluk, each from NETZ and NEDZ, were selected based on the percentage of net irrigated area to the net area sown. Accordingly, Aurad taluk, representing the rainfed area and Humnabad taluk, representing the irrigated area were selected from NETZ. Sedam taluk, representing the rainfed area and Devdurga taluk representing the irrigated area were selected from NEDZ for deriving empirical evidence on the nature and extent of crop diversification.

**Analytical tools**

**Compound Annual Growth Rate (CAGR)**

For analyzing the growth trend in area in different crop groups across the study area, the Compound Annual Growth Rate (CAGR) analysis was used. Similarly, Nadkarni and Deshpande (1982) used the CAGR to calculate the growth. It was calculated using the formula,

$$Y\_{t}=ab^{t}U\_{t}$$

Where,

Yt = Dependent variable for which the growth rate is estimated (area of different crop groups).

a = Intercept

b = Regression coefficient

t = Time in year 1,2,3,…,n.

Ut = Disturbance term for the years t.

The compound growth rate was obtained from the logarithmic form as below

$$ln Y=ln a +t ln b$$

The per cent compound growth rate was derived using the relationship

**CAGR = (Anti log of ln b –1) X 100**

# Instability analysis

The coefficient of variation was used as a measure to study the variability in area. The Coefficient of Variation (CV) was computed using the following formula given by Kent (1924),

$$CV=\frac{Standard Deviation (SD)}{Mean} \* 100$$

Whenever the trend of series was found to be significant, the variation around the trend rather than the variation around mean was used as an index of instability.

The formula suggested by Cuddy and Della (1978) was used to compute the degree of variation around the trend.

$$Instability Index=CV \* \sqrt{1-R^{2}}$$

Where, R2 = Coefficient of determination from a time-trend regression adjusted by the number of degrees of freedom.

**Results and discussion**

**Share** **of** **different** **crop** **groups** **in** **gross** **cropped** **area** **in** **North Eastern Transition Zone (NETZ)**

**Aurad taluk (rainfed)**

Preliminary insights into crop diversification can be obtained by analyzing the changes in crop area over a period of time. Data from the triennium periods ending in 2003-04 and 2022-23 indicated a substantial shift in crop distribution in Aurad taluk. Cereal crops dominated with a 28.38 per cent share in gross cropped area during the triennium ending 2003-04, however they had been overtaken by oilseed crops, which accounted for 50.00 per cent of the cropped area during TE 2022-23 (Table 1). The proportion of cereal crops fell from 28.38 per cent to 7.55 per cent. Similarly, the area under pulse crops decreased from 60.48 per cent to 39.92 per cent during the same period. Commercial crops also showed a marginal decline from 2.38 per cent to 1.39 per cent. Other crop groups declined from 0.64 per cent to 0.45 per cent.

Conversely, oilseeds experienced a significant increase in their share in the gross cropped area, from 7.83 per cent in TE 2003-04 to 50.00 per cent in TE 2022-23. Vegetable crops exhibited a modest increase from 0.23 per cent to 0.58 per cent, while fruit crops slightly grew from 0.07 per cent to 0.12 per cent. The significant rise in the area allocated to oilseeds in the atudy area might be attributed to the effects of the Technology Mission on Oilseeds and Pulses (TMoP) and the Accelerated Pulse Production Program (A3P) initiated in 2008. These initiatives had profoundly influenced crop area distributions, as detailed in the study by Mohan *et al.* (2020).

**Humnabad taluk (irrigated)**

Analysis of triennium-end data of 2003-04 and 2022-23 revealed that the agriculture system in Humnabad taluk had consistently been dominated by pulse crops. Cereal crops held a significant share of 34.64 per cent, but this had decreased to 10.84 per cent (Table 1). Similarly, the area under commercial crops declined from 13.30 per cent to 5.19 per cent.

In contrast, the area under pulse crops increased substantially from 39.11 per cent to 54.83 per cent. Oilseed crops also saw a notable rise in area from 9.36 per cent to 23.27 per cent. Vegetable crops experienced a modest increase from 1.37 per cent to 2.21 per cent, while fruit crops showed a marginal increase from 0.52 per cent to 1.05 per cent. Other crop groups area also increased from 1.70 per cent to 2.61 per cent.

The above findings clearly indicated that in Aurad (rainfed) taluk, there had been a notable decrease in the area under cereal and pulse crops, with a corresponding rise in the area under oilseed crops. Conversely, in Humnabad (irrigated) taluk, the area previously used for cereal and commercial crops had declined, making way for an increase in the cultivation of pulse and oilseed crops. The higher crop diversification was found in irrigated areas compared to rainfed areas, likely due to the greater number of crops grown, facilitated by the availability of irrigation. Similar results were reported by Reshma and Jain (2023) in their study.

**Table 1. Share of different crop groups in gross cropped area across NETZ**

**(Area in ha)**

|  |  |  |
| --- | --- | --- |
| **Particulars** | **Aurad (Rainfed)** | **Humnabad (Irrigated)** |
| **Crop Groups** | **TE** **2003-04** | **TE** **2022-23** | **TE** **2003-04** | **TE** **2022-23** |
| Cereal crops | 31206.67 (28.38) | 10509.00 (7.55) | 25731.67 (34.64) | 9282.00 (10.84) |
| Pulse crops | 66118.67 (60.48) | 55566.00 (39.92) | 29059.00 (39.11) | 46967.00 (54.83) |
| Oilseed crops | 8556.00(7.83) | 69582.33 (50.00) | 6950.33(9.36) | 19930.33 (23.27) |
| Fruit crops | 76.33(0.07) | 165.78(0.12) | 386.67(0.52) | 901.54(1.05) |
| Vegetable crops | 249.00(0.23) | 801.53(0.58) | 1017.00(1.37) | 1894.61(2.21) |
| Commercial crops | 2605.00(2.38) | 1933.67(1.39) | 9882.00 (13.30) | 4446.33(5.19) |
| Other crops | 698.00 (0.64) | 620.02 (0.45) | 1264.67 (1.70) | 2237.85 (2.61) |
| Gross cropped area | 109329.67 (100) | 139178.33 (100) | 74291.33 (100) | 85659.67 (100) |

 Note: Figures in parentheses indicate percent to gross cropped area

**Share** **of** **different** **crop** **groups** **in** **gross** **cropped** **area** **in** **North Eastern Dry Zone (NEDZ)**

 **Sedam taluk (rainfed)**

 The share of different crop groups during the triennium ending in 2003-04 and 2022-23 indicated that the agriculture system in Sedam taluk had continued to be predominantly characterized by pulse crops. The share of pulse crops increased from 65.15 per cent to 81.85 per cent (Table 2). Cereal crops also held a substantial share of 29.49 per cent, but this has decreased to 11.49 per cent.

The area allocated to oilseed crops declined from 4.17 per cent to 1.99 per cent. Similarly, fruit crops experienced a slight decrease from 0.26 per cent to 0.13 per cent. In contrast, the area dedicated to commercial crops increased significantly from 0.03 per cent to 3.99 per cent. Vegetable crops also shown an increase in their share from 0.15 per cent to 0.41 per cent. Other crop groups area declined from 0.76 per cent to 0.13 per cent. Shivagangavva and Reddy (2016) in their study, also reported a substantial increase in both area and production of pulses within the Karnataka state.

**Devdurga taluk (irrigated)**

Analysis of triennium ending data of 2003-04 and 2022-23 indicated a notable shift in the agricultural landscape of Devdurga taluk. The area earlier dominated by cereal crops, have been supplanted by commercial crop groups. The area under cereal crops decreased from 48.80 per cent to 38.84 per cent. Similarly, pulse crops experienced a decline in area from 14.32 per cent to 11.59 per cent (Table 2).

Oilseed crops revealed a significant drop in area share from 25.97 per cent to 2.45 per cent. The share of fruit crops also declined marginally, from 0.48 per cent to 0.11 per cent. In contrast, commercial crops exhibited a remarkable increase in area from 9.73 per cent to 38.50 per cent. Other crop groups area increased from 0.20 per cent to 4.41 per cent. A comparable trend was observed in the study by Saraswati *et al.* (2011), which reported that diversification was more significant among horticultural and commercial crops. This was largely due to a shift in acreage towards high-value crops, resulting in a notable improvement in farm income compared to conventional crops.

It can be concluded that in the case of Sedam (rainfed) taluk, there had been a substantial decrease in the area under cereal and oilseed crops, which had been offset by an increase in the area under pulse and commercial crops. Meanwhile, in Devdurga (irrigated) taluk, a significant reduction in the area under oilseed and cereal crops had occurred, with these areas now being replaced by commercial crops and vegetables.

**Table 2. Share of different crop groups in gross cropped area across NEDZ**

 **(Area in ha)**

|  |  |  |
| --- | --- | --- |
| **Particulars** | **Sedam (Rainfed)** | **Devdurga (Irrigated)** |
| **Crop Groups** | **TE** **2003-04** | **TE** **2022-23** | **TE** **2003-04** | **TE** **2022-23** |
| Cereal crops | 25619.33 (29.49) | 11468.00 (11.49) | 50484.33 (48.80) | 53486.67 (38.84) |
| Pulse crops | 55615.00 (65.15) | 81668.00 (81.85) | 14809.33 (14.32) | 15956.00 (11.59) |
| Oilseed crops | 3555.67(4.17) | 1990.33(1.99) | 26860.33 (25.97) | 3370.33(2.45) |
| Fruit crops | 222.00(0.26) | 133.00(0.13) | 498.33(0.48) | 153.47(0.11) |
| Vegetable crops | 131.00(0.15) | 411.00(0.41) | 509.00(0.49) | 5649.38(4.10) |
| Commercial crops | 24.00(0.03) | 3978.00(3.99) | 10068.33 (9.73) | 53013.33 (38.50) |
| Other crops | 645(0.76) | 134(0.13) | 211.33(0.20) | 6072.15(4.41) |
| Gross cropped area | 85362(100) | 99782.33(100) | 103441.00  (100) | 137701.33 (100) |

Note: Figures in parentheses indicate percent to gross cropped area

**Growth, instability and status of crop diversification across NETZ**

The Compound Annual Growth Rate (CAGR) and instability index provide valuable implications for long-term decision-making at the aggregate level to optimize crop production. The CAGR of the area for various crop groups in Aurad taluk over the years revealed a negative and statistically significant growth rate for cereals (-6.44%), pulses (-1.30%) and commercial crops (-2.89%). In contrast, the CAGR for oilseeds was positive and statistically significant (10.53%), while fruits (2.99%) and vegetables (2.66%) exhibited positive growth that was statistically non-significant (Table 3). This trend clearly illustrated a gradual shift in cultivated area from traditional/conventional crop groups to more modern and profitable ones over time. This observation aligns with the findings of Anjum and Madhulika (2018), who reported a negative growth rate for cereal crops such as paddy and wheat, alongside positive growth in oilseed and horticultural crops.

The coefficient of variation (CV) serves as a measure of variability within a dataset, with a low CV indicating minimal variability and a high CV denoting greater variability. In Aurad taluk, the CV values for various crop groups revealed that cereals, pulses and commercial crops exhibited lower levels of instability, whereas fruits and vegetables demonstrated higher levels of instability. The Cuddy Della Valle Index (CDVI), is employed to assess instability and indicates that cereals, pulses, oilseeds and commercial crops experienced medium instability over the years, with CDVI values ranging between 15 to 20 per cent. In contrast, vegetable and fruit crops were characterized by high instability.

 Humnabad taluk revealed that the area under cereal crops experienced the steepest decline, with a negative growth rate of 5.44 per cent, followed closely by commercial crops at 5.14 per cent. Across the study period, oilseed crops exhibited the highest positive growth at 7.20 per cent, followed by fruit crops (3.76 %) and pulses (1.66 %) and were statistically significant. Although vegetable crops displayed a positive growth rate of 2.37 per cent, this was statistically non-significant. A study by Joshi *et al.* (2006) observed a similar trend in horticultural and commercial crops, emphasizing the critical role played by these crops in sustaining farmer livelihood by implementing strategies to mitigate instability.

The coefficient of variation (CV) values for Humnabad taluk highlighted significant instability in oilseeds, fruits and vegetables (Table 3). The Cuddy Della Valle Index (CDVI) further revealed that cereal crops exhibited low instability, with CDVI values ranging from 0 to 10 per cent. Whereas, pulses, oilseeds and commercial crops were characterized by medium instability, while fruits and vegetables displayed high instability. Similar results were found by Krishan and Chanchal (2014).

**Table 3. Growth and instability of various crop groups across the NETZ (2001-2023)**

|  |  |  |
| --- | --- | --- |
| **Particulars** | **Aurad (Rainfed)** | **Humnabad (Irrigated)** |
| **Crop groups** | **CAGR****(%)** | **CV****(%)** | **CDVI** | **CAGR****(%)** | **CV****(%)** | **CDVI** |
| Cereals & Millets | -6.64\*\* | 42.38 | 15.60 | -5.44\*\* | 34.88 | 10.53 |
| Pulses | -1.30\*\* | 18.80 | 16.91 | 1.66\* | 25.35 | 23.72 |
| Oilseeds | 10.53\*\* | 61.68 | 23.45 | 7.20\*\* | 47.75 | 21.50 |
| Fruits | 2.99 | 130.07 | 127.80 | 3.76\*\* | 42.43 | 31.26 |
| Vegetables | 2.66 | 74.12 | 71.31 | 2.37 | 81.61 | 79.70 |
| Commercial crops | -2.89\*\* | 27.12 | 22.41 | -5.14\*\* | 35.18 | 23.00 |

Note: ‘\*\*’significant at 5 per cent level of significance,

 ‘\*’significant at 10 per cent level of significance.

**Growth, instability and status of crop diversification across NEDZ**

The estimated growth rate for Sedam taluk showed that oilseed crops experienced the most significant decline in area, with a negative (-4.20 %) growth, followed by fruit crops (-2.29 %) and cereals (-2.12 %). Across the entire period (Table 4), commercial crops exhibited the highest positive growth rate of 27.99 per cent, followed by vegetable crops at 7.84 per cent, both of which were statistically significant. Pulses also recorded a positive growth rate of 2.96 per cent. The coefficient of variation (CV) values indicated substantial instability for commercial crops, pulses and vegetables. The Cuddy Della Valle Index (CDVI) further revealed that cereal crops experienced medium instability, with CDVI values ranging between 15 per cent and 20 per cent, while other crop groups exhibited high instability.

Growth rate analysis for Devdurga taluk revealed that oilseeds experienced the steepest decline in area, with a negative growth of 10.92 per cent, followed by fruits at 5.41 per cent and cereals at 0.07 per cent. Among all crop groups, commercial crops recorded the highest growth in area with a positive growth of 7.88 per cent, closely followed by vegetables at 7.20 per cent. Pulses also showed a positive growth rate of 1.12 per cent. The coefficient of variation (CV) values for Devdurga taluk indicated high instability in vegetables and commercial crops, followed by fruits, while cereals and pulses displayed low instability. The Cuddy Della Valle Index (CDVI) also revealed that cereals exhibited medium instability, whereas other crop groups demonstrated high instability.

**Table 4. Growth and instability of various crop groups across the NEDZ (2001-2023)**

|  |  |  |
| --- | --- | --- |
| **Particulars** | **Sedam (Rainfed)** | **Devdurga (Irrigated)** |
| **Crop groups** | **CAGR****(%)** | **CV****(%)** | **CDVI** | **CAGR****(%)** | **CV****(%)** | **CDVI** |
| Cereals & Millets | -2.12\*\* | 24.19 | 21.42 | -0.07 | 22.43 | 22.43 |
| Pulses | 2.96 | 151.81 | 142.83 | 1.12 | 33.21 | 32.41 |
| Oilseeds | -4.20\*\* | 52.25 | 45.33 | -10.92\*\* | 66.15 | 45.12 |
| Fruits | -2.29\* | 36.09 | 33.39 | -5.41\* | 74.20 | 68.81 |
| Vegetables | 7.84\*\* | 85.93 | 65.80 | 7.20\* | 118.40 | 108.83 |
| Commercial crops | 27.99\*\* | 182.15 | 94.57 | 7.88\*\* | 100.77 | 85.62 |

Note: ‘\*\*’significant at 5 per cent level of significance,

 ‘\*’significant at 10 per cent level of significance.

**Conclusion**

Analysis of triennium-ending data of 2003-04 and 2022-23 in Aurad taluk of NETZ revealed a significant decrease in the share of cereal and pulse crops, whereas a positive trend was observed in the case of oilseed crops, fruits and vegetables. Similarly, Humnabad taluk of NETZ showed a significant decrease in the share of cereal and commercial crops. Whereas a positive trend was observed in the case of pulses, oilseed crops, fruits and vegetables. The triennium-ending data of 2003-04 and 2022-23 in Sedam taluk of NEDZ revealed a significant decrease in the share of cereal crops and a minor decline in oilseed crops and fruits, whereas a positive trend was observed in the case of pulse crops, commercial crops and vegetables. Similarly, Devdurga taluk of NEDZ showed a significant decrease in the share of oilseed crops, cereal crops and pulse crops. Whereas a positive trend was observed in case of commercial crops and vegetables.

The CAGR in the area for Aurad taluk of NETZ was negative for cereals and millets, pulses and commercial crops over the years. Whereas, oilseeds, fruits and vegetables have registered a positive growth, but instability was in a higher range. Similarly, Humnabad taluk of the same zone registered a negative CAGR in area for cereals and millets and commercial crops over the years whereas pulses, oilseeds, fruits and vegetables have registered a positive growth and instability was in the higher range for vegetables. The CAGR in the area for Sedam taluk of NETZ was negative for cereals and millets, oilseeds and fruits. Whereas, pulses, vegetables and commercial crops have registered a positive growth over the years. The instability was found higher in case of pulses, vegetables and commercial crops. Similarly, Devdurga taluk of the same zone registered a negative CAGR in area for cereals and millets, oilseeds and fruits, whereas a positive trend was observed in case of pulses, vegetables and commercial crops with higher instability found in vegetables and commercial crops. The higher degree of crop diversification was found in irrigated areas compared to rainfed areas, likely due to the greater number of crops grown, facilitated by the availability of irrigation. However, the moderate extent of crop diversification was observed in both agro-climatic zones of Karnataka.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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