Spatial analysis of horticulture crop distribution: A district-level analysis in Gujarat

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DECLARATION BY STUDENT

I hereby declare that the data presented in the Dissertation report entitled, "Spatial analysis of horticulture crop distribution: A district-level analysis in Gujarat" is based on the results of investigations carried out by me in the Economics Discipline at the Goa Business School, Goa University under the Supervision of Ms Heena Subrai Gaude and the same has not been submitted elsewhere for the award of a degree or diploma by me. Further, I understand that Goa University or its authorities will not be responsible for the correctness of observations / experimental or other findings given the dissertation.

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PREFACE

The intricate relationship between spatial patterns and agricultural practices has gained significant attention in recent times. This dissertation delves into this nexus by analysing the dynamics of spatial autocorrelation and crop diversification in the districts of Gujarat, India.

Gujarat, a state boasting a vibrant agricultural landscape, presents a compelling study for exploring this interplay. The spatial distribution of crops across the state's districts is likely to exhibit patterns of autocorrelation, where neighbouring districts cultivate similar sets of crops. This dissertation aims to analyse these spatial relationships and investigate their influence on crop diversification.

The findings of this dissertation hold significant implications for agricultural policymakers and stakeholders in Gujarat. By understanding the spatial autocorrelation, crop diversification and the potential hotspot and coldspot areas, policymakers can design targeted interventions to encourage a more diversified cropping pattern across the state's districts. This, in turn, can contribute to enhanced agricultural sustainability and improved livelihoods for Gujarat's farmers.

The subsequent chapters of this dissertation delve deeper into the theoretical underpinnings of spatial autocorrelation and crop diversification. A comprehensive review of relevant literature is presented, followed by a detailed explanation of the research methodology employed in this study. The dissertation subsequently analyses the findings and discusses their significance in the context of Gujarat's horticulture. Finally, the concluding chapter summarizes the key takeaways and proposes recommendations for future research and policy interventions.

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ABSTRACT

This study conducts an in-depth examination of horticulture crop productivity at the district level in Gujarat, with a specific focus on fruits, vegetables, spices, and flowers. The study employed methods like Simpson's Diversification Index, Moran's Spatial Autocorrelation, and hotspot and coldspot analysis to evaluate trends of diversification and spatial autocorrelation in crop productivity. The results indicate a notable increase in diversification among districts, with Navsari diversifying at a slow pace, pointing towards a promising future for the horticulture industry in Gujarat. Simpson's Index demonstrates favorable progress towards diversification. Spatial autocorrelation results indicate that an increase in productivity in a district has spillover effects on neighboring districts' horticulture productivity for crops like fruits and spices, while crops like vegetables and flowers show weak positive and weak negative spatial autocorrelation respectively. The study further analyses the visual hotspots and coldspots in horticulture productivity which helps to identify districts that can specialize in horticulture production and districts that experience coldspot for most of the horticulture crop production.

Keywords: Gujarat, horticulture, districts, Simpson's Diversification Index, Moran's Spatial Autocorrelation, Getis-Ord Gi

CHAPTER 1: INTRODUCTION

1.1 Background

Horticulture, the science and art of cultivating fruits, vegetables, flowers, and ornamental plants, plays a pivotal role in global food security, environmental sustainability, and economic development. In recent years, the horticulture industry has witnessed significant transformations driven by technological advancements, changing consumer preferences, and sustainability concerns. The horticulture industry is a dynamic sector that is continuously adjusting to meet global market demands. Horticulture contributes about 33% to the agriculture Gross Value Added (GVA) as of 2022 (Department of Agriculture & Farmers Welfare). With the rise of globalization, there has been heightened competition and a necessity for sustainable practices within the industry. Since the onset of the Green Revolution in the 1950s, there has been a significant shift in resources towards enhancing cereal grains over horticultural crops (Horticulture Statistics at a Glance, 2021). The productivity growth in horticultural crops lagged behind that of foodgrains pre 2009-2010. However, post 2009-2010, there has been an increase in horticulture production over foodgrain production (Horticulture Statistics at a Glance, 2021). Nonetheless, farmers worldwide have found it beneficial to venture into horticultural crops, leading to a faster growth in production compared to cereal crops, despite starting from a lower base. The global area dedicated to horticultural crops has more than doubled between 1960 and 2021. The surge in fruit and vegetable trade volumes globally has been remarkable, with the current total value of traded horticultural crops exceeding that of cereals. While the supply of fruits and vegetables has consistently risen on a global scale, the growth has been concentrated in Latin America and China, with other regions faring less favorably. Sub-Saharan Africa, in particular, faces inadequate per capita supply, with minimal growth observed over the past four decades. This deficiency in fruit and vegetable consumption in certain regions has severe health repercussions, contributing to an estimated 2.7 million deaths annually and ranking among the top ten mortality risk factors. The World Health Organization (WHO) has recommended consuming at least 400 grams each day to achieve their health and nutrition benefits. In 2017, around 3.9 million deaths worldwide were caused as a result of not eating enough fruit and vegetables (WHO, 2019). Reduced intake of fruit and vegetables is estimated to cause around 14 percent of deaths from gastro-intestinal cancer worldwide about 11 percent of those due to ischemic heart disease and another about 9 percent of those caused by stroke (Afshin et al., 2019). Despite the disproportionate focus on cereals by public research institutions, the yield improvements in cereal crops have surpassed those in horticultural crops. Nevertheless, the expansion of horticultural crops has outpaced that of rice, wheat, and maize worldwide. The proportion of land under horticultural cultivation is rising in all regions, currently standing at 6.7% globally. China stands out for its remarkable expansion in horticultural production, utilizing nearly 20% of arable land for fruit and vegetable cultivation and accounting for 47% of the world's vegetable supply (Food and Agriculture Organization). Despite occupying a smaller portion of arable land, the value added by horticultural production to total agriculture is noteworthy, even surpassing cereal production value in many countries.

There are multiple reasons behind the global surge in fruit and vegetable crop production and trade. Engaging in horticultural production proves to be highly lucrative, with farmers typically enjoying significantly higher incomes compared to cereal producers. The cultivation of fruits and vegetables offers ample opportunities for productive employment, especially in areas where the labor-to-land ratio is high due to the labor-intensive nature of horticultural production. The expansion of horticultural production plays a pivotal role in the commercialization of rural economies and the creation of numerous off-farm jobs. Nevertheless, the lack of market access, market information, and various biological factors often impede the scaling up of horticultural production. The demand for horticultural products is on the rise, both domestically and internationally (The Economic Times, 2023). Developed nations are witnessing an increasing desire for year-round access to a diverse array of foods, driven by a growing awareness of the correlation between diet and health. This heightened consumption of commodities includes a wide range of relatively costly items like out-of-season produce, exotic fruits and vegetables, and organic products. The rise in female participation in the labor force of developed countries has spurred the demand for convenient processed products, such as pre-cut fruits and salad mixes. Developing countries are capitalizing on this shift, with the growth in their processed food exports outpacing that of developed regions in recent years. Various labor-intensive tasks like chopping, washing, packaging, and barcoding are being outsourced to developing nations, leading to the creation of new employment opportunities, particularly for women.

After the Green Revolution in the mid-sixties, it has become evident that horticulture, a sector well-suited for the Indian topography and agro-climate, stands out as the most favorable choice. India is a prominent producer of horticultural crops globally, covering 18% of the area, and contributing around 33% of the gross value to the agricultural GDP. These crops represent 37% of the total exports of agricultural products. With a strategic focus on horticulture, India is recognized as the second-largest producer of fruits and vegetables (Handbook on Horticulture Statistics, 2021). Horticulture production has shot up by 13 times from 25 million tonnes in 1950-51 to 331 million tonnes in 2020-21, overtaking food grain production. This sector is widely recognized as an essential driver of economic growth, evolving into a well-structured industry interconnected with seed trading, value addition, and exports. In 2011-12, the area under fruit crops was 6.58 million hectares, yielding a total production of 77.52 million tonnes, contributing to a 32 percent share of the total horticultural production (Anon, 2012). India leads in the production and consumption of cashew nuts, tea, and spices, and is the third-largest producer of coconuts. The country exports a variety of products including fruits, vegetables, processed goods, flowers, seeds, spices, cashew nuts, tea, and coffee. India stands as the top producer of mangoes, bananas, grapes, and lychees, although the majority of the produce is consumed domestically. Despite being the largest producer of mangoes, India’s global fruit exports account for only 0.3%. Fruits make up about 11% of the total horticultural exports from the country, with grapes and mangoes collectively constituting 60% of India’s fresh fruit exports (APEDA). Citrus fruits, bananas, apples, and papayas are also significant fruits for export. The most notable development in the past decade has been the transition of horticulture from rural settings to commercial production. This shift has prompted increased private sector investments in production system management. Technological advancements such as micro-irrigation, precision farming, greenhouse cultivation, and enhanced post-harvest management have significantly influenced the sector’s progress.

Horticulture plays a vital role in improving the economic status of farmers, extending the availability of fruits and vegetables throughout the year, and increasing per capita consumption. Additionally, it has empowered women by providing employment opportunities in mushroom cultivation, floriculture, processing, nursery operations, vegetable seed production, and more. The national objective of achieving 4% growth in agriculture can be realized through the substantial contribution of horticulture to this growth. Enhancing horticultural seed distribution channels, and market information systems, and facilitating credit access for farmers are vital components of a strategy aimed at horticultural system development. Urban and peri-urban horticultural production also requires more attention due to increasing urbanization and the demand for food in growing cities. Despite advancements, 1.1 billion people still live in extreme poverty, while 1.6 billion live on meager incomes. The expansion of markets and trade liberalization offer new opportunities for rural communities to overcome poverty through non-staple crop production and trade. It is imperative to broaden the research scope in agriculture beyond cereal crops and prioritize horticulture to ensure that its growing importance benefits a significant portion of the world’s impoverished nations, farmers, and landless laborers.

1.2 Objectives

1. To assess the trends in the horticulture sector in Gujarat from 1999-2000 to 2022-23.
2. To analyse the magnitude of horticultural diversification across various districts.
3. To examine spatial autocorrelation in horticultural productivity across different horticulture crops among Gujarat’s districts.
4. To determine clusters of districts exhibiting similar patterns of crop productivity through the application of Getis Ord Gi analysis.

1.3 Research Question

1. What are the growth patterns of the horticulture sector in Gujarat from 1999-2000 to 2022-23?
2. How has horticultural diversification evolved across different districts of Gujarat?

3. How has horticultural productivity fluctuated spatially across different crops and districts in Gujarat?
4. Which districts in Gujarat exhibit similar patterns of crop productivity?

1.4 Scope

Horticulture plays a significant role in the economy, contributing to employment generation, income diversification, and rural development. The identification of clusters of districts exhibiting similar productivity patterns can facilitate the promotion of agro-industrial development, integration of value chains, and improvement of market access for horticultural products, thereby stimulating economic growth and livelihood opportunities. The comprehension of spatial and temporal variations in horticultural productivity can optimize the allocation of resources, including water, land, and agricultural inputs, among different districts, leading to increased efficiency and decreased resource wastage, hence contributing to overall agricultural sustainability. The analysis of trends in diversification and fluctuations in productivity can provide insights into the sector’s ability to withstand climate change and variability. By pinpointing districts with notable spatial clusters of high horticultural activity (hot spots) or low activity (cold spots), decision-makers and investors can prioritize targeted investments, infrastructure development, and supportive programs. For instance, regions with high horticultural productivity may profit from enhanced market access or the development of value chains, while areas with low productivity may necessitate interventions to improve agricultural practices or access to inputs. Therefore, this research facilitates informed decision-making, interventions tailored to specific locations, and comprehensive planning strategies to bolster the growth and resilience of horticultural activities throughout districts in Gujarat.

CHAPTER 2: LITERATURE REVIEW

Horticulture is a thriving sector globally, with over 145 nations actively engaged in commercial floriculture (Pal & Chakravarthy, 2020). Due to their labor-intensive cultivation methods, horticultural crops play a crucial role in enhancing rural income and providing employment opportunities (Pandey, 2015). Developing countries have shown remarkable growth in horticultural exports, surpassing developed nations' average growth rates (Singh, 2010).

India, the second largest producer of fruits and vegetables after China, has seen a shift towards horticulture in recent years, focusing on enhancing production and reducing post-harvest losses (Pandey, 2015). India's horticulture sector contributes over 30.5% to the country's GDP from agriculture (Surendran, 2014). The use of protected cultivation techniques, such as greenhouses, has expanded in regions like Maharashtra, driven by government schemes and the need to meet increasing demand (Nemali, K. 2022). On the other hand, China leads in global fruit production, with India following closely behind. India leads in the production of various fruits like mango, banana, and papaya. The sectors' evolution in India reflects a shift towards commercial production, attracting private investments and enhancing economic importance. The horticulture sector in Ghana and Kenya faces challenges in effectively participating in global value chains, impacting poverty alleviation efforts (Elizabeth, 2014).

Recognizing the prospects offered by this sector, the Government of India has launched various development schemes for horticultural crop cultivation since the Seventh Five-Year Plan (Singh, Nath, Dutta, & Sudha, 2004). Before the Seventh Plan, the sector remained relatively inactive as efforts were primarily directed towards enhancing the production and productivity of major food grains. Additionally, a significant portion of the budget was earmarked for poverty alleviation, technological self-sufficiency, and similar objectives. However, with the initiation of the Seventh Plan, an allocation of Rs. 21.94 crores was made for the advancement of horticulture through 10 sub-schemes, and subsequent measures were taken to integrate horticulture with agriculture in different regions such as hilly areas, dry-land areas, and coastal saline areas, to diversify agricultural output, boost incomes, and mitigating poverty, unemployment, and regional inequalities. The efforts undertaken for horticultural crops during the Eighth Plan were viewed as a promising avenue for creating employment opportunities (Planning Commission, 1992-1997). In Maharashtra, the government has been actively promoting horticulture since 1990 to enhance land productivity through diversification (Kaur et al., 2023). While the National Horticulture Mission led to increased area and production of vegetables post-implementation, fruit productivity saw a rise as well (Raghuraja, 2022). Singh, Ahmad, Pandey, and Sinha (2021) conducted a study on the Impact of the National Horticulture Mission (NHM) on the vegetable and fruit sectors in India. The study found that post-NHM, there was a significant increase in acreage and production of vegetables, although there was a slight decrease in productivity. Similarly, while the area under fruit cultivation decreased pre-NHM, post-NHM saw higher growth rates in production and productivity. The analysis also revealed increased stability in area, production, and productivity post-NHM. The study also highlights the positive impact of NHM on the national level, with most states experiencing a rise in both area and production of fruits and vegetables, showing the importance of technological interventions and infrastructural development in achieving agricultural growth and food security goals. Chand, et.al (2008) obtained data through the Central Statistical Organization (CSO) and the National Horticulture Board for analysis which highlighted that India’s crop production diversified away from cereals around 1983-84, with a significant boost in horticulture diversification in the early 1990s coinciding with economic liberalization. From

1980-81 to 2005-06, the share of fruits and vegetables in total cropped area and output increased substantially. There has been a slowdown in productivity growth post 2000-01, particularly for fruits and vegetables, necessitating attention. Domestic demand for horticultural products is rising, leading to increased imports, and highlighting the need for import substitution through improved production and efficiency. Sinha & Sharma (2022) in their study aimed to assess the influence of the National Horticulture Mission (NHM) on the Indian floriculture sector's expansion. Through trend analysis covering 2005-2021 and a pre- and post-mission examination from 1995-2021, they evaluated metrics such as flower cultivation area, loose and cut flower production, and floriculture product exports in terms of both value and volume. Their findings suggested that while the NHM did not significantly affect the volume of floriculture product exports, the increased export value could be attributed to inflation rates and international market prices rather than a surge in export quantity from India. Similarly, Madisa et al. (2012) found that there was an increase in horticulture production from 1997 to 2009 using secondary data and regression analysis using PROG REG in SAS Institute. Import of fruits and vegetables declined as total production increased. They also suggested that there should be an emphasis on training farmers on good management of crops to increase crop productivity.

The horticulture industry in Gujarat has shown significant growth and development in recent years. While the state ranks fourth nationally in fruit production, there are challenges such as the poor performance of fruit trees in the Kachchh region with less than 1% area under fruit crops due to low productivity (Swati et al., 2019). The state has seen an increase in the cultivation of vegetables, with a focus on trends and variability in area, production, and productivity (Chaudari,2008). Additionally, initiatives like Greenhouse farming technology have revolutionized agriculture in

Gujarat, offering maximum yields with minimum area utilization and providing economic, social, and cultural benefits. Furthermore, cooperative marketing societies have played a vital role in the growth of horticulture production in the region, particularly in Gandevi Taluka of Navsari District (Kantariya et al., 2018). Weather parameters have also been correlated with the production of major fruit crops in Navsari District, showing moderate negative correlations with mean annual temperature for certain fruits (Swati et al., 2019). Gujarat's prominence in onion cultivation, with high productivity levels, has also contributed to the state's horticultural (Kantariya et al., 2018). Initiatives like the National Horticulture Mission and Gujarat State Horticulture Mission aim to further develop horticulture in the state, with projects mapping fruit crop plantations using satellite data for accurate assessment and planning (Bhaskarcharya Institute for Space Applications and Geo-informatics (BISAG), Department of Science & Technology, Government of Gujarat, Gandhinagar, Gujarat, India et al., 2017).

The magnitude of diversification can be measured by several statistical tools, including the Index of maximum proportions, Simpson Index, Entropy Index, Modified Entropy Index, Composite Entropy Index, Herfindahl-Hirschman Index, etc. Each of these tools has its advantages and limitations regarding data requirement, level of sophistication, and ease of computation and interpretation. Further, the results obtained through these methods are more or less similar (Kumar et al., 2012).

Various indexes are utilized to measure crop diversification. The Gibbs-Martin technique is employed to calculate absolute diversification indexes, while the Simpson diversity index assesses homogeneity in diversification (Mzyece et al., 2023). Additionally, the Shannon-Wiener diversification index is impacted by factors like rural literacy, irrigation intensity, and regional economic indicators, reflecting the diversification trends in agriculturally prosperous states in India (Rahaman, 2021). Furthermore, the Varietal Threat Index, proposed for monitoring varietal diversity, uses the four-cell analysis (FCA) participatory methodology to track changes in varietal diversity on farms, especially focusing on landraces and the need for conservation interventions (Neogi & Ghosh, 2022). The Shannon Diversity Index (SHDI) is employed to capture both the richness and evenness of crops in organic and conventional farming systems (Jahanshiri et al., 2020). Climate variability's impact on crop diversification in West African countries was analyzed using a composite entropy index, showing that temperature and precipitation variability did not significantly affect cereal, root, and tuber crop diversification over decades (Kevin, 2022). This highlights the importance of utilizing diverse indexes to comprehensively evaluate and plan for crop diversification strategies in different regions. Although there are several methods to calculate diversification, the Simpson Index was taken for the present analysis because of its ease of formulae and understanding.

Simpson's Diversification Index has been utilized in various contexts to assess diversity levels. It has been extensively utilized to assess crop diversification, including in horticulture. The study of plant communities was applied to compare biodiversity between Ras El-Hekma and Omayed protectorate, showing higher diversity in Omayed (Sharashy, 2022). In the agricultural sector, the index was employed to analyze crop diversification towards horticulture in Karnataka, categorizing districts based on growth trends and agro-climatic zones (Singha et al., 2014). Additionally, Simpson's Index was adapted for search result diversification, emphasizing the importance of evenness in multi-aspect search outcomes, leading to improved algorithms (Zhou et al., 2020). Studies in India, particularly in Karnataka, have employed Simpson's Index to analyze the shift towards horticulture crops across different districts. The research highlights varying levels of diversification, with some districts completely transitioning to horticulture crops while others show minimal. Simpson's Diversification Index has been utilized to analyze crop diversification trends in horticulture across different regions. In Karnataka, India, the index revealed a shift towards horticulture crops, with districts like Gulbarga, Raichur, and others showing complete diversification (Singha et al., 2014). The study also highlighted that districts with complete diversification allocated a smaller portion of cultivable land to horticulture crops, while those less diversified dedicated a higher share. Additionally, the application of Simpson's index in assessing plant biodiversity in different areas demonstrated varying levels of diversity, with higher values indicating greater environmental wellness and biodiversity (Zhou et al., 2020). Similarly, Debasis et al. (2018) in their analysis reveals that diversification towards horticulture has resulted in higher returns and increased employment opportunities compared to traditional food grain crops. An econometric model was employed to assess the impact of crop diversification on farmer income and employment, using variables such as farm size, education level, and technology. The findings suggest that promoting crop diversification towards horticulture could enhance farmers' well-being in the state.

The clustering of horticulture districts is crucial in enhancing overall growth and productivity in agriculture. By forming clusters, such as in the Grobogan District in Indonesia, regions can capitalize on their geographical advantages and agroclimatic conditions to boost horticulture production (Matheos & Mulyono, 2019). Through cluster analysis, potential areas for agricultural development can be identified, allowing for strategic planning and resource allocation (Wahyudi et al., 2016). Additionally, cluster formation in various economic sectors, including agriculture, has been shown to reduce transactional costs, encourage innovation, and enhance labor and production efficiency (Dotdueva et al., 2016).

Moran’s I test can be a valuable tool for predicting crop yield and growth in horticulture. It is widely used to evaluate spatial autocorrelation, which is crucial in understanding the spatial patterns of crop growth. By visualizing spatial instability and exploring spatial dependence and heterogeneity, Moran’s I can help identify areas with similar growth patterns, aiding in predicting crop yield variations (Xiong et al., 2019). Additionally, Moran’s theorem has been tested in agroecosystems, showing that spatial synchrony in fruit production can be influenced by environmental factors (Rosenstock et al., 2011). This suggests that Moran’s I can capture the impact of the local environment on crop growth, making it a potentially reliable tool for predicting crop yield and growth dynamics in horticulture. In grassland soils, Moran’s I was utilized to analyze the spatial patterns of soil nutrients, revealing significant positive spatial autocorrelations for soil test phosphorus (STP), magnesium (Mg), pH, and lime requirement (Fu et al., 2011).

Getis-Ord Gi analysis is another valuable tool in horticulture for detecting spatial patterns and hotspots related to various factors. In the context of horticulture, the Getis-Ord Gi analysis has been utilized to predict the formation of endemic areas for brown planthoppers in rice fields (Bharti & Minz, 2022). Additionally, in agriculture, the combination of Getis-Ord Gi analysis with support vector machine (SVM) algorithms has shown promising results in classifying high-resolution images from digital sensor systems, improving overall accuracy in feature classification (Kumar & Parida, 2021). This demonstrates the versatility of Getis-Ord Gi analysis in horticulture, enabling the identification of spatial trends, risk areas, and hotspot detection for better decision-making and resource allocation in agricultural practices. This method aids in identifying hotspots or areas with significant clustering of specific attributes related to horticulture, such as vegetable production factors (Yulianto J. P. et al., 2014). Additionally, Getis-Ord Gi analysis is employed in conjunction with other spatial statistics tools like Moran's Index to detect clustered patterns and create hotspot maps for various agricultural aspects (Rossi & Becker, 2019). By applying the Getis-Ord Gi analysis, horticulturists can pinpoint regions with high or low values of certain variables, facilitating targeted interventions and decision-making processes in horticulture (Wang et al., 2011). This spatial analysis technique enhances the understanding of spatial trends, risks, and connectivity within horticultural landscapes, aiding in effective planning and management strategies.

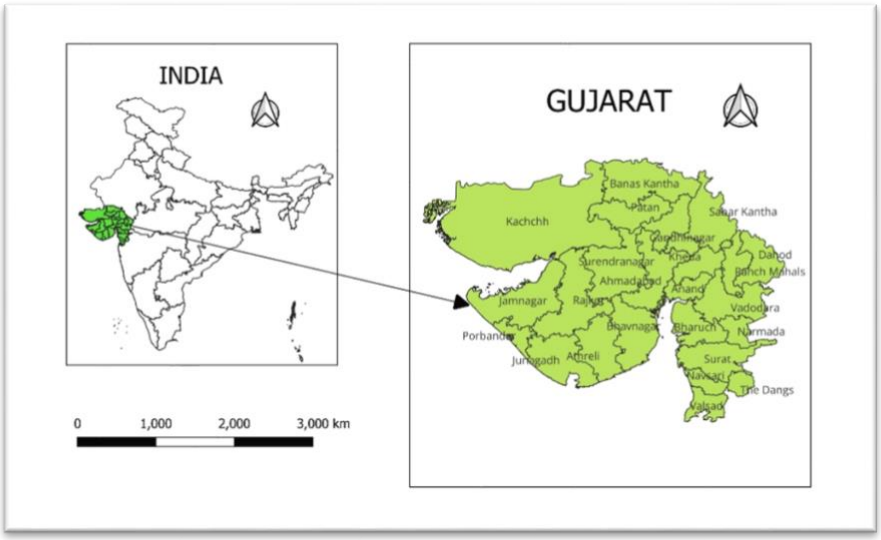
2.1 Research gap

The existing literature lacks an in-depth study of horticulture productivity and diversification trends at the district level in Gujarat. Previous studies have focused more on descriptive analyses and have not utilized any GIS-based techniques such as spatial autocorrelation techniques to explore the spatial patterns and clustering of different horticulture crops across Gujarat's districts, thereby overlooking valuable insights into spatial relationships.

CHAPTER 3: METHODOLOGY

3.1: Study area and its rationale:

Figure 3.1.1. Map of the study area



As India's ninth most populous state, Gujarat presents an interesting area of study due to its unique socio-cultural and geographical characteristics. Gujarat in the overall horticulture production of the country, which was ranked at eighth position in 2011-12, has jumped to the fifth spot in 2021-22. The state's total geographical area measures around 161.98 lakh hectares. Notably, 61% of this area is specifically reserved for cultivation within the state. Districts like Kheda, Mehsana, Amreli, Surat, Gandhinagar, Anand, Patan, Bhavnagar, and Banaskantha have over 70% of their land allocated for cultivation. A significant portion, precisely 9.00%, is categorized as wasteland, which has the potential for effective utilization through various watershed projects. Moreover, 5.00% of the land is assigned as pasture land, while approximately 15.00% is classified as non-agricultural use or cultivable unutilized land. The state showcases diverse tropical climatic types, encompassing sub-humid, arid, and semi-arid climates spread across different regions. A majority, specifically 58.60%, of the state's total area falls under the arid and semi-arid climatic zones, with the arid zone constituting 24.94% and the semi-arid zone 33.66% of the total area. The arid climate prevails in regions like the extreme north including the district of Kachchh, western parts of Banaskantha and Mehsana, and the northern fringe of Saurashtra (Jamnagar), while the remaining areas experience a semi-arid climate. Conversely, districts like Valsad, Dangs, Surat, Vadodara, and Kheda in the far south of the state display a sub-humid climate. In Gujarat, horticulture production is dominated by Vegetables (55%) followed by Fruits (40%), Spices (4%), and Flowers (1%). The state's contribution at the national level in fruit crop production is 9%, vegetable crop 8%, spice crop 12%, and flower crop 8% for the year 2018-19. Prominent fruit crops cultivated in Gujarat include Banana, Mango, Citrus, Papaya, Pomegranate, Guava, and Sapota, while vegetable crops grown are Onion, Potato, Brinjal, Tomato, Okra, Tuber, and Cucurbits. Spices like Cumin, Fennel, Coriander, Chilly, and Garlic are mainly produced in the State. Gujarat holds a significant position in the cultivation of seed spices and Isabgul, a prominent medicinal crop. There is a consistent increase in cultivating new fruit crops like Tissue Culture Date Palm, Dragon Fruit (Kamalam fruit), and Strawberry. Additionally, the State has introduced horticulture crops such as cashew nut, palmarosa, sweet orange, and various medicinal crops. The onion dehydration industry in the State ranks as the largest in the country. High-tech greenhouses are employed for growing flowers like carnations, gerbera, and roses in floriculture. In the year 2019-20, compared to 2018-19, fruit crop production surged to 9261 lakh tonnes from 92.26 lakh tonnes, vegetable crop to 132.30 lakh tonnes from 125.40 lakh tonnes, spices to 10.96 lakh tonnes from 8.24 lakh tonnes, while flower production remained stable at 1.96 lakh tonnes. Gujarat holds the top position globally in the production of Castor, Cumin, Fennel seeds, and Psyllium Husk. Therefore, there is a need to study the growth and diversification patterns along with spatial autocorrelation to delve into the horticulture growth analysis of Gujarat.

3.2: Trend analysis

The district-level analysis has been aimed at for the current study. For this, the districts are selected according to the census of 2001, and the newly formed districts are merged to form a single value from the district from which it was bifurcated. Therefore, a total of 25 districts have been selected for the analysis. Each district has its unique geography, culture, and history. These districts are an important part of the state's governance and contribute to its economic growth and development. To achieve the defined objectives of the study, four-step analyses have been done. First, a trend analysis is done to determine the growth pattern of horticulture crops using variables like area, production, and productivity of horticulture crops in Gujarat. Pie charts and graphs have been used to analyze the performance and position of Gujarat in terms of percentage share across different horticulture crops. For conducting this analysis, secondary data has been utilized from the Director of Horticulture: Agriculture, Farmers Welfare and Co-operation Department, Government of Gujarat. The dataset spans over 24 years, starting from 1999-2000 and extending up to the latest available data for 2022-2023, with a specific emphasis on Horticulture crop area, production, and productivity among all districts.

3.3: Simpson's Diversification Index

To understand the cropping intensity, Simpson's Diversification Index (SDI) was utilized for the horticulture crops in all the districts of the state from 2014-2015 to 2020-2021. Although there are different types of methods to calculate diversification, for example, the Ogive Index and Entropy Index, the Simpson Index was taken for the present analysis due to its ease of the formula and understanding. The required data was collected from the Directorate of Economics and Statistics, Ministry of Agriculture, NHB. The SDI of the districts was estimated by using the following equation:

$$\textbf{SDI}= \mathbf{1} - \sum(\frac{\boldsymbol{n}}{\boldsymbol{N}})^{\mathbf{2}} \qquad \text{(Eqn 1)}$$

where n stands for the horticulture crop area under ith district (1, 2, . . . 25) and N implies GCA of the district. Index value ranges from 0 to 1, wherein, there is a complete diversification towards the horticulture crops if the SDI value approaches close to 1 or complete specialization of one crop if the SDI value approaches 0, which means that there's no diversification (Eqn 1)

3.4: Moran's Spatial Autocorrelation:

The Moran's I test is a statistical technique utilized for evaluating spatial autocorrelation within data. It derives its name from Patrick Alfred Pierce Moran, an Irish-born British-Australian statistician credited with the test's development in the mid-20th century. This particular test holds significance in the realms of spatial statistics and geographical analysis, where comprehending spatial patterns and interdependencies in data proves essential for various practical applications like urban planning, epidemiology, ecology, and economics. Before engaging with Moran's I test, acquiring an understanding of spatial autocorrelation is crucial. Within spatial data, autocorrelation denotes the association between variable values at distinct locations. Spatial autocorrelation emerges when values nearby exhibit greater similarity compared to those situated farther apart. This phenomenon can manifest diversely—such as in a geographic dataset, indicating that neighboring regions commonly display akin economic indicators or environmental traits compared to regions distantly located from one another. The mathematical expression of Moran's I is as follows:

$$\textbf{Moran's I} = \frac{n}{S_o} \times \frac{\sum_i \sum_i W_{ij}(x_i)[x_j - \bar{X}]}{\sum_i [x_i - \bar{X}]^2} \qquad \textbf{(Eqn 2)}$$

where x represents the interest variable, X denotes the mean of x, n signifies the count of spatial units, Wij stands for the standardized weight matrix connecting observation I and j, which features zeroes on the diagonal, and SO represents the aggregate sum of all spatial weights., i.e., SO = ∑I∑J Wij (Eqn 2).

Interpreting Moran's I statistic involves understanding whether there is spatial autocorrelation in your dataset and the nature of that autocorrelation. The Moran's I statistic ranges between +1 to -1. Positive Moran's I (I > 0), indicates positive spatial autocorrelation, which means that nearby locations tend to have similar attribute values. It is most commonly observed when there are spatial clusters of similar values, indicating spatial aggregation or clustering. Negative Moran's I (I < 0), indicates negative spatial autocorrelation, meaning nearby locations tend to have dissimilar attribute values. This suggests spatial dispersion, where areas with high values are surrounded by areas with low values, or vice versa. Values close to 0 (I ≈ 0), suggest no significant spatial autocorrelation, implying that attribute values are randomly distributed across space. However, it's essential to consider the statistical significance of Moran's I value to determine if the observed pattern is significant or just due to random chance.

A significant Moran's I value (usually with a p-value < 0.05) indicates that the observed spatial pattern is unlikely to have occurred by random chance alone. In contrast, a non-significant p-value suggests that the spatial pattern observed could plausibly occur under spatial randomness.

Moran's I scatter plots and the associated quadrants are used for the visualization of spatial autocorrelation, which is the degree to which the values of a variable in geographic space are correlated. The X-axis contains the variable of interest, while the Y-axis represents the average value of the variable among neighboring spatial units.

Quadrants in Moran's I Scatter Plot:

Quadrant I (High-High): Spatial units with high values surrounded by spatial units with high values. This suggests positive spatial autocorrelation (clusters of high values).

Quadrant II (Low-High): Spatial units with low values surrounded by spatial units with high values. This indicates negative spatial autocorrelation (low values surrounded by high values).

Quadrant III (Low-Low): Spatial units with low values surrounded by spatial units with low values. This also suggests positive spatial autocorrelation (clusters of low values).

Quadrant IV (High-Low): Spatial units with high values surrounded by spatial units with low values. This indicates negative spatial autocorrelation (high values surrounded by low values).

Positive autocorrelation is indicated when you see a concentration of points in Quadrants I and III. It suggests that similar values are clustered together in space. Similarly, negative autocorrelation is indicated by a concentration of points in Quadrants II and IV. It suggests a pattern where dissimilar values are adjacent to each other in space. Autocorrelation is likely present when you observe a non-random pattern in the Moran's I scatter plot. This can be confirmed by calculating Moran's I statistic.

For the current study, Moran's Spatial Autocorrelation test was performed using R software to get the desired results. The district-level shapefile for the state of Gujarat was obtained from the Census of India website for analysis.

3.5: Hotspot and coldspot analysis: Getis- Ord Gi*

The Getis-Ord Gi, which is named after Arthur Getis and J.K. Ord, represents a spatial statistics method utilized for examining spatial clustering or spatial autocorrelation in data. It is exceptionally beneficial in pinpointing hotspots or coldspots within a spatial dataset, signifying areas where values deviate significantly higher or lower than anticipated based on their spatial distribution. Put simply, it helps in identifying whether certain values are closely grouped in space, proving valuable in diverse fields like epidemiology, urban planning, criminology, and environmental science. The Gi statistic gauges the spatial autocorrelation of a variable, revealing whether values are clustered, dispersed, or randomly spread out across space.

In this study, the Getis-Ord Gi statistic is used for the identification of significant hotspots and coldspots, thereby illuminating the spatial distribution of productivity within the region. The results of the Getis-Ord Gi analysis are analyzed using maps that are created in R software. This has helped in identifying the location and extent of hotspots or coldspots within the study area. The mathematical expression of Getis-Ord Gi* is as follows:

$$Gi = \frac{\sum_{j=1}^{n} w_{i,j} x_j - \bar{X} \sum_{j=1}^{n} w_{i,j}}{S \sqrt{\frac{\left[\sum_{j=1}^{n} w^2{}_{i,j} x_j - \left(\sum_{j=1}^{n} w_{i,j} \right)^2 \right]}{n-1}}} \qquad \textbf{(Eqn 3)}$$

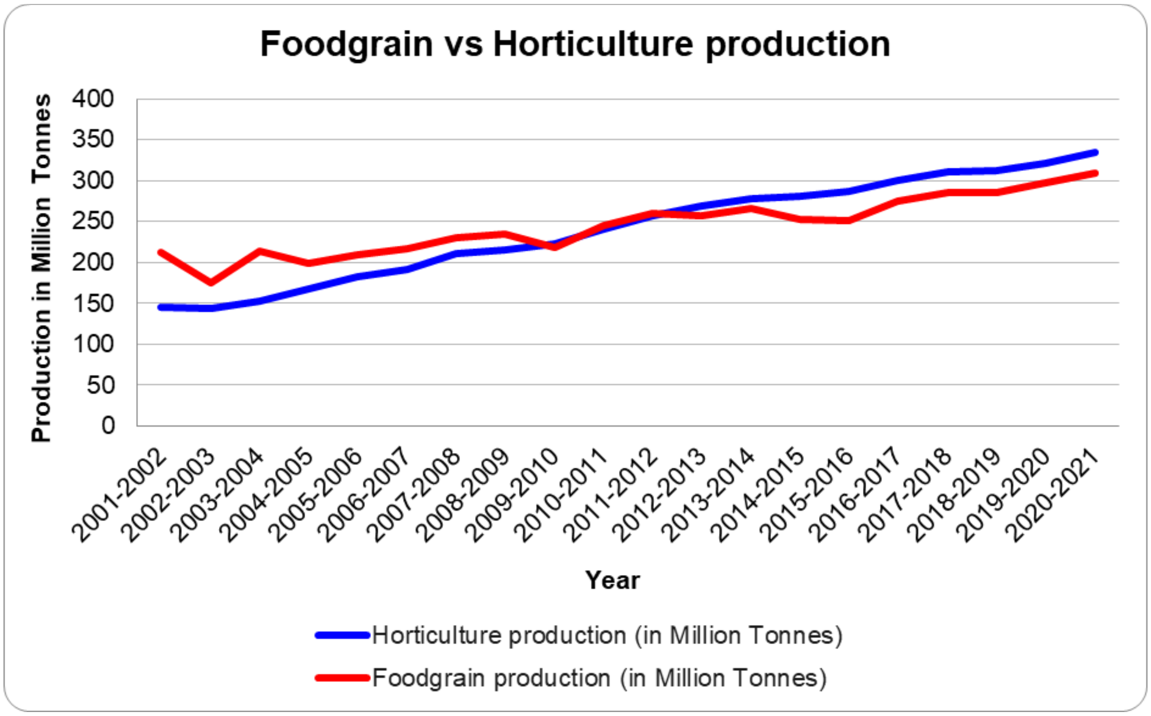
Where xj represents the feature value attribute for j, Wj signifies the spatial weight between I and j, and n denotes the total features count (Eqn 3). The results were also interpreted considering the gstat values obtained, where positive Gi values indicate hot spots where high values cluster together, suggesting areas of high significance. Negative Gi values indicate cold spots where low values cluster together, suggesting areas of low significance. The Gi values closer to zero suggest that the feature's value is not significantly different from its neighbors.

CHAPTER 4: ANALYSIS

4.1 Trend analysis

As per the Annual Horticulture Statistics at a Glance Report 2021, the production of food grains used to surpass horticulture production pre-2009. However, post-2010, horticulture production exceeded food grain production, with the gap between the two widening as observed in Figure 4.1.1. The shift in market demand from food grains to fruits and vegetables can be attributed to several reasons. Firstly, the consumption of fruits and vegetables is directly linked to income levels. With the increase in average income due to the 6th pay commission recommendation, consumers' purchasing power rose, leading to a higher demand for fruits and vegetables in India. Secondly, the trend of growing urbanization encouraged consumers to explore different diet plans involving fruits and vegetables. Thirdly, factors such as Westernization (vegan culture), the desire for a healthier lifestyle, and the revival of yoga practices have steered people towards preferring fresh and light foods like fruits and vegetables over traditional staples like rice, pulses, and spices. Lastly, international health reports have emphasized the significance of incorporating fruits and vegetables into one's diet to mitigate health risks. India is embracing floriculture, considering it as an emerging sector, driven by modernization and the increasing influence of foreign cultures and traditions. While flowers were previously used mainly for religious or auspicious events, they are now exchanged on various occasions such as birthdays, weddings, friendship Day and more.

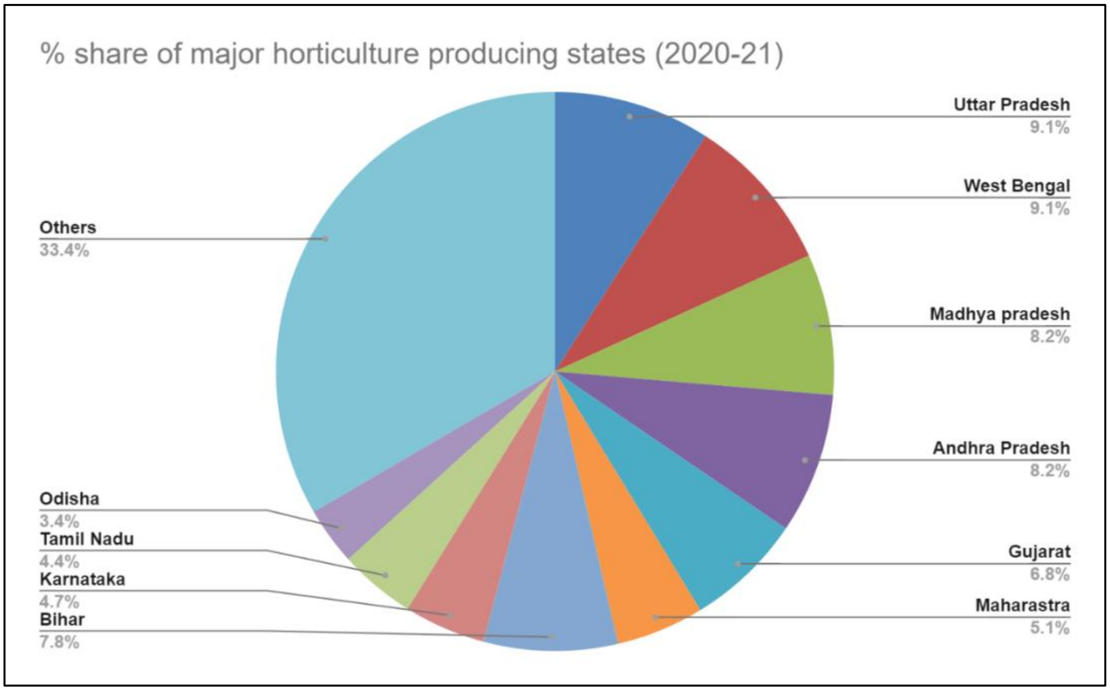
Figure 4.1.1 Foodgrain and Horticulture Production in India



Source: Horticulture Statistics at a Glance 2021

The Compound Annual Growth Rate (CAGR) of horticulture production in India was 2.96% during 2011-12 to 2020-21. This growth rate indicates a steady increase in horticultural crop output over the decade, reflecting both increased cultivation and the possibility of improved productivity. This shift towards horticulture reflects the diversification of agriculture away from staple food grains towards high-value crops. Since 1990-91, the area under horticulture has also been increasing continuously. The Compound Annual Growth Rate (CAGR) in the horticulture area was 1.88% from 2011-12 to 2020-21, which signifies the ongoing efforts taken to allocate more land towards horticulture crop cultivation.

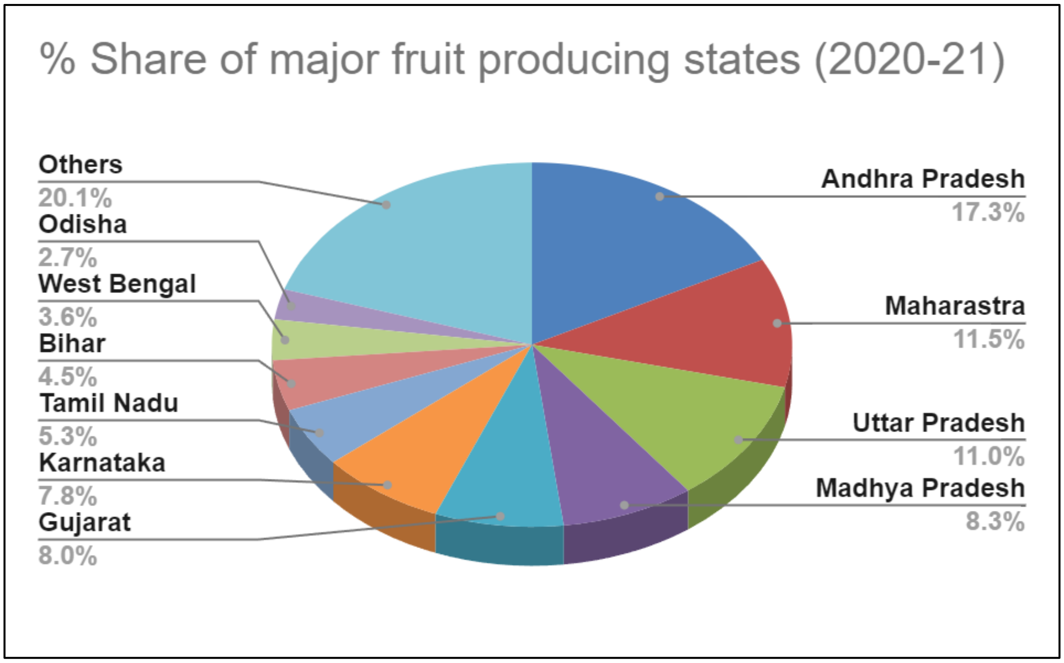
Figure 4.1.2. Percentage share of major horticulture-producing states (2020-21)



Source 1: Horticulture Statistics at a Glance 2021

In 2020-21, as seen in Figure 4.1.2, the percentage share of total horticulture production was highest in the state of Uttar Pradesh (408.13 Lakh Tonnes) followed by West Bengal (348.62 Lakh Tonnes) and Madhya Pradesh (337.04 Lakh Tonnes). In the case of Gujarat, the total production was 242.06 Lakh Tonnes, thus occupying the fifth place in the total horticulture production.

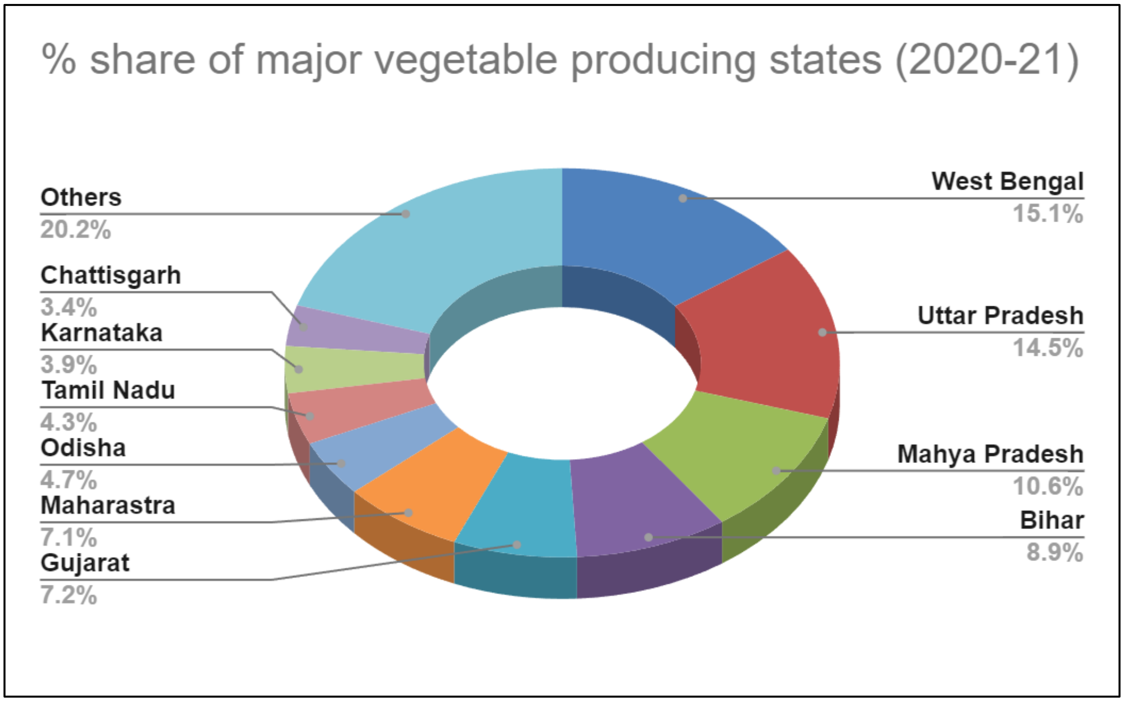
Figure 4.1.3. Percentage share of major fruit-producing states (2020-21)



Source: Horticulture Statistics at a Glance 2021

As seen in Figure 4.1.3, the total production of fruits in the fiscal year 2020-21 was highest in the case of Andhra Pradesh (177.08 Lakh Tonne) followed by Maharashtra (117.38 Lakh Tonne) and Uttar Pradesh (112.31 Lakh Tonne). The percentage share of Gujarat in terms of fruit production was 8%, thereby occupying the fifth position in total fruit production in India in the year 2020-21.

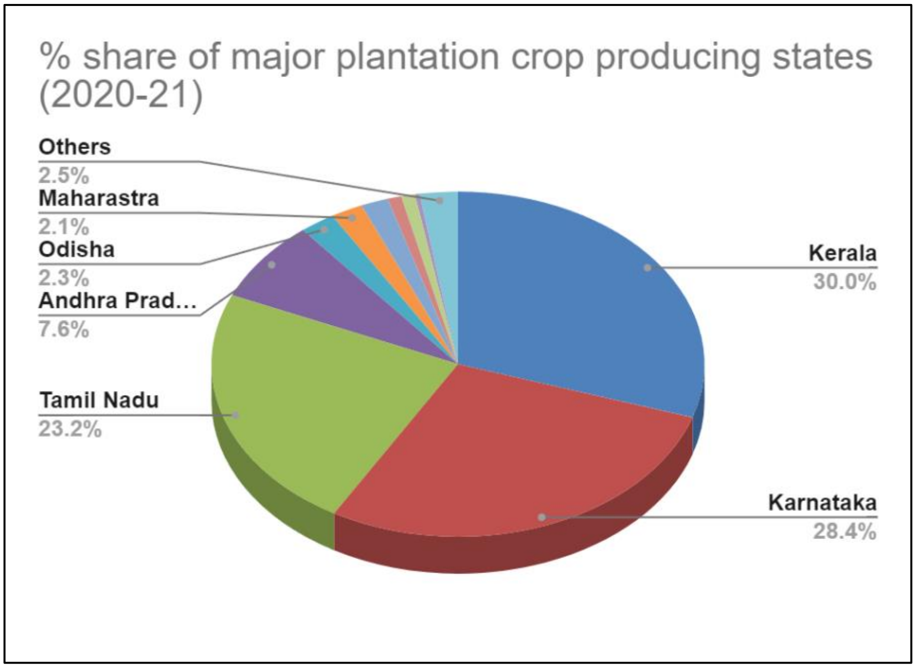
Figure 1.1.4. Percentage share of major vegetable-producing states (2020-21)



Source: Horticulture Statistics at a Glance 2021

Apart from providing nutritional benefits, a robust vegetable sector contributes to agricultural diversification, reducing dependency on traditional crops and improving resilience against price fluctuations or crop failure. During 2020-21, the area under vegetable production was 10.86 Million Hectares covering production of 200.45 Million Tonne in India. As seen in Figure 4.1.4, the majority share in horticulture production is occupied by West Bengal (15.1%), followed by Uttar Pradesh (14.5%). The share of Gujarat in total vegetable production was 7.2% occupying the fifth position in the year 2020-21.

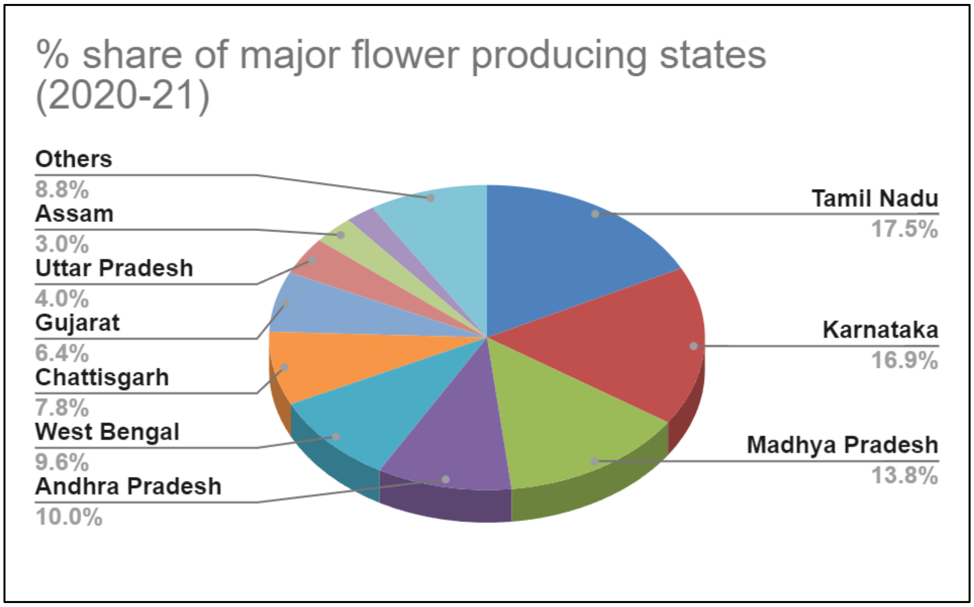
Figure 4.1.5. Percentage share of major plantation crop-producing states (2020-21)



Source: Horticulture Statistics at a Glance 2021

During 2020-21, the area under plantation crops was 42.55 Lakh hectares having a total production of 166.29 Lakh Tonne in India. During this period, the highest percentage share was in Kerala (29.9%), followed by Karnataka (28.3%) and Tamil Nadu (23.1%). The share of Gujarat in total plantation crops was very meager, that is, 0.9% as seen in Figure 4.1.5.

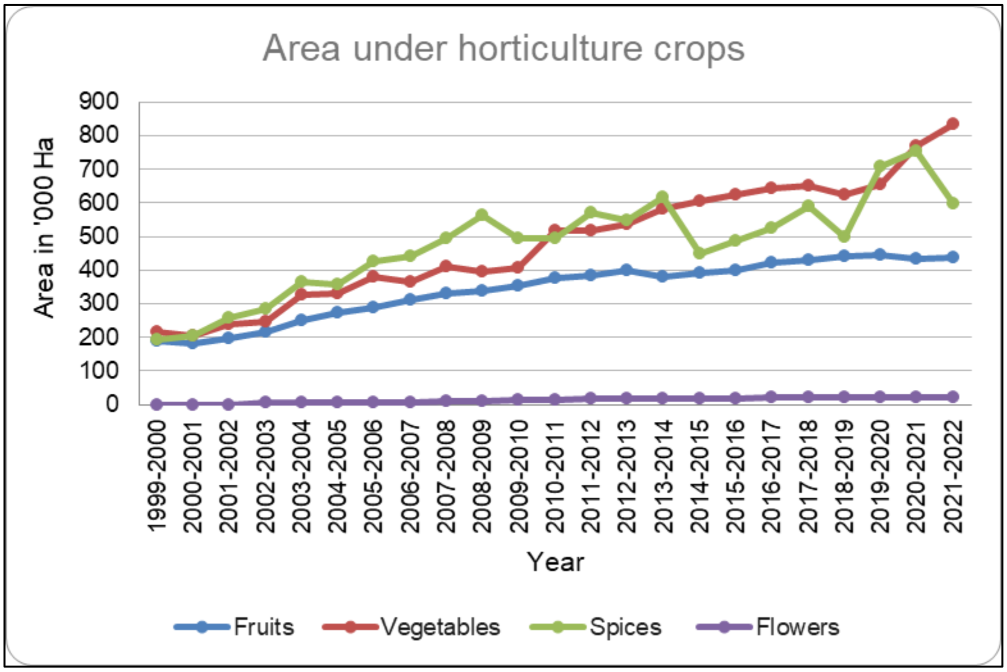
Figure 4.1.6. Percentage share of major flower-producing states (2020-21)



Source: Horticulture Statistics at a Glance 2021

There has been a significant increase in area and production under flower cultivation observed in India since 2003-04. Catering to both domestic as well as international demand, floriculture has a very good scope in the country. Indian farmers have realized the importance of floriculture for bee-keeping which is an alternate income-earning source for the farmers. As seen in Figure 4.1.6, Tamil Nadu (17.5%) occupies the highest percentage share in floriculture for the year 2020-21, followed by Karnataka (16.9%) and Madhya Pradesh (13.8%). The percentage share of Gujarat in total flower production is 6.4% occupying the 7th position.

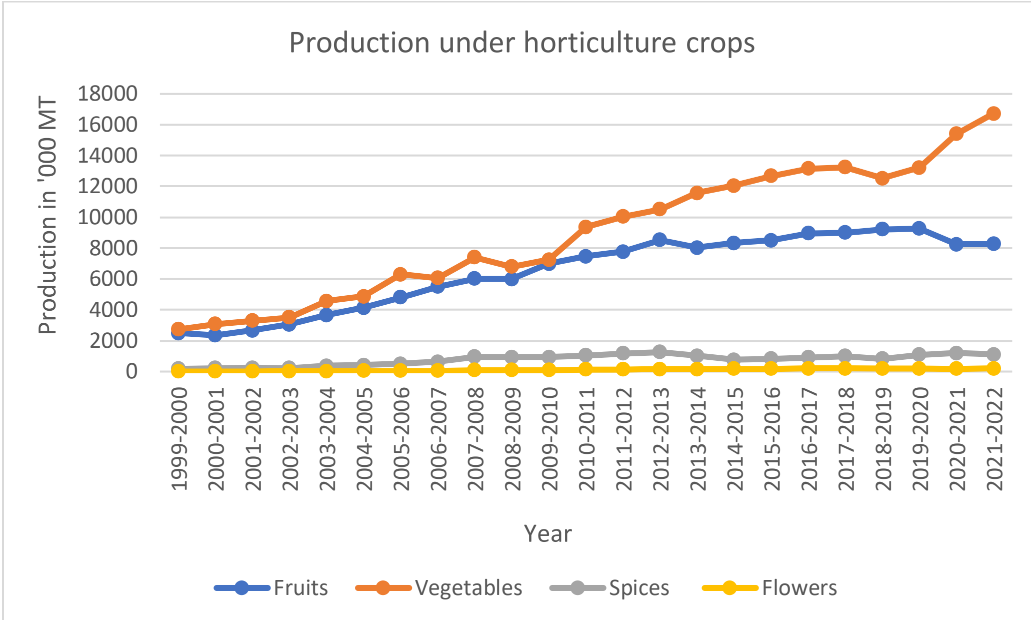
Figure 4.1.7. Total area under horticulture crops in Gujarat (1999-2022)



Source: Director of Horticulture, Government of Gujarat

As seen in Figure 4.1.7, the area under flower production has been stable over the years. In 2021-22, the total area under flower production was 21 thousand Hectares. The area under fruit production has been increasing over the years from 189 thousand Hectares in 1999-200 to 439 thousand Hectares in 2021-22. The area under vegetable production has also been showing a tremendous increasing trend over the years in Gujarat from 216 thousand Hectares to 833 thousand Hectares in 2021-22. There has been frequent variation observed in spice production over the years. Spice production has shown a deep after moving along with vegetable production in 2021-22. In 1999-200, the total area under spices was 192 thousand Hectares, which increased to 755 thousand Hectares in 2020-21 and thereafter decreased significantly to 597 Thousand Hectares in 2021-22.

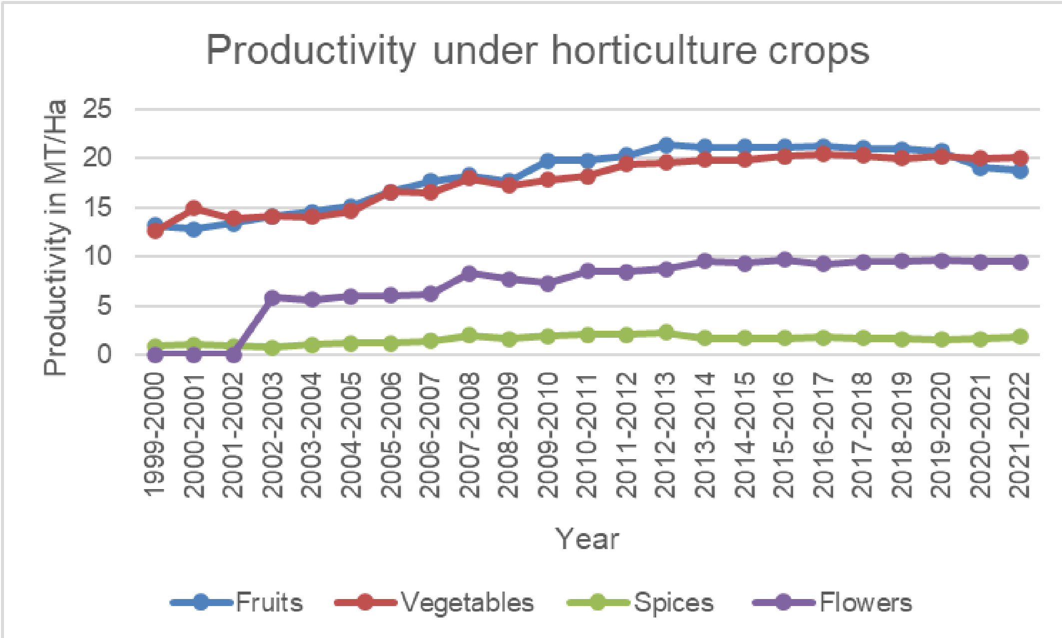
Figure 4.1.8. Total production of horticulture crops in Gujarat (1999-2022)



Source: Director of Horticulture, Government of Gujarat

In terms of production, there has been a significant increase in the production of vegetables over the years in Gujarat as observed in Figure 4.1.8. The production has increased by almost six times from 2730 MT in 1999-2000 to 16733MT in 2021-22. The fruit production is also growing. Fruit production has increased from 2491 MT to 8268 MT in 2021-22. The production of flowers is quite low as seen in the figure. There has been a fluctuation in flower production observed over the years. From 0 production in 1999-2000, the production has increased to 195 MT in 2021-22. Spice production has shown stable growth over the years. From production of 170 MT in 1999-2000, spice production has shown an increasing trend up to 2013-14 before showing a significant deep in 2014-15 to a production of 767 MT. The production has been showing fluctuations post 2014-15.

Figure 4.1.9. Total productivity of horticulture crops in Gujarat (1999-2022)



Source: Director of Horticulture, Government of Gujarat

Fruits and vegetables indicate the highest productivity in Gujarat over the years as seen in Figure 4.1.9. The productivity of spices has more or less been constant over the period from 1999-2000 to 2021-22. Flower productivity, on the other hand, has shown an increase although it has remained stable in the later period.

4.2 Simpson's Diversification Index:

Indian agriculture has experienced a dramatic shift from traditional to high-value agriculture in recent years. The economy has also seen a change in consumption patterns, moving from traditional cereals to a more comprehensive and nutritious diet including fruits, vegetables, milk, fish, meat, and poultry due to the rapid economic growth. Therefore, the introduction of high-value crops into Indian agriculture has been established. Many scholars suggest that agricultural diversification can be a tool to boost farm incomes, create employment opportunities, reduce poverty, and conserve natural resources. Crop diversification holds great potential as an economic catalyst in the agricultural sector, which could be critical in addressing challenges following the green revolution. With agricultural land shrinking due to urban expansion, high population growth, and changes in food habits, farmers are under pressure to integrate or replace high-value crops into their farming systems.

Crop diversification is a strategic approach aimed at optimizing the utilization of land, water, and various resources to enhance overall agricultural progress. It presents farmers with viable alternatives for cultivating different crops in diverse agro-climatic conditions, mitigating risks linked to climatic and biological uncertainties (Acharya et al., 2011). Over the past two decades, Indian agriculture has been shifting towards High-Value Commodities (HVCs), particularly fruits, and vegetables, as well as dairy, meat, and aquatic products. The surge in this transition occurred notably during the 1990s. HVCs play a significant role in the total agricultural production value, influenced by factors on both the supply and demand sides in conjunction with infrastructural advancements and innovative establishments (Bhattacharyya, 2008). The diversification of crops is a prevalent trend in the Indian agricultural sector, offering substantial opportunities to enhance economic sustainability and diminish reliance on primary subsidized agricultural goods.

Tabel 4.2.1 Simpsons Diversification Index for horticulture crops in Gujarat

District	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021
Ahmadabad	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Amreli	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Anand	0.96	0.97	0.97	0.97	0.97	0.97	0.96
Banas Kantha	0.98	0.98	0.98	0.97	0.97	0.97	0.98
Bharuch	0.98	0.99	0.99	0.99	0.99	0.99	0.99
Bhavnagar	0.99	0.99	0.99	0.99	0.99	1.00	1.00
Dahod	1.00	0.99	0.99	1.00	0.99	0.99	0.99
Gandhinagar	0.98	0.98	0.98	0.99	0.99	0.98	0.96
Jamnagar	1.00	1.00	1.00	0.99	1.00	0.97	0.97
Junagadh	0.97	0.97	0.97	0.98	0.97	0.98	0.98
Kachchh	0.99	0.99	0.98	0.98	0.94	0.97	0.97
Kheda	0.98	0.99	0.99	0.99	0.99	0.99	0.98
Mahesana	0.99	0.99	0.98	0.99	0.98	0.98	0.98
Narmada	0.97	0.97	0.97	0.97	0.98	0.98	0.98
Navsari	0.68	0.70	0.71	0.60	0.66	0.72	0.71
Panch Mahals	1.00	1.00	1.00	1.00	1.00	1.00	0.99
Patan	0.99	0.97	0.98	0.97	0.97	0.98	0.99
Porbandar	0.97	0.99	0.97	0.95	1.00	0.96	0.97
Rajkot	1.00	0.99	1.00	0.99	1.00	0.99	0.99
Sabar Kantha	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Surat	0.94	0.97	0.96	0.96	0.95	0.96	0.96
Surendranaga	0.97	0.98	0.97	0.98	0.97	0.98	0.98
The Dangs	0.98	0.97	0.98	0.98	0.97	0.98	0.97
Vadodara	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Valsad	0.88	0.88	0.89	0.91	0.92	0.91	0.91

Source: Authors Calculation

Table 4.2.1 consists of 25 districts of Gujarat, with data spanning from 2014-15 to 2020-21. Each district has values corresponding to each year within this period. The values represent some measure of diversification, with higher values indicating greater diversity within the district and lower values indicating less diversification.

As seen in the table, districts such as Amreli, Bhavnagar, and Panchmahal have achieved complete diversification of crops from 2014-15 to 2020-21. Ahmadabad, Banaaskantha, Bharuch, Dahod, Gandhinagar, Kheda, Junagadh, Mehsana, Narmada, Patan, Rajkot, Sabarkantha, Surendranagar and Vadodara have almost achieved the path towards reaching complete diversification. Fluctuations have been noticed in terms of crop diversification over the years in the districts of Anand, Jamnagar, Kachchh, Porbandar, Surat, and Dangs. On the other hand, Valsad District is moving on the path of diversification at a slow pace compared to the other districts. Navsari District is far from achieving complete diversification. There are frequent fluctuations and variations noticed over the years from 2014-15 to 2020-21.

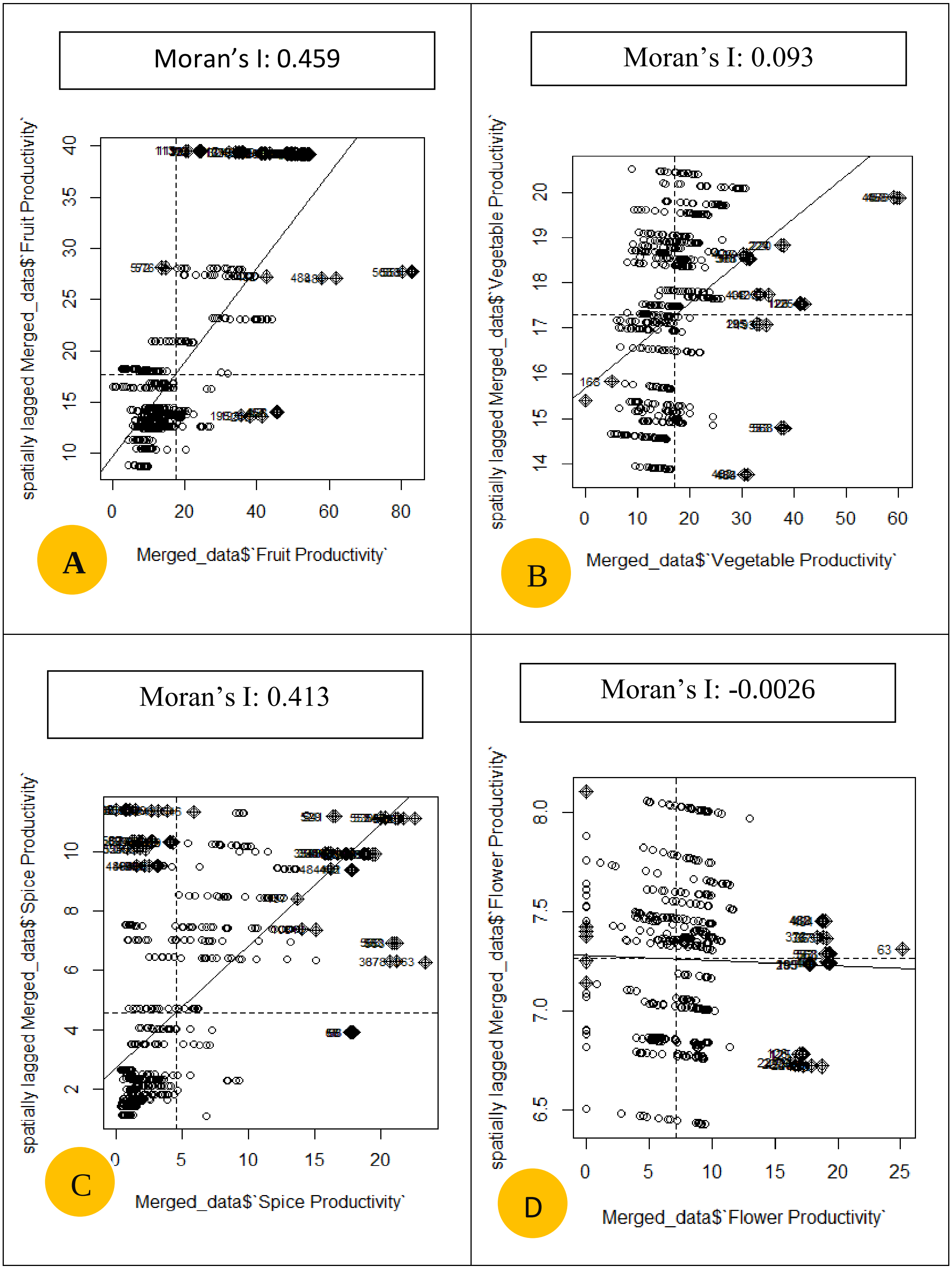
4.3 Moran's I: For identifying spatial autocorrelation:

In this study, the findings of Moran's I analysis provide crucial evidence regarding the spatial autocorrelation of productivity of various horticulture crops within the designated research area. While Moran's I test provides valuable quantitative insights, visual representation through scatter plots offers a complementary perspective on spatial relationships. Scatter plots allow us to visualize the spatial distribution of observations, providing insights into the clustering or dispersion of values across space. Each point on the scatter plot corresponds to an observation within the dataset, with the x-axis and y-axis representing spatial coordinates and the variable of interest, respectively. By plotting these points on a two-dimensional plane, we gain visual clarity regarding the spatial structure of the dataset.

The outcomes in Figure 4.3.1 indicate that higher positive values of the Moran index (explicitly about fruit productivity and spice productivity) suggest a more pronounced inclination towards spatial clustering. This implies the existence of localized hotspots where these are concentrated. Conversely, lower positive values (particularly about vegetable productivity) point towards a relatively weaker tendency for spatial clustering. It is observed that fruit productivity exhibits a notably higher Moran's I value of 0.459 compared to other horticulture crops. This indicates a stronger positive spatial autocorrelation, implying that districts with elevated fruit productivity tend to be geographically clustered together. Following this trend is spice productivity, which displays a substantial Moran's I value of 0.413, suggesting moderate positive spatial autocorrelation. Consequently, districts with heightened spice productivity also exhibit geographical clustering tendencies. In comparison, vegetable productivity demonstrates a considerably lower level of positive spatial autocorrelation with an associated Moran's I value of 0.093.

However, flower productivity corresponds to a Moran's I value of -0.002. This indicates a weak negative spatial autocorrelation. This indicates that neighboring observations are slightly less similar than would be expected by random chance, but the effect is very small. Spatial patterns in the data are likely minimal or insignificant. The associated p-value of 0.5782 indicates that this observed Moran's I value is not statistically significant. Therefore, we cannot conclude that there is any meaningful spatial autocorrelation in the data.

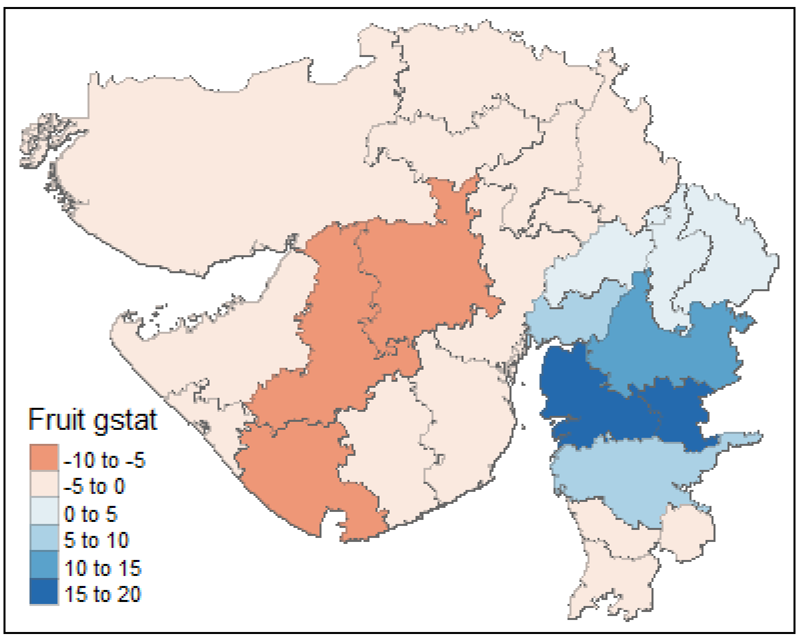
Figure 4.3.1 Moran's I scatter plots of productivity across different horticulture crops in Gujarat



4.4 Hotspots and coldspots analysis: Getis-Ord Gi*

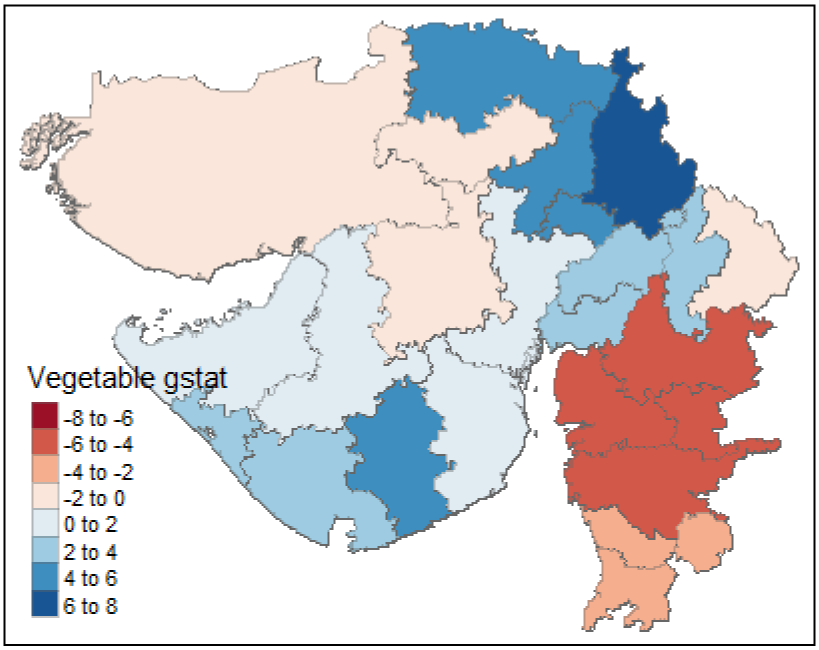
The utilization of the Getis-Ord Gi* method for hotspot and coldspot analysis yields incredible insights into the heterogeneous nature of horticulture crop productivity. This analytical approach not only unveils spatial patterns in horticulture crop productivity but also sheds light on how certain types of horticulture crops tend to concentrate within particular neighborhoods or districts. By identifying areas of statistically significant clustering, this methodology effectively distinguishes between hotspots—characterized by high concentrations of horticulture crop productivity—and coldspots—marked by low concentrations of productivity of horticulture crops.

Figure 4.4.1 Hotspot and coldspot map of fruit productivity in Gujarat



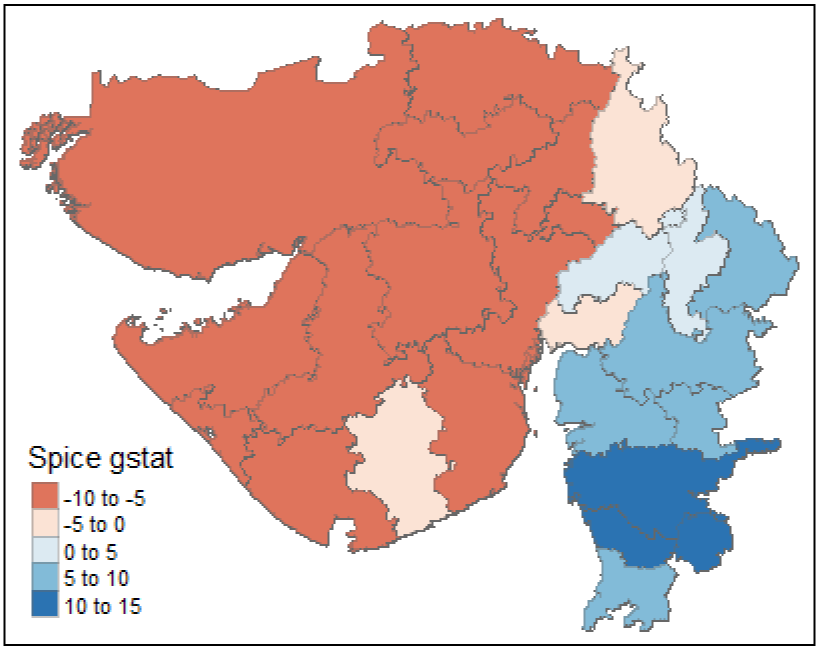
However, in the case of fruit productivity, as seen in Figure 4.4.1, five districts, namely Anand, Bharuch, Narmada, Surat, and Vadodara have emerged as neighboring hotspots. This indicates a high concentration of fruit productivity compared to other districts and demonstrates a clustering pattern. In contrast, Surendranagar, Rajkot, and Junagadh have emerged as districts with neighboring coldspots, indicating a low concentration of fruit productivity.

Figure 4.4.2 Hotspot and coldspot analysis of vegetable productivity in Gujarat



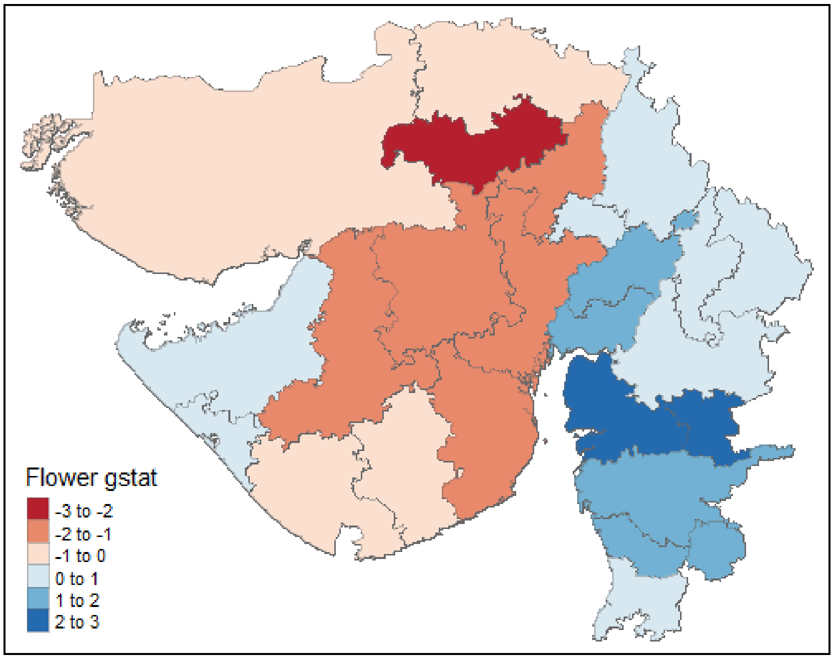
Regarding vegetable productivity, as seen in Figure 4.4.2, ten neighboring districts- Porbandar, Junagadh, Amreli, Anand, Kheda, Pachmahal, Sabarkantha, Gandhinagar, Mahesana, and Banaaskantha have emerged as hotspots, while Surat, Bharuch, Narmada, and Vadodara has been identified as coldspot districts.

Figure 4.4.3 Hotspot and coldspot maps of spice productivity in Gujarat



As seen in Figure 4.4.3, in the case of Spice productivity, Valsad, Navsari, Dang, Surat, Narmada, Bharuch, Dahod and Vadodara were added as hotspots. Meanwhile, Kachchh, Banaaskantha, Patan, Mahesana, Ahmadabad, Surendranagar, Rajkot, Jamnagar, Porbandar, Junagadh, Bhavnagar, and Gandhinagar have emerged as coldspots for spice productivity, suggesting similarly low concentrations within those neighboring areas.

Figure 4.4.4 Hotspot and coldspot map of flower productivity of Gujarat



Moreover, as seen in Figure 4.4.4, Navsari, Dang, Surat, Anand, Kheda, Bharuch, and Narmada have been identified as hotspots for flower productivity, while Patan, Mahesana, Surendranagar, Rajkot, Bhavnagar, and Ahmadabad are considered coldspot districts based on their significantly lower productivity.

CHAPTER 5: CONCLUSION AND POLICY IMPLICATIONS

By taking into account these insights and implementing targeted policies and interventions, policymakers can cultivate the growth of a vibrant, diversified, and sustainable horticulture sector that contributes to the socio-economic development of the region. The horticulture sector in Gujarat has witnessed notable diversification across various districts with Navsari district diversifying at a slow pace. The Simpson's diversification index indicates a positive trend towards diversification in horticulture, which holds promise for the overall growth and resilience of the sector. Nevertheless, the analysis conducted by Moran's I reveal disparities in productivity levels among different types of horticulture crops. Fruit productivity displays a relatively high spatial autocorrelation (0.459), indicating clusters of high or low fruit productivity in specific areas. Similarly, spice productivity also demonstrates significant spatial autocorrelation (0.413), implying localized patterns of spice cultivation. Conversely, vegetable productivity shows a lower degree of spatial autocorrelation (0.093), suggesting a more dispersed distribution throughout the region. Interestingly, flower productivity exhibits a negative spatial autocorrelation (-0.0026), indicating a lack of clustering or dispersion in flower cultivation.

These findings provide valuable insights for policymakers and stakeholders in the horticulture sector. Policymakers should persist in supporting initiatives that promote the cultivation of a diverse array of crops by farmers. This approach not only mitigates the risks associated with mono-cropping but also enriches market opportunities and resilience to external shocks. The spatial autocorrelation analysis provided by Moran's I underscore the necessity for tailored interventions based on the distinct characteristics of various horticulture crops. For example, regions with clusters of high fruit productivity could benefit from infrastructure development and market linkages to capitalize on their comparative advantage in fruit cultivation. Similarly, areas with low vegetable productivity may necessitate investment in technologies and extension services to enhance productivity levels. The disparities in spatial autocorrelation among different crops hint at the presence of underlying factors influencing productivity. Policymakers should delve into these factors, which may encompass soil quality, access to irrigation, agro-climatic conditions, and socio-economic factors. By addressing these disparities, policymakers can strive towards achieving a more equitable distribution of productivity gains across regions and communities. Beyond production, there is a need to concentrate on value addition and market access for horticulture products. This encompasses supporting initiatives like food processing, cold chain infrastructure, quality certification, and market intelligence systems. By enhancing the value of horticulture products, farmers can secure a larger portion of the consumer value chain, resulting in increased income and sustainability. To tackle the challenges and seize the opportunities in the horticulture sector, continual investment in research, technology development, and extension services is imperative. This includes breeding programs for high-yielding and disease-resistant varieties, training programs for farmers on optimal agricultural practices, and dissemination of pertinent information on market trends and innovations. As the horticulture sector expands, it is crucial to prioritize sustainability and environmental conservation. Policymakers ought to advocate for sustainable farming practices, such as organic farming, integrated pest management, water conservation measures, and agroforestry. By embracing sustainable practices, farmers can uphold the long-term viability of the horticulture sector while conserving natural resources for future generations.

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