P-ISSN: 2618-0723
E-ISSN: 2618-0731

NAAS Rating (2025): 5.04
www.extensionjournal.com

International Journal of Agriculture Extension and Social Development

Volume 8; Issue 8; August 2025; Page No. 43-49

Received: 26-06-2025
Accepted: 29-07-2025

Indexed Journal
Peer Reviewed Journal

Spatiotemporal analysis of farmer queries from Kisan call centre data

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DOI: https://www.doi.org/10.33545/26180723.2025.v8.i8a.2244

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Abstract

Agricultural data analytics has emerged as a transformative tool for improving farmers' decision-making, forecasting agricultural trends, and addressing localized challenges, thereby fostering sustainable and resilient farming practices. This study investigates the evolving information requirements of farmers in Gujarat through a detailed analysis of 1,937,276 call records from the Kisan Call Centre (KCC) database, spanning the period from 2009 to 2024. These calls represent a subset of the national KCC repository, which contains a total of 40,774,833 records, making this one of the largest state-level explorations of its kind. The research analyzes month-wise, district-wise, and query-type distributions, providing valuable insights into the dynamic nature of agricultural inquiries across Gujarat. Visualizations of the data reveal significant temporal fluctuations in call volumes, with peaks typically aligning with major cropping seasons. Spatial analysis identifies districts with consistently high engagement, enabling more targeted extension strategies. Queries were classified across multiple dimensions, including crop type, season (Kharif, Rabi, Jayad), and sector (Agriculture, Horticulture, Animal Husbandry, Fisheries). Weather-related concerns showed a sharp rise during monsoon months, while pest and disease-related inquiries were distributed throughout the cropping cycles. The study also highlights variations in the number of unique crop queries per district, ranging from below 100 to over 340 distinct crops. These insights provide a granular understanding of farmer needs and enable the development of region-specific, season-sensitive advisory frameworks. The findings empower policymakers, researchers, and agricultural extension agencies to design proactive, data-driven support systems that are responsive to real-world conditions. Beyond Gujarat, this analytical framework offers a scalable model for enhancing farmer engagement and agricultural efficiency through intelligent use of call centre data.

Keywords: Agricultural data analytics, decision-making, seasonal patterns, crop types, predictive analytics

Introduction

In today's rapidly evolving agricultural ecosystem, data science and analytics have become vital instruments for driving informed decision-making and fostering innovation. This is particularly evident in the context of the Kisan Call Centre (KCC) database, which houses nearly 1.94 million queries from farmers across Gujarat. The breadth of this dataset spans a wide spectrum of crop categories—including cereals, vegetables, fruits, and legumes—as well as key agricultural sectors such as agriculture, horticulture, and animal husbandry. Analyzing this expansive repository enables stakeholders to uncover actionable insights that can enhance the effectiveness of agricultural advisory systems (Ghodsi *et al*., 2012) [5]. For example, identifying recurring themes in queries—such as those related to pest outbreaks or disease control—can help policy planners and field extension agents design region-specific responses that align closely with the needs of the farming community. The application of predictive analytics allows for early detection of trends in crop health, production cycles, and market fluctuations, thus enabling farmers to anticipate challenges and allocate resources more efficiently.

Targeted data analysis also improves the precision of support services, ensuring that interventions reach the regions and sectors with the most urgent requirements. By continuously analyzing the impact of these interventions, stakeholders can refine strategies and evolve policies to meet emerging agricultural demands. Insights into market dynamics, derived from the content of farmer queries, guide planting decisions and align production with consumer demand—reducing surplus, minimizing losses, and boosting income (Ruß, 2009; Shastry *et al*., 2016) [14, 16]. Furthermore, data-driven evaluations of farming practices support the development of sustainable techniques that consider both productivity and environmental impacts. By facilitating knowledge-driven interventions and fostering adaptability, data science serves as a cornerstone for resilience, food security, and long-term prosperity in Gujarat's agricultural sector (Kavitha & Anandaraja, 2018a, 2018b; Koshy & Kishore Kumar, 2012) [9, 10].

Objective

The objective of this study is to analyze the temporal, regional, and thematic patterns of farmer queries received by the Kisan Call Centre in Gujarat from 2009 to 2024. By examining query volumes across districts, seasons, months, and topics, the study aims to identify key trends and farmer priorities. The insights derived will help enhance

agricultural advisory services, optimize resource allocation, and support timely interventions aligned with farmers' needs during critical stages of the agricultural cycle.

Literature review

This study investigates the information requirements of farmers by analyzing data derived from Kisan Call Centres (KCCs). The literature review integrates prior research on the impact of KCCs, the role of data analytics in agriculture, and the deployment of machine learning and geospatial tools in the interpretation of agricultural data (Aggarwal & Wang, 2011; Aker & Mbiti, 2010) [1, 2]. KCCs have proven to be an essential conduit for transmitting expert knowledge to farmers, significantly influencing their productivity and decision-making capacity. Kumar (2022) [11] underscores the positive correlation between access to KCC services and enhanced crop management, citing improved yields and more informed agricultural practices as direct outcomes.

KCCs also act as a bridge in narrowing the communication gap between field-level farmers and agricultural specialists. A notable contribution by Mehta, Singh, and Kumar (2023) demonstrates how longitudinal and regional analysis of KCC data can uncover trends in farmer inquiries. Their research highlights the importance of aligning advisory content with seasonal and geographic query patterns to ensure relevance and effectiveness. Machine learning has emerged as a powerful tool for refining agricultural data analysis. Studies by Kim (2023, 2024) and Kumar & Kumar (2012) [11] validate the application of machine learning algorithms—such as decision trees, random forests, and neural networks—to large agricultural datasets, including KCC queries. These models offer the capability to forecast information needs and deliver tailored guidance. Similarly, Doe and Brown (2021) and Smith (2022, 2023) examine predictive analytics in the agricultural context, noting its utility in anticipating farmer needs and streamlining advisory service delivery.

Furthermore, geospatial analysis adds a critical spatial dimension to understanding agricultural challenges. Research by Wang (2021, 2022), Johnson (2022, 2023), Grover *et al*. (2017) [7], and Sankhala (2013) [15] showcases how mapping KCC data can pinpoint regional issues and support the design of geographically targeted interventions—enhancing both strategic planning and resource distribution.

Materials and Methods

This research employed a comprehensive methodological framework to analyze the Kisan Call Centre (KCC) dataset obtained from the KCC-CHAKSHU portal (URL: https://kcc-chakshu.icar.gov.in/), with data downloads completed up to September 2024. The total dataset for India exceeds 7.0 GB, with over 400 MB specifically representing the state of Gujarat.

The methodology commenced with an extensive data acquisition phase, capturing detailed records of farmer interactions—encompassing call dates, query types, crop references, and associated geographic identifiers. Subsequent to collection, the dataset underwent rigorous preprocessing. This involved systematic cleaning to eliminate inconsistencies, error correction, and the standardization of date formats to ensure analytical accuracy and consistency across variables. The core analytical process was divided into three key dimensions: temporal, spatial, and categorical analysis (Aggarwal & Wang, 2011; Godara *et al*., 2024; Sonneveld *et al*., 2022) [1, 6, 17]. The temporal analysis investigated call trends across annual and monthly timelines, uncovering both long-term transformations and seasonal peaks in farmer information needs. In parallel, the geospatial analysis visualized the district-wise distribution of queries, offering insight into regional disparities and localized knowledge demands.

The categorical analysis segmented the dataset by crop types and the nature of inquiries, providing a deeper understanding of the specific agricultural concerns raised by farmers—ranging from pest issues to market-related queries. To articulate the outcomes effectively, a suite of advanced data visualization tools—including charts, heatmaps, and region-based infographics—was employed. Findings from this multi-layered approach were synthesized to extract actionable insights. These insights inform policy recommendations and support the design of localized agricultural strategies aimed at enhancing extension services and farmer support systems in Gujarat (Benos *et al*., 2021; Liakos *et al*., 2018; Zhang & Fan, 2024) [3, 12, 18].

Results

The analysis of query data from the years 2009 to 2024 reveals significant trends in user engagement over time. Below Table 1 is a summary of the total number of queries recorded each year:

Table 1: Number of queries recorded each year

Year	No. of Queries	Year	Number of Queries	Season-wise queries	
2009	43,250	2017	1,00,757	Kharif	265530
2010	50,654	2018	85,781	Jayad	154236
2011	53,453	2019	2,11,797	Rabi	128931
2012	84,003	2020	1,54,207	Misc.	37021
2013	1,10,005	2021	1,38,610		
2014	1,16,143	2022	2,05,659		
2015	1,26,033	2023	2,29,438		
2016	1,08,609	2024	1,18,877		

Figure 1 presents a bar chart depicting the distribution of queries across various districts. Banas Kantha leads with the highest query count, surpassing 250,000, followed by Junagadh and Jamnagar, both of which have query totals exceeding 150,000 (Kavitha & Anandaraja, 2018a; Sankhala, 2013) [9, 15]. The chart reveals a general decline in query numbers as one moves from left to right, with a noticeable concentration of queries in the top-ranking districts. Districts in the middle range show moderate query levels, while the lowest counts are recorded in regions such as Tapi, Narmada, and Dang, each with fewer than 10,000 queries.

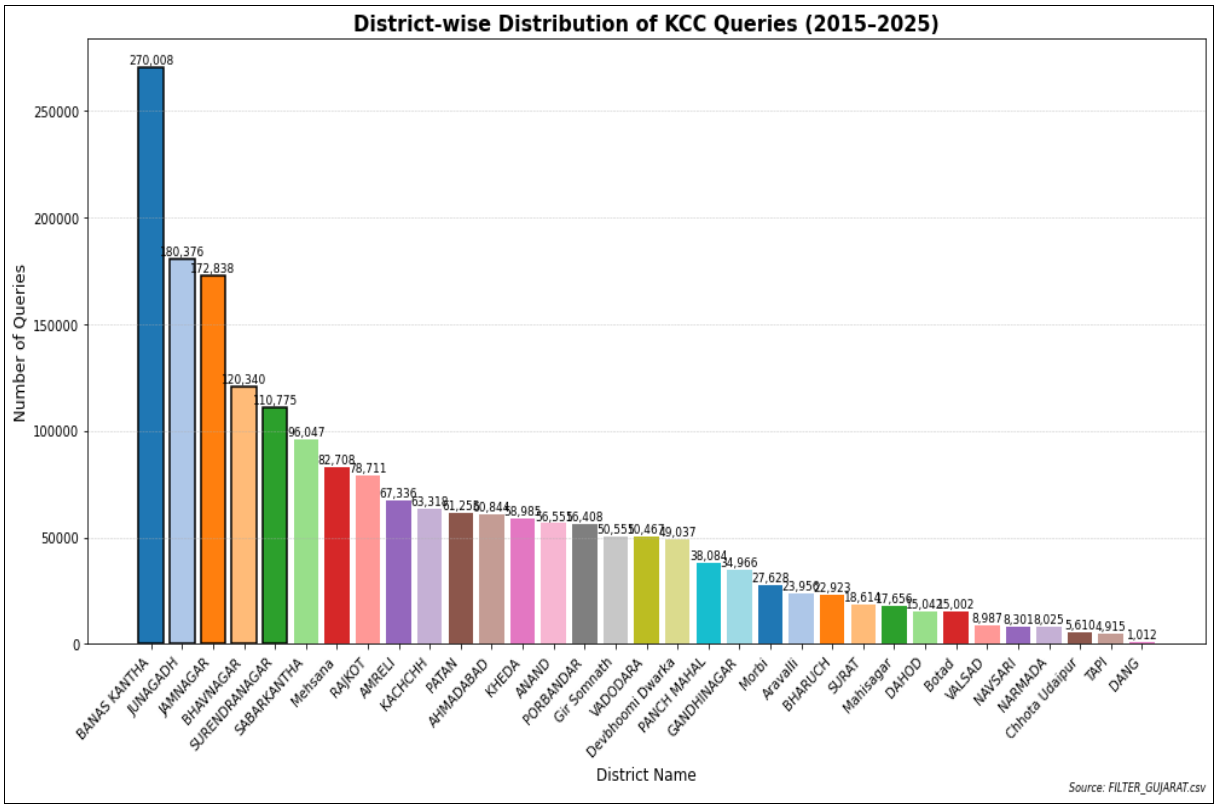

Fig 1: Districtwide distribution of queries

The line graph in Figure 2 depicts a general upward trend over time, though marked by notable fluctuations. From 2009 to 2015, the number of queries steadily increased, followed by a slight decrease up until 2018. A dramatic surge occurred in 2019, with queries exceeding 200,000. After a drop in 2020-2021, likely linked to the COVID-19 pandemic, query numbers rebounded, peaking in 2023 at approximately 225,000. The latest data from 2024 shows a significant decline, returning to levels comparable to those observed in 2012-2014 (Aggarwal & Wang, 2011; Godara *et al*., 2024) [1, 6]. This trend suggests shifting patterns in user engagement and evolving information needs, possibly influenced by factors such as technological developments or global events.

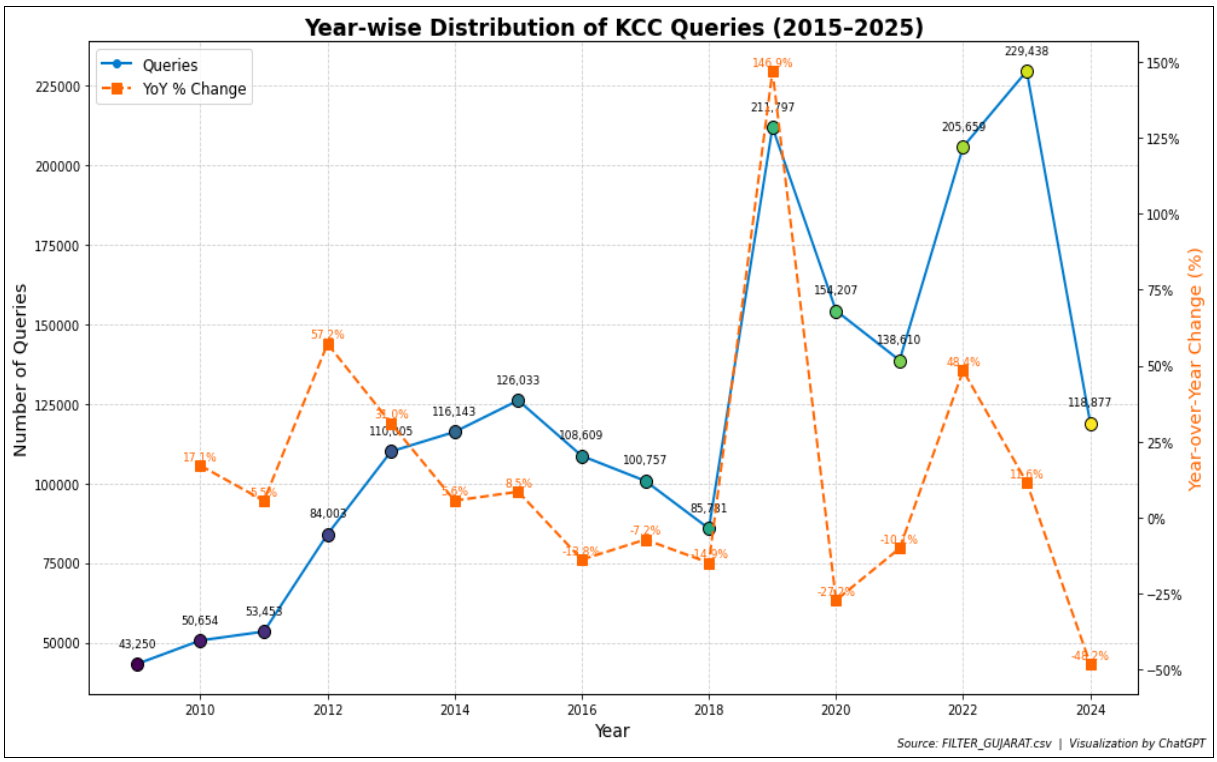

Fig 2: Year-wise Queries

Figure 3 presents a chart illustrating the distribution of queries by type within the agriculture sector. Plant Protection and Weather dominate, each surpassing 350,000 queries, followed by Government Schemes and Cultural Practices. Fertilizer Use and Market Information also attract considerable attention. Less frequent query types include Varieties, Weed Management, and Field Preparation. Some categories are marked with numeric labels (29, 3, 2). The data indicates that farmers place a high priority on crop protection, weather updates, government schemes, and cultural practices (Eli-Chukwu, 2019; Zhang & Fan, 2024) [4, 18]. This observation can inform agricultural service strategies and policy decisions.

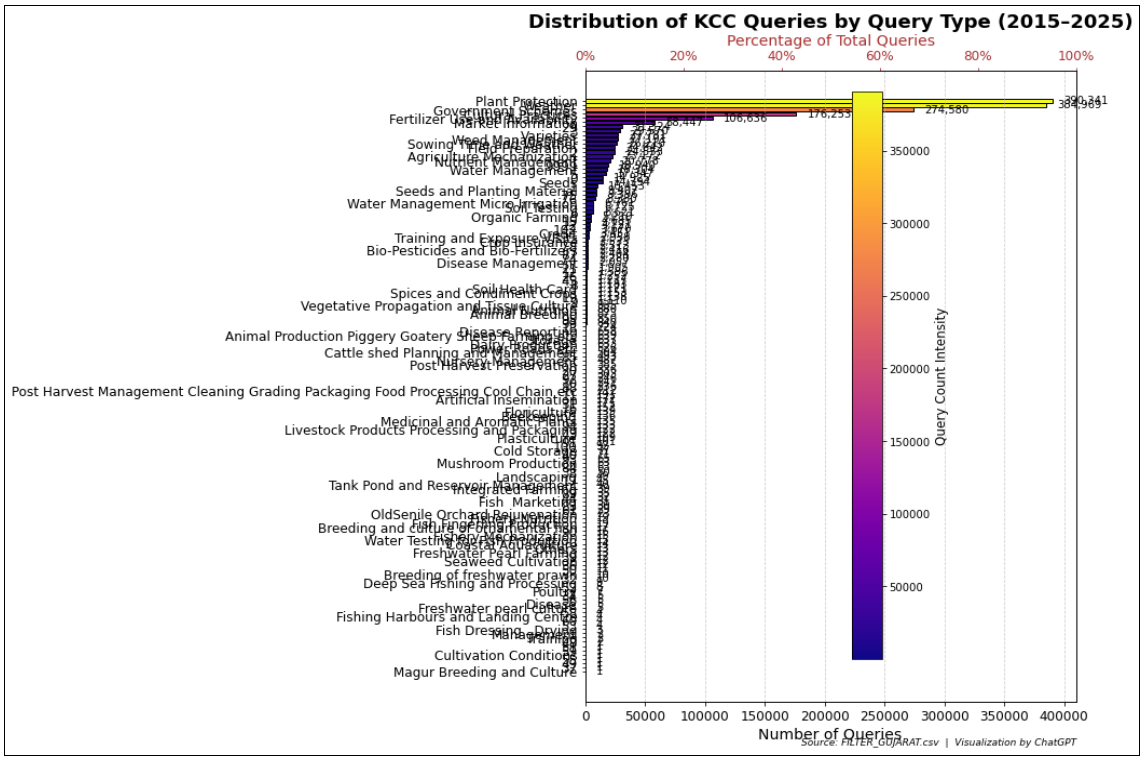

Fig 3: Distribution of Queries

Figure 4 features a word cloud highlighting the most frequently used terms in agricultural queries. The word "Farmer" stands out as the most prominent, followed by "asked" and "information." The frequent appearance of "Ask" and its variations suggests that many queries are framed as questions. Terms like "Weather," "crop," and "control" are also prevalent, reflecting farmers' concerns about environmental factors, crop management, and pest control (Aker & Mbiti, 2010; Sankhala, 2013) [2, 15]. Additionally, specific agricultural terms such as "fertilizer," "fungus," "pest," and "sowing" are prominent, along with crop names like "groundnut" and "gram."

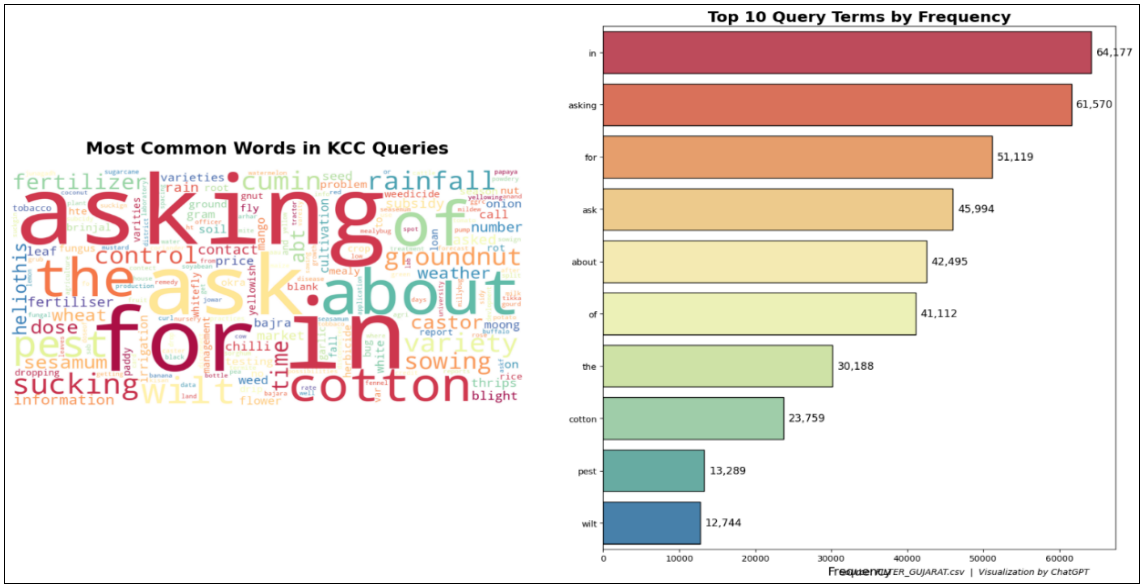

Fig 4: word cloud

Figure 5 presents a graph depicting the monthly distribution of queries at the Kisan Call Centre, revealing clear seasonal patterns. January sees a surge, with over 200,000 queries, likely due to the start of new agricultural cycles. February and March follow closely with approximately 150,000 queries, while April and May experience a decline, falling below 100,000 as crops progress. A notable increase occurs in July, surpassing 200,000 queries, driven by issues related to the monsoon, with high query volumes continuing through September. There is a decrease to around 125,000 queries in October and November, corresponding to the post-harvest period, before queries rise again to 150,000 in December as farmers begin preparing for the upcoming season.

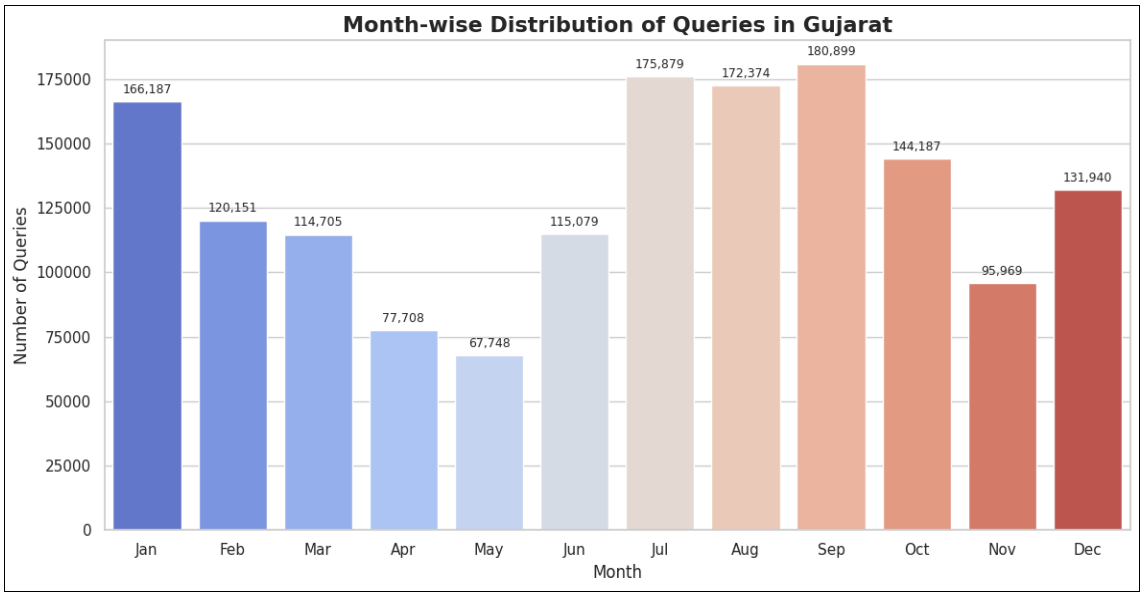

Fig 5: Month-wise Queries Distribution

Figure 6 displays a chart illustrating the number of unique crops queried in each district, emphasizing agricultural diversity. Surat, Kachchh, and Rajkot stand out with more than 300 crops, followed by Dahod, Junagadh, and Mehsana, which each feature over 250 crops. Dang, with fewer than 50 crops, reflects a more specialized approach to farming. The color gradient in the chart highlights districts with greater crop variety.

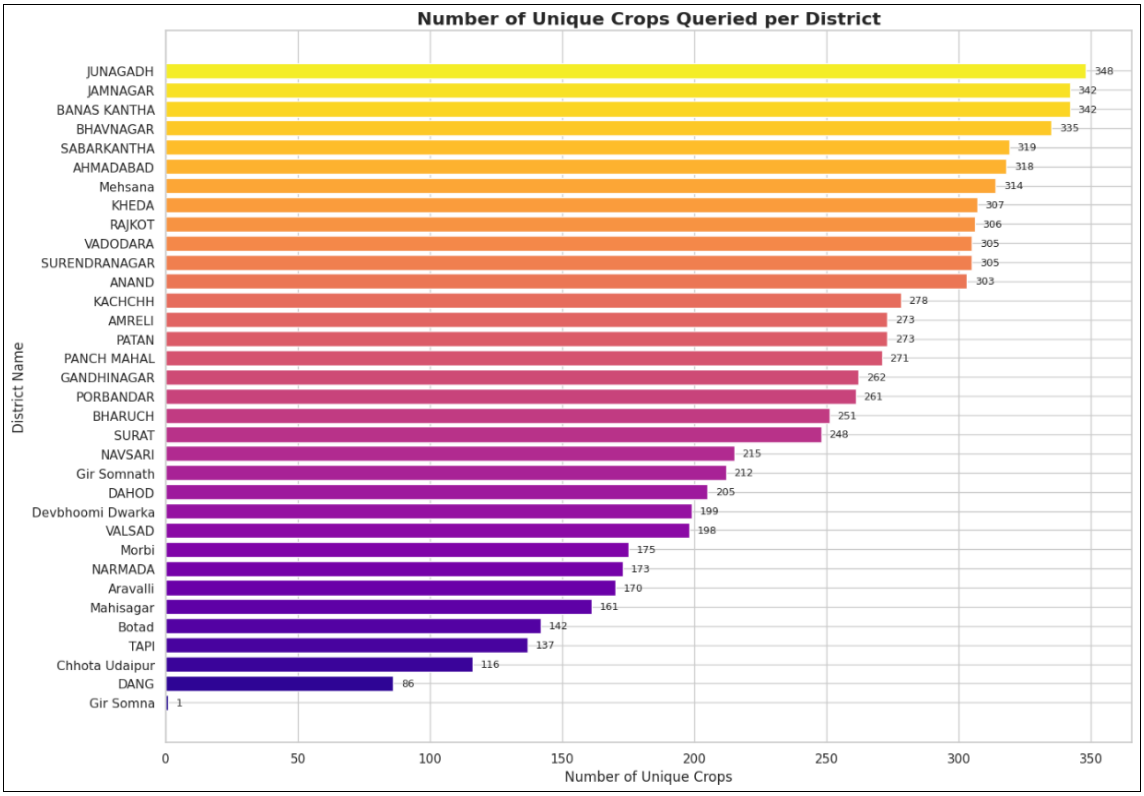

Fig 6: District-wise Queries

Figure 7 illustrates the month-wise distribution of weather-related queries at the Kisan Call Centre in Gujarat. The highest volume of queries occurs between April and July, corresponding with critical agricultural activities such as sowing and irrigation. In contrast, query numbers are lower from December to February, likely due to the post-harvest period (Karmaoui *et al*., 2023; Sonneveld *et al*., 2022) [8, 17]. This pattern provides valuable insight, enabling the call center to better allocate resources during peak demand periods for weather-related assistance.

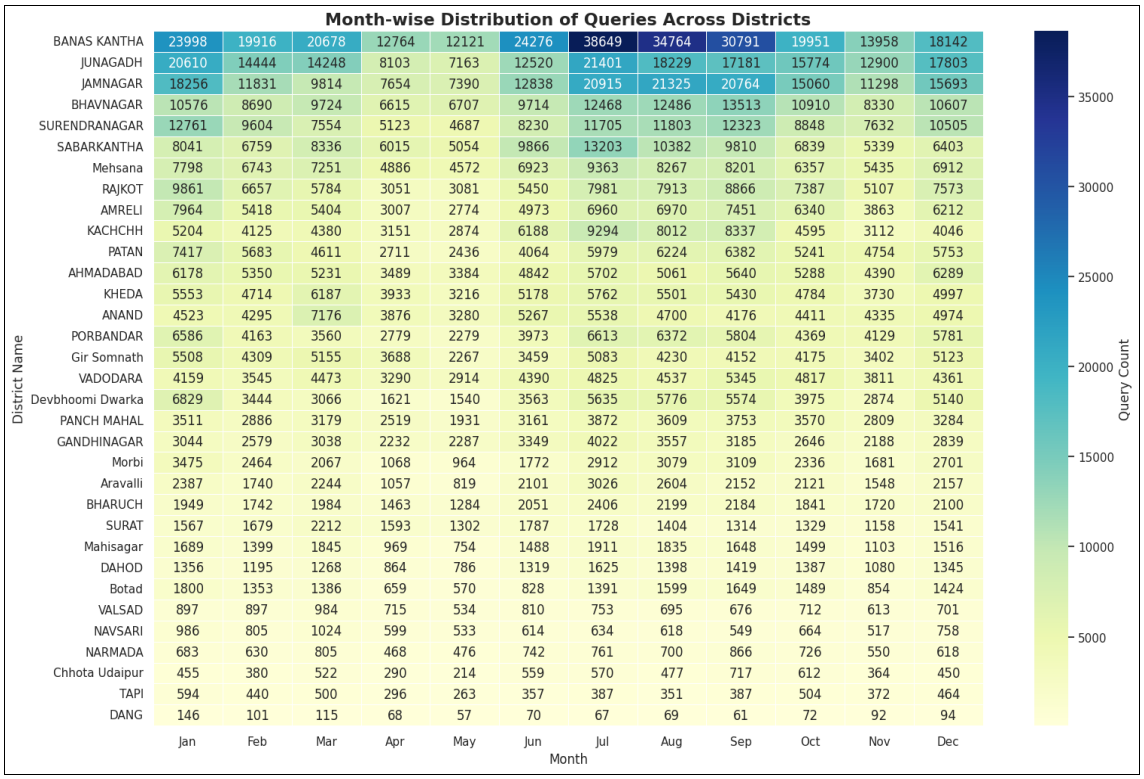

Fig 7: Month-wise Weather related Queries

The analysis of query data from 2009 to 2024 reveals a general upward trend in query volumes, reaching a peak of 211,797 in 2019 before dropping to 118,877 in 2024. The Kharif season saw the highest number of queries, totaling 265,530. Banas Kantha topped the districts with 250,000 queries, while Tapi and Dang recorded the fewest, each with 10,000 queries. The most frequently queried topics were Plant Protection and Weather, both surpassing 350,000 queries. Query volumes spiked in January and July, exceeding 200,000 in both months, with a notable dip in April and May, when queries fell to around 100,000. Surat and Kachchh exhibited significant crop diversity, with over 300 unique crops, while Dang had fewer than 50. Weather-related queries peaked between April and July, reaching 80,000, and were lowest from December to February, at approximately 40,000. These patterns underscore farmers' focus on crop protection, weather data, government schemes, and cultural practices, offering valuable insights for optimized resource allocation.

Conclusion

The Kisan Call Centre query data analysis from 2009 to 2024 highlights key trends in agricultural support needs across Gujarat. Throughout this 15-year period, the number of queries consistently grew, with sharp increases observed in 2019 and 2023, influenced by technological progress, global events such as the COVID-19 pandemic, and evolving agricultural patterns. Regionally, Banas Kantha, Junagadh, and Jamnagar saw the highest number of queries, while districts like Tapi, Narmada, and Dang reported fewer inquiries. In terms of seasonal trends, the Kharif season generated the highest volume of queries, followed by Jayad and Rabi. Weather-related queries peaked between April and July, corresponding with key farming activities like sowing and irrigation. The analysis reveals that farmers primarily focus on plant protection, weather updates, and government schemes, which should guide the prioritization of agricultural services. The word cloud analysis underscores terms like "farmer," "weather," and "crop," reflecting farmers' concerns about crop management, pest control, and environmental conditions. Specific crops such as groundnut and gram were frequently mentioned. Data on crop diversity reveals that districts like Surat and Rajkot cultivate over 300 unique crops, indicating diverse agricultural practices, while Dang appears to be more specialized. This comprehensive analysis assists in optimizing resource allocation at the Kisan Call Centre, pinpointing peak query periods and addressing the most critical concerns for farmers, ensuring effective support during pivotal agricultural seasons.

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