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BUSINESS ANALYTICS FOR VEHICLE MODEL USAGE PATTERN FOR TRANSPORTATION OF SEASONAL PERISHABLE GOODS

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ABSTRACT

This paper presents a data analytics framework that aims to analyze the vehicle types and models used to transport seasonal perishable goods. The framework helps manufacturers identify nascent market opportunities and also be prepared for service to reduce vehicle downtime while transporting perishable goods. Three seasonal perishable fruits and vegetables were identified, and the peak production months and states where there was peak production were analyzed. Vehicle telematics data was collected and analyzed in these months and states after peak production months and states were identified. This paper also presents a complete analysis and visualization of the vehicle types used for the transportation of these goods.

Keywords: Data Analysis, Seasonal Perishable Goods, Nascent Market Opportunities, Peak Production.

I. INTRODUCTION

Agriculture is the main source of livelihood in most households in India. 70 percent of India's rural households still depend on agriculture for their livelihood. [1]. India's diverse agro-climate is conducive to the production of fruits and vegetables. This makes India one of the leading producers of pervasive types of seasonal, perishable fruits and vegetables; it ranks second after China [2]. However, the production of such perishable crops is highly localized due to different weather and soil requirements. The timely transportation of such perishable goods is essential to profiting from the production [4].

There has been a steady increase in demand for such products in Tier 1 and Tier 2 cities in India. The demand for most of these products has increased exponentially during the COVID-19 pandemic [4]. India wastes a whopping 16% of its harvested fruits and vegetables every year [5]. 11% of the world's vegetables are produced in India; however, India only contributes to 1.7% of the world's total vegetable exports [3]. 40% of all food produced never reaches the consumer [6]. The main reason for this has been attributed to the improper transport facilities for these perishable goods [4].

When it comes to the transportation of seasonal perishable goods, timely delivery of goods along with proper cold storage of goods is very important. It is essential for vehicle manufacturers to ensure proper cold storage facilities are provided in vehicles to help prolong the shelf life of these perishable goods and also to ensure the low downtime of vehicles while transporting these goods. Efforts are being taken by the Indian government to streamline logistics and focus more on the transportation of perishables, to ensure remunerative returns to the farmers. The perishable goods transportation market is projected to increase by USD 6.43 billion by 2026 [7], which provide an opportunity that vehicle manufacturers can capitalize on to make profits [7]. Hence, this paper presents an analysis for vehicle manufacturers to capitalize on the logistics industry for the transportation of such perishable seasonal goods. Vehicle manufacturers can either increase production of the type of vehicle used to transport perishable goods, set up service points, stock up on vehicle parts to reduce downtime while transporting said goods, or provide additional resources in vehicles to extend the shelf life of such goods.

Commercial vehicles in India are broadly classified, based on gross vehicle weight (GVW), into three categories: LCV (light commercial vehicles), ICV (intermediate commercial vehicles), and M&HCV (medium and heavy-duty commercial vehicles). LCV trucks have a GVW range of 3.5 T to 7 T; ICV trucks have a GVW range of 9 T to 17 T; and tonnage greater than 19 T is classified as M&HCV [9], [10]. Some of the commonly used vehicles under the M&HCV category are 10x2, 8x2, 6x2, and 4x2 based on the number of wheels and axles in the vehicle. Other naming conventions followed in M&HCV are tractor trailer, tipper, and haulage, based on the application for which they are used.

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II. METHODOLOGY

1) Selection of appropriate Perishable goods for analysis

The first step as part of this analysis would be to choose appropriate perishable goods to be analyzed and generalized. India is an agrarian country, and the majority of its perishable harvests are exported. Goods to be selected for this analysis should have a high rate of production in the country for the analysis to be generalized. India was placed second in the cultivation of onions, potatoes, and cauliflower, among other vegetables. The country is first in producing fruits like bananas, papayas, and mangoes. [8]. Grapes, Pomegranates, Mangoes, Bananas, and Oranges were among the most exported fruits, while onions, mixed vegetables, potatoes, tomatoes, and green chilies were among the most exported vegetables. In the year 2020–2021, 1,575,922.59 metric tonnes (MT) of onions, 21,033.58 MT of mangoes, and 246,107.38 MT of grapes were exported, which provided profits of 282,202.08, 27,187.83, and 229,845.04 lakh rupees, respectively [8]. Since these fruits and vegetables are a significant contributor to the Indian export and profit market, it is a high priority to reduce wastage of these goods while transporting. As a result, onions, mangoes, and grapes were identified as the goods of study for this analysis.

2) Identify harvesting pattern

Horticulture data for the chosen perishable goods is required to analyse the harvest trends. Horticulture data was obtained from [11] for the year 2021. State-wise data on the amount of production for these perishable goods was collected. Based on the amount of production, 3 seasons for production were identified: the peak season, where the production of goods is the highest, the lean season, where there is moderate production of these products, and the off season, where there is little to no production of these products. For each of these products, the peak, lean, and off seasons were identified.

State	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Andhra Pradesh		Lean season	Lean season	Peak season	Peak season	Lean season	Lean season					
Gujarat				Lean season	Peak season	Peak season	Lean season					
Karnataka				Lean season	Peak season	Peak season	Lean season					
Maharashtra			Lean season	Peak season	Peak season	Lean season	Lean season					
Uttar Pradesh					Lean season	Peak season		Lean season				

Figure 1: Harvesting Pattern for Mango in leading Mango producing states

State	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Maharashtra	Lean season	Lean season	Lean season	Peak season	Peak season	Lean season				Lean season	Peak season	Lean season
Gujarat	Lean season	Peak season	Lean season	Lean season	Lean season	Lean season				Lean season	Peak season	Lean season
Bihar		Lean season	Peak season	Lean season								
Karnataka	Lean season							Lean season	Lean season	Peak season	Peak season	Peak season
Andhra Pradesh			Lean season	Peak season	Peak season	Lean season		Lean season	Peak season	Peak season	Peak season	Lean season
Madhya Pradesh				Lean season	Peak season	Lean season	Lean season					
Rajasthan			Lean season	Peak season	Lean season	Lean season					Lean season	Lean season
Haryana			Lean season	Peak season	Lean season	Lean season					Lean season	Lean season
Uttar Pradesh		Lean season	Peak season	Peak season	Peak season	Lean season					Lean season	Lean season

Figure 2: Harvesting Pattern for Onion in leading Onion producing states

This was then used to analyze the following:

- States in which there is peak production
- Months in which there is peak production in these states.

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3) Vehicle Telematics Data Acquisition

Vehicle telematics data is required to analyze vehicle trends and correlate them with this seasonal data. For example, if there is a peak season for mangoes in the month of May in Maharashtra, vehicle telematics data for the month of May in the state of Maharashtra is essential to analyze vehicle trends. Vehicle telematics data for the year 2021 was collected from a leading vehicle manufacturer in India with the required features for analysis (state, month, lat-lon, vehicle sub segment, and count). The data was then pre-processed for merging and analysis.

4) Analysis and Inference

Seasonal data for the identified goods and vehicle telematics data should be merged to perform the analysis and determine which vehicle sub segments are used for the majority of perishable goods transportation. After the required pre-processing of both datasets was done, a left join was performed for the two datasets based on the common features, which were state, month, and district.

5) Visualization

After performing a left join, visualization was done to extract insights from the data.

III. RESULTS AND DISCUSSION

State wise trend data for selected perishable products

The first step was to identify the states in which each product has its peak production and the months in which these states exhibit this property. From the visualizations below, the different seasons exhibited by each state for each product (from January to August) are identified.

Mango:

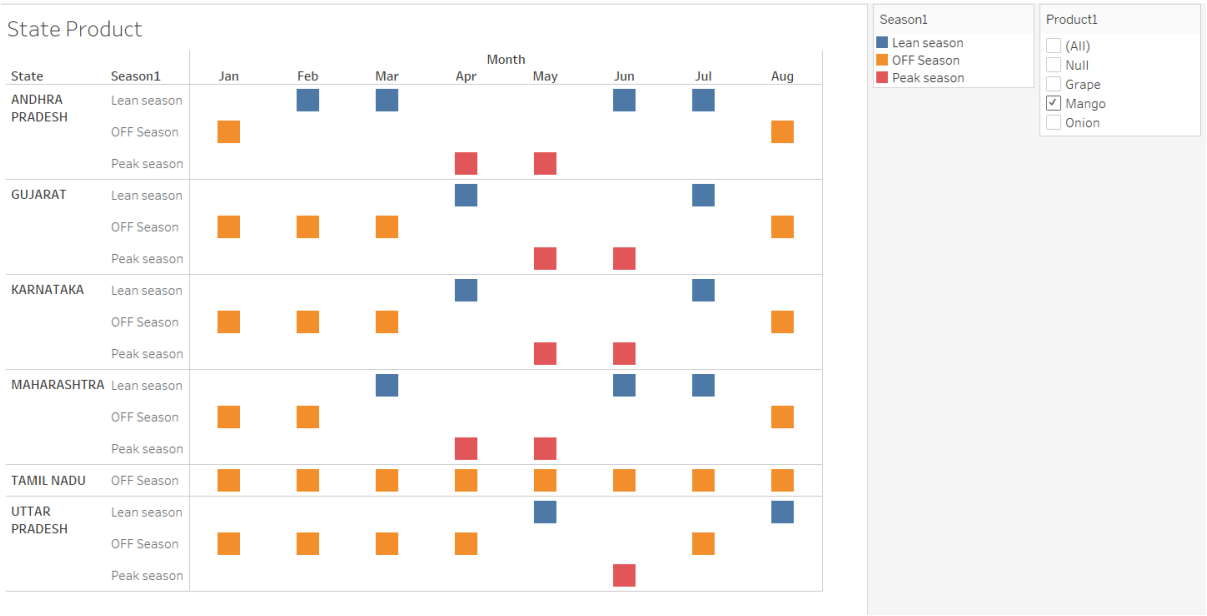

Figure 3: Seasons exhibited by Lead Producing States for Mango from January-August

From this visualization (**Figure 3**), it is seen that mango has a peak season in the months of April and May in Andhra Pradesh, in the months of May and June in Gujarat, in the months of May and June in Karnataka, in the months of April and May in Maharashtra, and in the month of June in Uttar Pradesh.

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Grape:

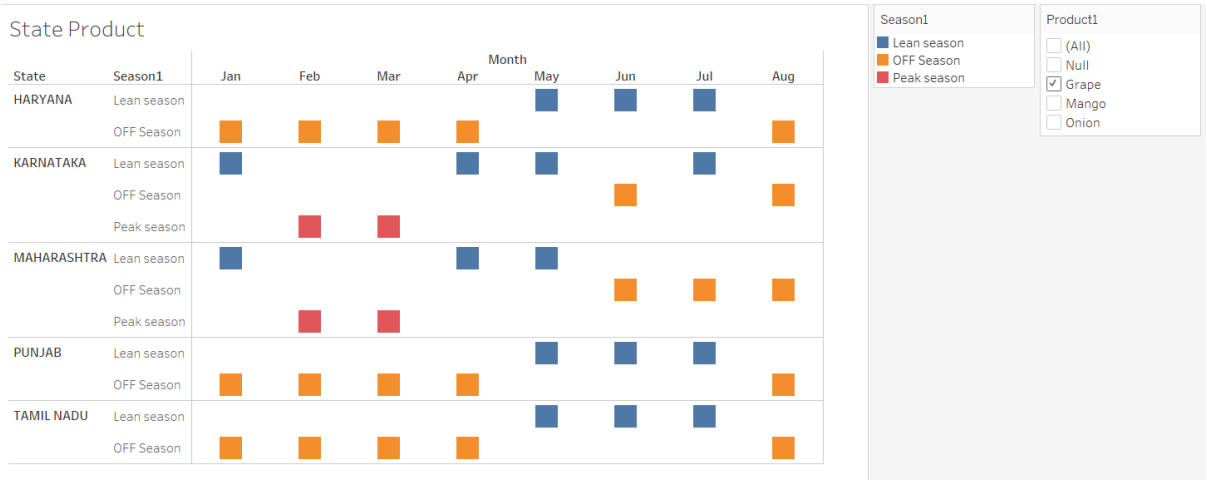

Figure 4: Seasons exhibited by Lead Producing States for Grape from January-August

From this visualization (**Figure 4**), it is seen that Grape has a Peak season in the months of February and March in Karnataka and in the months of February and March in Maharashtra.

Onion:

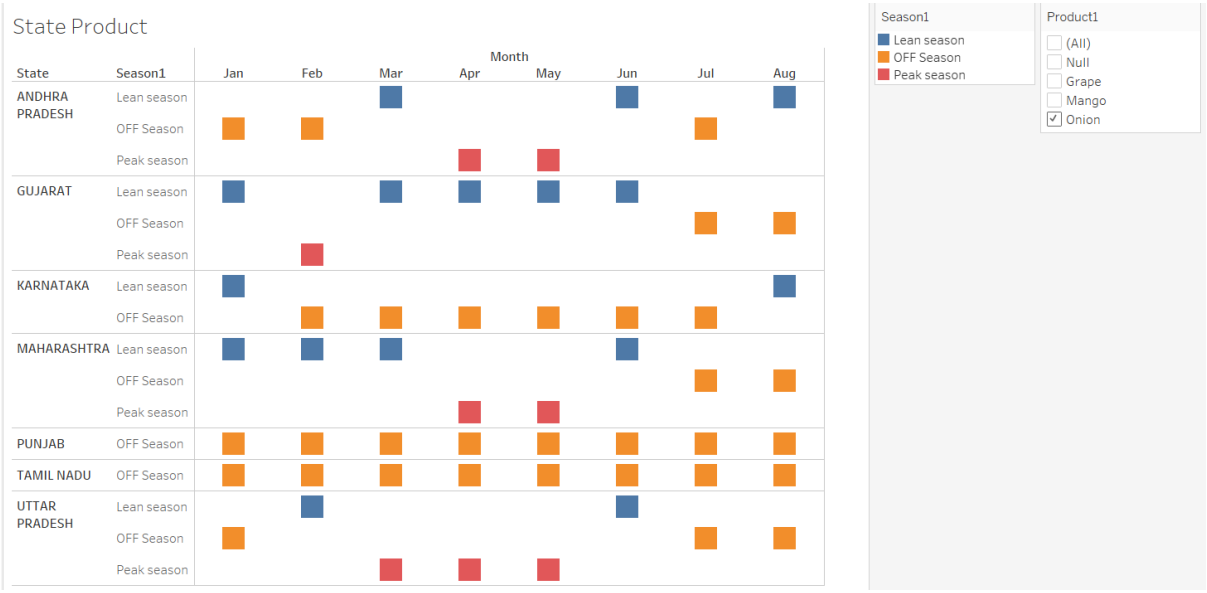

Figure 5: Seasons exhibited by Lead Producing States for Onion from January-August

From the visualization above (**Figure 5**), it is seen that Onion has a Peak season in the months of April and May in Andhra Pradesh, in the month of February in Gujarat, in the months of April and May in Maharashtra and in the months of March, April and May in Uttar Pradesh.

Table 1: Peak Production Months for identified seasonal perishable goods in respective states

Product	State	Months of Peak season
Mango	Andhra Pradesh	April, May
	Gujarat	May, June
	Karnataka	May, June
	Maharashtra	April, May
	Uttar Pradesh	June
	Karnataka	February, March

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Grape	Maharashtra	February, March
Onion	Andhra Pradesh	April, May
	Gujarat	February
	Maharashtra	April, May
	Uttar Pradesh	March,April,May

The results from **Figure 3, Figure4 and Figure 5** have been tabulated as seen in **Table 1.**

District wise for each product

After identifying the peak months for each state for each seasonal perishable good, the districts where there is peak production in each of these states were analyzed and tabulated as seen in **Table 2**.

Table 2: Districts with Peak Production for identified perishable goods

Product	State	Districts with Peak Production
Mango	Andhra Pradesh	Vizianagarm, Nellore, Chittoor, Cuddapah
	Gujarat	Surat, Valsad, Vadodara, Navsari, Bhavnagar, Amreli
	Karnataka	Kolar, Tumkur, Mysore, Mandya, Hassan, Chitradurga
	Maharashtra	Ratnagiri, Kolhapur, Sangli, Satara, Latur, Jalna, Akola, Osmanabad
	Uttar Pradesh	Lucknow, Barabanki, Deoria, Basti, Faizabad, Unnao, Sitapur, Hardoi, Moradabad, Meerut, Muzaffarnagar, Saharanpur
Grape	Karnataka	Kolar, Bagalkot, Bijapur, Belgaum
	Maharashtra	Sangli, Satara, Solapur, Osmanabad, Pune
Onion	Andhra Pradesh	Kurnool, Cuddapah
	Gujarat	Surendranagar, Bhavnagar
	Maharashtra	Pune
	Uttar Pradesh	Lucknow, Faizabad, Allahabad, Varanasi

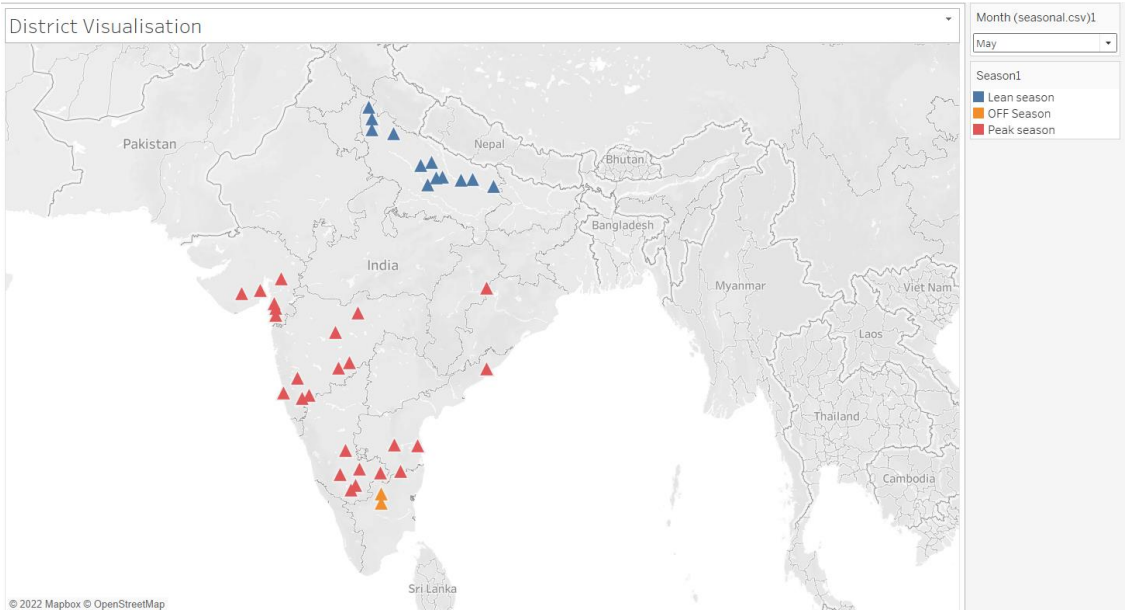

Figure 6: District Season Visualization for Mango in the month of May

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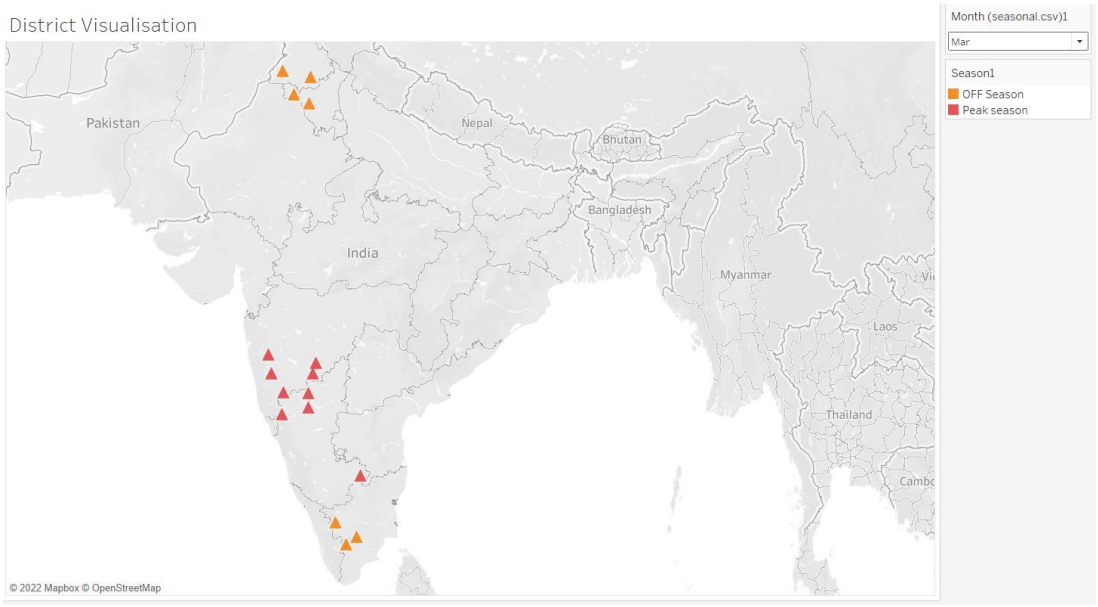

Figure 7: District Season Visualization for Grape in the month of March

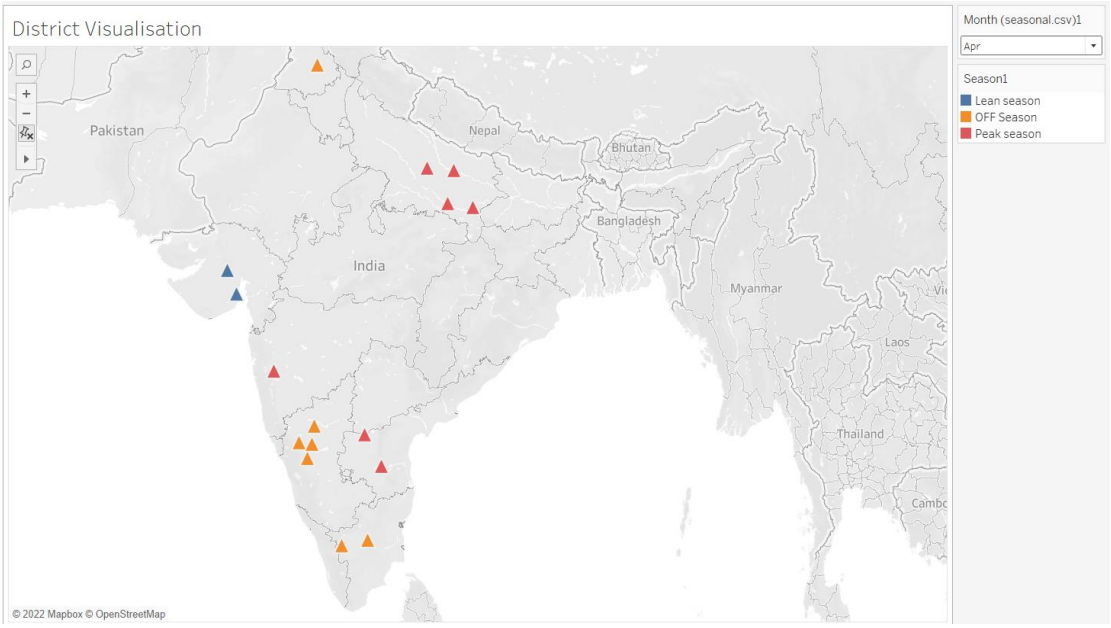

Figure 8: District Season Visualization for Onion in the month of April

State wise Vehicle Telematics Analysis:

After analysing the states and districts in which there is peak production of mango, grape, and onion, vehicle telematics data was identified for these states and analysed to determine which vehicle sub segments were used predominantly for the transport of these goods.

Seasons were analysed by state, along with the average vehicle density for these states in the given month. The purpose of this analysis was to identify whether a peak season corresponds to a high average vehicle density.

In the visualisation given below (**Figure 9**), it can be seen that for the product grape, in the states of Karnataka and Maharashtra, there is a peak season of production in the months of February and March. Accordingly, there is a very high vehicle density in these states in the months of February and March.

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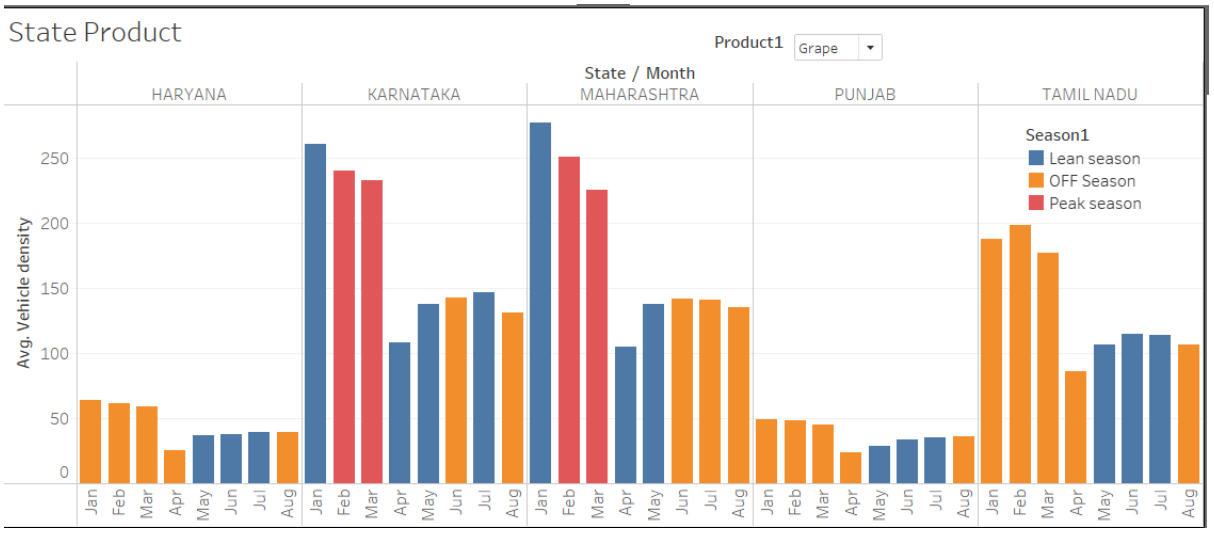

Figure 9: State Wise Vehicle Density from January-August

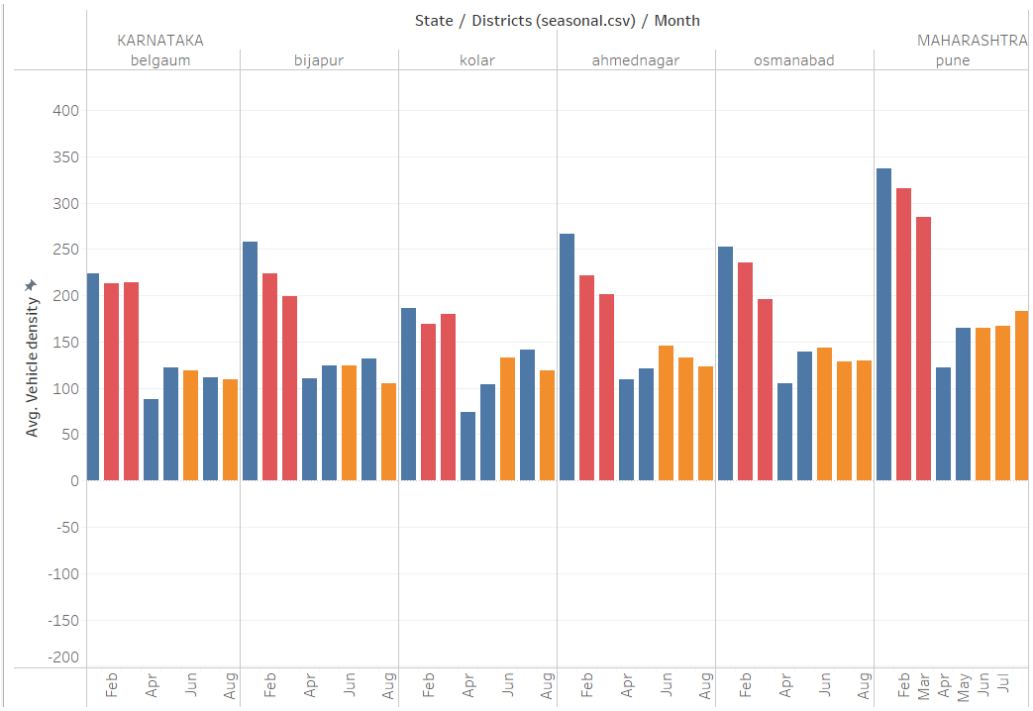

Figure 10: District wise Vehicle Density from January-August

Similarly it can be seen in the visualization above (**Figure 10**) that in the districts where there is peak production of grape in Karnataka and Maharashtra there is a high vehicle density.

District wise Vehicle Telematics Analysis:

Following the identification of the states and districts within these states where peak production existed, vehicle telematics data for these districts was analysed for each product to determine which vehicle sub segment was primarily used for the transport of these identified seasonal perishable goods. From the tableau visualization, for each of the identified perishable goods, the top 3 sub-segments with the highest movement in the districts where there was peak production were tabulated, as seen in Table 3.

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Table 3: Sub-segments used predominantly during Onion Peak season in identified districts

Product	State	District	Sub segment
Onion	Maharashtra	Pune	10X2, 8X2,10X2 MAV
	Andhra Pradesh	Kurnool	10X2,8X2,10X2 MAV
		Cuddapah	10X2,8X2,10X2 MAV
	Gujarat	Surendranagar	10X2,8X2,6X2
		Bhavnagar	10X2,8X2,10X2 MAV
	Uttar Pradesh	Luck now	10X2,6X2,ICV
		Faizabad	10X2,6X2,55T Tractor
		Allahabad	10X2,6X2,8X2
		Varanasi	10X2,6X2,ICV

From **Table 3,** it is evident that the 10X2, 8X2, and 10X2 MAV sub segments have the highest movement in Maharashtra during onion peak season, the 10X2, 8X2, and 10X2 MAV, 6X2 sub segments have the highest movement in Andhra Pradesh during onion peak season, the 10X2, 8X2, and 10X2 MAV, 6X2 sub segments have the highest movement in Gujarat during onion peak season, and the 10X2, 6X2, ICV, 8X2, and 55T tractor have the highest movement in Uttar Pradesh during onion peak season.

Table 4: Sub-segments used predominantly during Grape Peak season in identified districts

Product	State	District	Subsegment
Grape	Karnataka	Kolar	10X2,8X2,4X2 FF
		Bagalkot	10X2,8X2,4X2 FF
		Bijapur	10X2,8X2,4X2 FF
		Belgaum	10X2,4X2 FF,6X2
	Maharashtra	Sangli	10X2,4X2 FF,6X2
		Satara	4X2 FF,10X2,6X2
		Solapur	10X2,8X2,4X2 FF
		Osmanabad	10X2,8X2,6X2
		Pune	10X2,4X2 FF,8X2

From **Table 4**, it can be seen that the 10X2, 8X2, 4X2 FF sub segments had the highest movement in Karnataka during grape peak season, and the 10X2, 4X2 FF, 8X2, 6X2 sub segments had the highest movement in Maharashtra during grape peak season.

Table 5: Sub-segments used predominantly during Mango Peak season in identified districts

Product	State	District	Subsegment
Mango	Andhra Pradesh	Vizianagarm	10X2,8X2,10X2 MAV
		Nellore	10X2,8X2,10X2 MAV
		Chittoor	10X2,8X2,10X2 MAV
		Cuddapah	10X2,8X2,10X2 MAV
	Gujarat	Surat	10X2,10X2 MAV,ICV
		Valsad	ICV,10X2,4X2 Haulage
		Vadodara	10X2,10X2 MAV,ICV
		Navsari	ICV,10X2,10X2 MAV

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		Bhavnagar	10X2,10X2 MAV,ICV
		Amreli	10X2 MAV,10X2,40T
	Karnataka	Kolar	10X2,8X2,4X2 Haulage
		Tumkur	10X2,8X2,10X2 MAV
		Mysore	10X2,,ICV
		Mandya	10X2,ICV,
		Hassan	10X2,ICV,8X2
		Chitradurga	10X2,8X2,10X2 MAV
	Maharashtra	Ratnagiri	10X2,10X2 MAV,8X2
		Kolhapur	10X2,4X2 FF,8X2
		Sangli	10X2,10X2 MAV,4X2 FF
		Satara	10X2,4X2 FF,ICV
		Latur	10X2,10X2 MAV,8X2
		Jalna	10X2,10X2 MAV,8X2
		Akola	10X2,10X2 MAV,ICV
		Osmanabad	10X2,8X2,10X2 MAV
	Uttar Pradesh	Lucknow	ICV,6X2,4X2 Haulage
		Barabanki	ICV,10X2,6X2
		Faizabad	6X2,10X2,ICV
		Meerut	6X2,ICV,4X2 Haulage
		Sitapur	ICV,6X2,10X2
		Hardoi	ICV,55T Tractor,6X2
		Moradabad	6X2,52T Tractor,46T Tractor
		Saharanpur	ICV,6X2,10X2
		Muzaffarnagar	6X2,ICV,4X2 Haulage
		Deoria	10X2,ICV,6X2

From **Table 5** it can be seen that the 10X2, 10X2 MAV ,8X2 and 4X2 FF sub segments have the highest movement in Maharashtra Mango peak season, the 10X2, 8X2 and 10X2 MAV sub segments have the highest movement in Andhra Pradesh during Mango peak season, 10X2, 10X2 MAV,ICV and the 4X2 Haulage have the highest movement in Gujarat during Mango peak season, 10X2, 10X2 MAV,ICV and the 4X2 Haulage and 8X2 have the highest movement in Karnataka during Mango peak season and the ICV,6X2 ,10X2,4X2 Haulage and 55T Tractor have the highest movement in Uttar Pradesh during Mango peak season.

The district wise sub segment trends were analyzed and the top 3 sub segment's predominantly used in each of these districts during the peak season were identified and tabulated as seen in **Table 3,4,5** and summarized for each state in **Table 6**.

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Table 6: Sub segments predominantly used in states during peak season

Product	State	Sub segment Predominantly Used
Mango	Andhra Pradesh	10X2,8X2,10X2 MAV
	Gujarat	10X2,10X2 MAV,ICV
	Karnataka	10X2,8X2,ICV
	Maharashtra	10X2,10X2 MAV,8X2
	Uttar Pradesh	ICV,10X2,6X2
Grape	Karnataka	10X2,8X2,4X2 FF
	Maharashtra	10X2,4X FF,6X2
Onion	Andhra Pradesh	10X2,8X2,10X2 MAV
	Gujarat	10X2,8X2,10X2 MAV
	Maharashtra	10X2,8X2,10X2 MAV
	Uttar Pradesh	10X2,6X2,ICV

From **Table 6,** it is evident that the 10X2, 8X2, 10X2 MAV, and ICV had the highest movement in states where there was a peak production of mango, the 10X2, 8X2, 4X2FF, and 6X2 sub segments had peak movement in states where there was a peak production of grape; and the 10X2, 8X2, 10X2MAV, and ICV had the highest movement in states where there was a peak production of onion, during their respective peak production seasons.

After the sub segments with the highest movement during the respective peak seasons, for each state were identified and summarized, vehicle telematics data was used to visualize the top 3 sub segments during the off seasons for each product. It was discovered that either different sub segments experienced peak activity during the off season or the total number of vehicles belonging to the identified sub segments decreased dramatically. Thus, it can be concluded that the identified subsegments from **Tables 3, 4, and 5** were used for the transportation of the three seasonal perishable goods.

IV. CONCLUSION

Thus, from the analysis provided in the previous section, it can be concluded that 10X2, 8X2, 10X2 MAV, and ICV sub segments were used predominantly for the transport of mango; 10X2, 8X2, and 10X2 MAV and ICV sub segments were used predominantly for the transport of onion; and 10X2, 8X2, 4X2 FF, and 6X2 sub segments were used predominantly for the transport of grape.

Commercial vehicle manufacturers can use this information and carry out the following steps for increased profits:

- Sales teams can prepare ahead of time by putting more of these sub segments on the market before the peak seasons begin to boost company profits.
- Further analysis can be done to determine which parts usually fail in these subsegments. This can help companies prepare beforehand and stock up on these parts. This is a very important step as, when transporting perishable goods, the vehicle down time needs to be reduced.
- Manufacturers can also modify these sub-segments to conform to the requirements of perishable goods. Additional services like refrigeration to prevent spoilage of goods can be provided in the identified subsegments as well.

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