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EFFECTS OF WEATHER ON AGRICULTURAL INDEX IN INDIA: A STUDY WITH REFERENCE TO MCX AGRI

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ABSTRACT

Many behavioral studies have been analyzed and discussed, to find the link between weather factors and market returns. However, the present study examines the impact of three weather factors, in the five major cities of India, on the daily commodity index returns of the MCX Agri, for the period of January 1st 2007 to December 31st 2017 (11years). OLS Regression model has been applied to investigate the market's response to climate change. The empirical evidence shows that Chennai Temperature, Delhi Humidity and Mumbai Wind Speed affected the commodity index returns in India. The findings of present study further support the earlier findings about the inclusion of economically neutral behavioral variables in asset pricing models. The study has also important suggestion for individual investors and financial institutions planning, to invest in the MCX Agricultural commodity market. The results of the study suggest that investors can be benefited if they consider the weather factors and climate conditions. These findings also provide innovative perspective on investment decision by the investors who are trading in agricultural products

Keywords: Commodity market returns; Weather factors; Behavior Finance; Agricultural futures; Environmental economics.

JEL Classification: D03, G14

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1. INTRODUCTION

It is a well-accepted fact that agricultural commodities are considered the back bone of the economies of majority of the developing and developed countries, as they have been creating income-generating opportunities, providing food and earnings to the people who are involved in the agricultural process, directly and indirectly (**Kedar nath Mukherjee, 2011).** The Oxford English Dictionary explains the term commodity as a "valuable thing" while **CFA Institute (USA)** Financial Glossary defines commodities as an important product of commerce such as agricultural products, petroleum and metals. By the way of production method, commodities are divided into many groups – agriculture commodities, hard commodities and energy commodities (**Eugene Filimon, 2011)**. Agricultural Commodities from an important part of commodity markets. Commodity markets are influenced by different factors such as supply and demand, macroeconomic, and weather factors (**Guangxi Cao et al 2016)**. The price of agricultural commodity products is influenced more by different weather factors **Chinnadurai Kathiravan et al. (2018 & 2019)**.

In recent years, many behavioral studies discussed how weather factors affected stock markets, using traditional financial theory but less number of research has been done, focusing on how weather factors affected agricultural products **(Guangxi Cao, et al 2018).** The relationship between different climate conditions and human beings has become a global issue. This study thus examines the effects of weather factors on the commodity market, mainly focusing on agricultural commodity index in India, from the viewpoint of behavioral finance. This study mainly looks at the relationships that exist between the agricultural commodity index returns and different weather variables in India.

The rest of this paper is ordered as follows. Section Two reviews literature relating to the investor sentiment and weather factor impact on investment decision. Section Three describes the objectives, hypotheses and data used in this study. Section Four discusses and presents the empirical results. Section Five concludes this paper.

2. LITERATURE REVIEW

In the behavioral finance, many studies investigated weather factors, which influenced the investor's investment decision via investor's moods. The first part of the section covers reviews relating to weather and investors' mood, judgments and decisions while the second part includes the reviews on weather factors and investment decision, covering different weather variables.

2.1. Reviews on Weather and Investors' Mood, Judgments and Decisions

In general, the changes in weather could lead to changes in the investors' psychological condition and they experience violent behavior and problems in interpersonal interactions **(Hui-Chu Shu & Mao-Wei Hung, 2009). Howarth and Hoffman (1984)** investigated the weather variables and moods of the investors using Correlation Matrix and Regression. It was found that weather factors did contribute to the changes in the mood dimensions of investors. Mostly, humidity influenced many mood segments. **Viswanathan and Krishna murti (1989)** studied the effects of temperature and humidity on human mood and behavior. It was found that investing under different weather conditions, could influence negatively human bodies in different forms. **Nofsinger (2005)** examined the relationships between social mood and

financial economics. It was found that weather conditions could influence the investors' behavior and moods. **Lucey and Dowling (2005)** analyzed the economic psychology and decision-making process. It was found that investors appeared to be satisfied on sunny days than on cloudy and rainy days. **Symeonidis et al. (2010)** demonstrated connection between the weather conditions and investors' mood. The findings indicated that sunny weather affected the mood of the investors and taking long positions, leading to higher returns.

2.2. Reviews on Weather factors and Index Returns

This segment presents recent and select studies relating to different weather variables and their effects on index returns.

Chinnadurai Kathiravan et al. (2017) investigated the relationship between temperature of five sample cities of India and two Indian stock indices, using GARCH model. The study reported that the temperature of Chennai, Mumbai, Kolkata and Hyderabad influenced the investors' decision making process. **Kim (2017)** focused on the two studies of investors' mood in stock market. It was found that the test was severely biased against the null hypothesis of no effect. **Sheikh et al. (2017)** identified six weather variables (temperature, humidity, cloud cover, air pressure, visibility, and wind speed) and two biorhythmic variables (SAD and lunar phases). By covering stock indices of South Asian capital markets (BSE500, NSE500, KSE100, LSE30 LSE, CASP, CSE and Colombo Stock Exchange), the study found that mood proxy variables recorded some convincing influence in South Asian markets. In addition, **Nikolaos Sariannidis (2015)** examined the weather effect on the European stock market. The result revealed that humidity and wind speed affected the investors' mood positively. **Vijayakumar Narayanamoorthy et al. (2015)** incorporated different weather factors in order to examine if weather factors affected the stock returns in India. The results established that stock returns were influenced by temperature in Chennai and the stock return volatility was influenced by temperature in Mumbai, Delhi and Kolkata. **Mitra Akhtari (2011)** asserted Wall Street weather effect and stock prices movement, using Regression model. The study found that the relationship between weather and stock market slightly increased over the past half-century. There was relationship between local weather and the within day return of the DJI index. Furthermore, **Christiane Goodfellow et al. (2010)** studied the weather effect on German Stock Exchange and found that cloudy skies influenced high liquidity levels and low liquidity injected by market makers. **Sang Hoon Kang et al. (2010)** examined the weather factors, namely, temperature, humidity and sunshine on the returns and volatility of the Shanghai stock market in order to investigate their impact on Shanghai stock market. It was found that weather effect exercised significant influence on the Shanghai stock market returns. **Seong-Min Yoona and Sang Hoon Kang (2009)** investigated whether there was a relationship between stock returns and the weather variables (temperature, humidity, and cloud cover) in the Korean stock market, using GJR-GARCH. It was found that these three weather variables determined the choice of investors and thus influenced the stock market returns. **Hui-Chu Shu & Mao-Wei Hung (2009)** examined how the 18 sample European markets were influenced by wind speed, using Univariate regression analysis. There was strong temperature effect in European stock markets. More specifically, the wind speed on stock returns was considered significant than that of sunlight. **Christos Floros (2008)** determined the temperature effect on the Stock market returns of five European cities and their stock indices, namely, ATX index (Austria for the period), Bel-20 index (Belgium), CAC-40 index (France), ASE index (Greece) and FTSE-100 index (UK). The study found negative relationship between temperature and stock market returns for Austria, Belgium and France. But Greece and UK showed a positive but not significant correlation between temperature and stock market returns. **Stephen P. Keef and Melvin L. Roush (2007)** investigated the relationship between daily weather effects on the Australian indices returns. The study found that stock index return was not influenced by wind speed and

cloud cover but stock indices were negatively influenced by temperature. **Keef and Roush (2002)** investigated the relationship between Wellington's weather factors and the New Zealand Stock Exchange. The study found that the wind speed exercised significant influence on the stock market. **Hirshleifer and Shumway (2001)** analysed different weather factors and their impact on 26 countries stock market. The study found that the weather variables strongly influenced the stock markets. In addition, **Paula Pereda and Denisard Alves (2014)** examined the impact of Weather on agriculture commodity in Brazil. Weather influenced the agricultural production and price of agricultural commodity. Finally, **Alisher Mirzabaev and Daniel Tsegai (2012)** focused on the effect of weather shocks on agricultural commodity prices in Central Asia. It was found that weather fluctuations created significant negative impact on Central Asia.

Majority of studies discussed above assumed that investors' mood and investment decision could be influenced by different weather conditions while taking investment decisions. Besides, many of the studies were done in developed countries like USA, UK and China while less number of studies were carried out in India on the weather effect in commodity market. Thus, the importance of present study which examines to study the influence of weather factors in commodity market investors.

3. METHODOLOGY

3.1. Objectives of the Study

The main objective of this study was to examine the impact of weather factors (Temperature, Humidity and Wind speed), in five cities, over the sample period

3.2. Hypotheses of the Study

- **NH1:** There is no normal distribution among the Commodity Index and weather factors in five sample cities.
- **NH2:** There is no stationary among the Commodity Index and weather factors in five sample cities.
- **NH3:** There is no influence among the Commodity Index and weather factors in five sample cities.

3.3. Limitations of the study

This study suffered from the following limitations.

- Only one index, namely, MCX AGRI, was selected as the sample for this study
- The study was limited to only three weather factors (temperature, humidity and wind speed) and only in five Indian metro cities (Bangalore, Chennai, Delhi, Kolkata and Mumbai).
- The study was based only on secondary data.
- The limitations, associated with various statistical tools, may also apply to this study.

3.4. Data

For the purpose of testing the hypothesis, the study used two types of data sets, namely, weather data and index returns data. The study analysed three daily weather variables, including humidity in percentage, temperature in degrees and wind speed in meters per second, in five metro cities of India (Bangalore, Chennai, Delhi, Mumbai, and Kolkata.), for the period from January 1st 2007 to December 31st 2017 (11years), obtained from Indian Meteorological

Department website i.e. www.imd.gov.in/. The daily MCX AGRI index data were collected from respective website https://www.mcxindia.com/market-data/index-history. This study focusses on returns of all values at stationary levels, but the original values were non-stationary (unable to reject the hypothesis in non-stationary in levels).

3.5. Tools used for analysis

To obtain stationary levels, the study used the returns of all data (three weather factors and index return). The returns were calculated for Commodity market data and Weather Data as;

$$R_t = L_n (P_t) - L_n (P_t - 1)$$

Where,

R_t is daily return,

Pt and $P_t - 1$ are closing values and

"t refer time.

The following tools were used for the analysis.

- Descriptive Statistics (to find out the normal distribution of returns of sample index and weather factors in five sample cities).
- Unit Root Test (to test stationary among the returns of sample index and weather factors in five sample cities).
- Regression Model (to test the impact of sample index and weather factors in five sample cities).

4. EMPIRICAL FINDINGS

For the purpose of this study, the empirical analysis of commodity index and weather factors was undertaken.

4.1 Analysis of Normality for the Sample Commodity Index and Weather Factors in India

4.2 Analysis of Stationary for the Sample Index and Weather Factors in India

4.3 Analysis of impact for the Sample Index and Weather Factors in five cities in India

4.1 Analysis of Normality for the Sample Commodity Index and Weather Factors in India

Table-1 displays the descriptive statistics of daily returns of sample weather factors, in five sample cities in India and Commodity Index returns, during the study period from January 1st 2007 to December 31st 2017. The mean value and standard deviation value of commodity index return were at -0.91964 and 13.00076 respectively, during the study period. Regarding market risk, as measured by the standard deviation, the daily returns of sample commodity index was 13.00076 during the study period. But the skewness value was negative at -4.932882. According to the Jarque-Bera (JB), the values of commodity index were normally distributed during the study period. From the weather data, it is important to note that the mean values of all the five sample cities in India were positive and it shows that in all the five cities, weather factors earned significant return during the study period. In the Information Technology corridor of India – Bangalore, the wind speed earned the highest mean value of 0.12512 but at Chennai, the temperature recorded the lowest mean value (0.0006). As per the results of standard deviation, Mumbai, the business city of India achieved the highest value of 1.1419 and it denotes the fact that wind speed was considered a dominated factor rather than in Mumbai than other sample cities. But in Chennai, temperature earned the minimum standard deviation

value of 0.0351 during the study period. The analysis of Skewness, Kurtosis and Jarque-Bera clearly demonstrated that the data of temperature, humidity and wind speed were distributed normally. The overall analysis established the fact that there was normal distribution of data, relating to sample commodity index and weather factors, in all the five sample cities, during the study period. Hence the null hypothesis (NH01), "**There is no normal distribution among the sample commodity index and weather factors in five cities,** was rejected

4.2. Analysis of Stationarity for the Sample Index and Weather Factors in India

The results of Augmented Dickey Fuller (ADF) Test and Phillips-Perron Test (PP), for sample index and five cities in India respect of weather factors during the study period, from January 2007 to December 2017, are presented in **Table-2.** It is to be noted from the table that the probability values (P Value) for sample commodity index and sample weather factors in five sample cities of India were nearly zero (0.0001 to 0), during the study period. The statistical values of ADF test and PP test for the commodity index return were negative, with values of -53.2772 and -53.36834 respectively. The result of Unite Root Test clearly confirmed that the sample commodity index and weather factors data series in five sample cities of India obtained stationary. Hence the Null Hypothesis (NH2), **there is no stationarity among the sample commodity index and weather factors in five cities,** was rejected**.**

Table – 1 Results of Descriptive Statistics of Commodity index return and Weather Factors for Five Cities in India from 1st January 2007 to 31st December 2017

		MCXAGRI	HUMIDITY	TEMPERATURE	WIND_SPEED
Bangalore	Mean	-0.91964	0.0085	0.0009	0.1251
	Std. Dev.	13.00076	0.1332	0.0411	0.7373
	Skewness	-4.932882	1.101222	-0.092861	5.953271
	Kurtosis	215.4062	8.170713	4.750706	67.96696
	Jarque-Bera	5352174	3739.115	366.899	516407.5
	Probability	0	0	0	0
	Observations	2842	2842	2842	2842
Chennai	Mean	-0.91964	0.0035	0.0006	0.0572
	Std. Dev.	13.00076	0.0852	0.0351	0.5669
	Skewness	-4.932882	0.706087	0.04559	20.47441
	Kurtosis	215.4062	5.926471	7.031606	673.674
	Jarque-Bera	5352174	1250.299	1925.711	53462807
	Probability	0	0	0	0
	Observations	2842	2842	2842	2842
Delhi	Mean	-0.91964	0.0182	0.0064	0.1060
	Std. Dev.	13.00076	0.2091	0.1289	0.5980
	Skewness	-4.932882	2.469668	10.63084	4.193629
	Kurtosis	215.4062	21.0602	316.335	43.82936
	Jarque-Bera	5352174	41513.07	11679543	205735.1
	Probability	0	0	0	0
	Observations	2842	2842	2842	2842
Kolkat	Mean	-0.91964	0.0051	0.0015	0.1454
	Std. Dev.	13.00076	0.1075	0.0567	1.1419

	Skewness	-4.932882	0.797005	0.045539	25.84725
	Kurtosis	215.4062	11.54858	5.093068	1010.372
	Jarque-Bera	5352174	8938.798	518.8433	1.20E+08
	Probability	0	0	0	0
	Observations	2842	2842	2842	2842
Mumbai	Mean	-0.91964	0.0095	0.0007	0.0264
	Std. Dev.	13.00076	0.1449	0.0379	0.2434
	Skewness	-4.932882	1.745399	0.340813	1.75506
	Kurtosis	215.4062	13.75137	7.526556	11.81466
	Jarque-Bera	5352174	15131.01	2481.342	10659.76
	Probability	0	0	0	0
	Observations	2842	2842	2842	2842

Source: Compiled from MCX Agri and IMD/ and Computed using E-Views 6 Version

Table – 2 The Results of Unit Root Test for Commodity index return and Weather Factors for Five Cities in India from 1st January 2007 to 31st December 2017

		COMMODITY INDEX RETURN		***HUMIDITY***		***TEMPERATURE***		***WIND_SPEED***	
		Statistical Value	Prob.*	Statistical Value	Prob.*	Statistical Value	Prob.*	Statistical Value	Prob.*
Bangalore	*ADF TEST*	-53.2772	0.0001	-26.926	0	-24.759	0	-63.081	0.0001
	PP TEST	-53.36834	0.0001	-83.7451	0.0001	-89.3018	0.0001	-63.0002	0.0001
Chennai	*ADF TEST*	-53.2772	0.0001	-25.539	0	-24.759	0	-60.697	0.0001
	PP TEST	-53.36834	0.0001	-129.816	0.0001	-87.2461	0.0001	-60.8319	0.0001
Delhi	*ADF TEST*	-53.2772	0.0001	-66.12	0.0001	-38.177	0	-48.509	0.0001
	PP TEST	-53.36834	0.0001	-66.1204	0.0001	-66.2758	0.0001	-69.7079	0.0001
Kolkata	*ADF TEST*	-53.2772	0.0001	-28.599	0	-27.298	0	-57.585	0.0001
	PP TEST	-53.36834	0.0001	-88.5339	0.0001	-64.6554	0.0001	-57.7106	0.0001
Mumbai	*ADF TEST*	-53.2772	0.0001	-27.445	0	-30.21	0	-40.809	0
	PP TEST	-53.36834	0.0001	-69.6166	0.0001	-92.9501	0.0001	-80.3342	0.0001

Source: Compiled from MCX Agri and IMD/ and Computed using E-Views 6 Version

4.3. Analysis of impact for the Sample Index and Weather Factors in five cities in India

Table 3 shows the results of OLS Regression Test, for the sample commodity index and weather factors, in Bangalore city during the study period from January 2007 to December 2017. The Table clearly explains that there was negative coefficient value for all weather factors in Bangalore City. It is to be noted that *t* statistics and significant value were compared with the values of independent variables (three weather factors in Mumbai City) and dependent variable (MCXAGRI). The comparison reveals that the *t* statistics values for weather variables were found to be in negative but the values for temperature at 0.450, humidity at 0.309 and wind speed at 0.695, were significant and positive, during the study period. But the significant value did not attain conventional levels of significance and it shows that weather factors in Bangalore did not influence commodity index return during the study period.

Table 3 The Results of OLS Regression Model for testing the influence of Commodity index return and Weather Factors in Mumbai City from 1st January 2007 to 31st December 2017

MODEL	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
(Constant)	-0.881	0.248		-3.549	0.000
TEMPERATURE	-5.102	6.748	-0.016	-0.756	0.450
HUMIDITY	-2.126	2.091	-0.022	-1.017	0.309
WIND SPEED	-0.130	0.332	-0.007	-0.392	0.695
Dependent Variable: MCXAGRI					

Source: Compiled from yahoo finance and Computed by using SPSS

The results of OLS Regression Test, for the sample commodity index and weather factors in **Chennai City** during the study period from January 2007 to December 2017 are given in **Table-4**. It is evident from the Table that except temperature, two weather variables attained negative coefficient values (humidity with the value of -0.047 and wind speed with the value of -0.520) during the study period. It is to be noted that there was positive and significant value for *t* statistics but temperature in Chennai earned a value of 0.021, which is a conventional level of significance. It is concluded that temperature in Chennai influenced the MCXAGRI and the investors' mood and their investment decision during the study period.

Table 4 The Results of OLS Regression Model for testing the influence of Commodity index return and Weather Factors in Chennai City from 1st January 2007 to 31st December 2017

MODEL	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-0.892	0.246		-3.620	0.000
TEMPERATURE	0.197	0.022	0.001	2.622	0.021
HUMIDITY	-0.167	3.564	-0.001	-0.047	0.963
WIND SPEED	-0.230	0.443	-0.010	-0.520	0.603
Dependent Variable: MCXAGRI					

Source: Compiled from yahoo finance and Computed by using SPSS

Table-5 exhibits the results of OLS Regression, for daily data, in respect of sample commodity index and weather factors in **Delhi** City during the study period from January 2007 to December 2017. The value Coefficients for Delhi City and for two weather factors attained negative values (temperature -2.805 and wind speed -0.485) during the study period but humidity attained a positive value (0.360). The values of the weather factors, namely, temperature (0.758), humidity (0.134) and wind speed (0.236) were significant. This indicates that among three weather factor, only one factors, namely, humidity recorded significant influence on the MCXAGRI during the study period.

Table 5 The Results of OLS Regression Model for testing the influence of Commodity index return and Weather Factors in Delhi City from 1st January 2007 to 31st December 2017

MODEL	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-0.843	0.250		-3.377	0.001
TEMPERATURE	-2.805	1.897	0.006	-1.479	0.758
HUMIDITY	0.360	1.169	0.022	0.308	0.134
WIND SPEED	-0.485	0.409	-0.028	-1.186	0.236
Dependent Variable: MCXAGRI					

Source: Compiled from yahoo finance and Computed by using SPSS

Table-6 shows the results of OLS Regression Test, for the sample commodity index and three weather factors, in **Kolkata City** during the study period from January 2007 to December 2017. It is observed from the **Table-6** that for two weather factors, out of three, coefficient values were positive, i.e. Temperature at 2.329 and humidity at 0.575 but wind speed scored a negative value of -0.048 during the study period. It is clearly understood that there were positive values for two factors but no one weather factor attained conventional levels of significance. This implies that fact that weather factors in Kolkata City did not influence MCXAGRI and the investors' moods and their sentiment during the study period.

Table 6 The Results of OLS Regression Model for testing the influence of Commodity index return and Weather Factors in Kolkata City from 1st January 2007 to 31st December 2017

MODEL	Unstandardized	Standardized

	Coefficients		Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-0.904	0.247		-3.653	0.000
TEMPERATURE	2.329	4.535	0.010	0.513	0.608
HUMIDITY	0.575	2.389	0.005	0.241	0.810
WIND SPEED	-0.048	0.215	-0.004	-0.225	0.822
Dependent Variable: MCXAGRI					

Source: Compiled from yahoo finance and Computed by using SPSS

The results of the OLS Regression analysis for Commodity index and Weather Factors in **Mumbai City,** from 1st January 2007 to 31st December 2017, are presented in **Table-7.** The estimated coefficient t-values and their level of significance were analysed. The analysis clearly shows that out of three weather factors, only one weather factor, namely, wind speed earned positive coefficient value (1.348). But at the same time, wind speed received *t* statistic value of 1.328, which is a conventional level of significance (**0.004).** It indicates the fact that one weather factor, namely, wind speed recorded statistically significant relationship with MCXAGRI during the study period.

Table 7 The Results of OLS Regression Model for testing the influence of Commodity index return and Weather Factors in Mumbai City from 1st January 2007 to 31st December 2017

MODEL	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-0.920	0.247		-3.727	0.000
TEMPERATURE	-0.520	7.338	-0.002	-0.071	0.944
HUMIDITY	-2.191	1.922	-0.024	-1.140	0.254
WIND SPEED	1.348	1.015	0.025	1.328	0.004
Dependent Variable: MCXAGRI					

Source: Compiled from yahoo finance and Computed by using SPSS

According to the results of the Tables 3-7, temperature in Chennai earned the value of **0.021,** humidity in Delhi received the value of **0.134** and wind speed in Mumbai got the value of **0.004** during the study period. This shows that only these three factors influenced MCXAGRI and the investors' moods and their investment decision making process during the study period. Hence, the Null hypothesis (NH3), **there is no influence among the sample commodity index and weather factors in five cities,** is partially accepted

4- SUMMARY AND CONCLUSIONS

The present study arrived at important findings to help conventional and socially responsible investors, trading in India. It is well established in psychological studies that individual mood, feelings and emotions could affect the investor's decision-making while investors' mood would also be influenced by different environmental factors, including weather conditions

(Chinnadurai Kathiravan et al., 2018). The socially responsible investors are more sensitive to handle social and environmental issues than conventional investors. Delhi humidity affected the commodity index returns, which confirmed with the findings of **Dowling and Lucey, (2005).** This shows that a high degree of humidity affected the human comfort and thus, generally aggressive behavior **(Cao and Wei, 2005**). On the other side, Chennai Temperature influenced investors' mood negatively, which also is confirmed with the finding of **Chinnadurai Kathiravan et al., (2017)**. Wind Speed in Mumbai created impact on the agricultural commodity index, namely, MCX Agri and the investors' mood in India. The results of the study are consistent with views of psychologists, who found that weather created an impact on the psychological aspects of human beings and thus investors and their decisions **(Thaler, 1999)**. It means that there are different weather factors that create impact on the investors, decisions making process. The results of the study suggest that investors can be benefited if they consider the weather factors and climate conditions. These findings also provide innovative perspective on investment decision by the investors who are trading in agricultural products.

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