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Crop Price Prediction Using Machine Learning in Madhya Pradesh: A Pilot Study

Project Report

Atal Bihari Vajpayee Institute of Good Governance and Policy Analysis

State Agriculture Marketing (Mandi) Board, Government of Madhya Pradesh

PROJECT REPORT

Crop Price Prediction using Machine Learning in Madhya Pradesh: A Pilot Study

Submitted to:

State Agricultural Marketing (Mandi) Board,

Government of Madhya Pradesh

Atal Bihari Vajpayee Institute of Good Governance and Policy Analysis

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This report is the output of the pilot study commissioned by Centre for NRM and Decentralised Governance, Institute of Good Governance (IGG) on request of State Agricultural Marketing (Mandi) Board, Government of Madhya Pradesh, to explore to what level of accuracy the prices of agricultural crops can be predicted using machine learning.

Funded by:

State Agricultural Marketing (Mandi) Board, Government of Madhya Pradesh.

Project Guidance:

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Mr. Vikram Sarbhajna, Machine Learning Consultant.

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Preface

Discovering the best possible price and for covering both weather and market induced risks for produce are challenges that confront the farmers before, during and after the completion of the crop cycle. The ability to make a fair assessment of how the market is likely to behave, especially so in the short term when the harvested commodity is about to be taken to the market, can help bridge the information-gap for the farmer to make a selling decision.

Price forecasting methods and techniques continue to evolve and sharpened by various agencies. In the recent past, machine learning technology is gaining traction as an important tool in the hands of the policy makers. We at the Institute of Good Governance (IGG) have been able to seize the opportunity to take up work in this direction during 2018-19. The first pilot study using machine learning technology was commissioned by us in collaboration with the M.P. State Agricultural Marketing Board (Mandi Board). Working on the parameters agreed with the Mandi Board, the study was able to predict prices 15 days before the actual arrival up to 95 percent accuracy for the Soyabean crop. Encouraged by the results, a second study has been taken up now. During this second pilot study, modelling for predictions has been made for major Rabi and Kharif crops like Maize, Bengal gram (Chana), Mustard, Lentil (Masur), Black gram (Urad) and Red gram (Tur) which witness high price volatility has been tried out. In this model, fortnightly predictions at the micro level, i.e. at the level of individual mandis, are envisaged. These can help the farmers in sharpening their decision-making ability to sell at a mandi of his choice.

The project was funded by the Mandi Board and would not have been possible without the active support of the officers at the State Agricultural Marketing (Mandi) Board. They extended all-round support by sharing data on arrivals and prices at individual market yards and helped coordinate interaction with a wide range of stakeholders.

Mr. Faiz Ahmed Kidwai, the then Managing Director, Mandi Board took keen interest and extended full support from conceptualisation to completion.

I would like to thank **Mrs. Neelam Rao**, the then Principal Secretary, Department of Food and Civil Supplies, **Mrs. Swati Meena,** MD, MARKFED, **Mr. Vikas Narwal** and **Mrs. Sufia Farooqi,** successive Managing Directors of MPSCSC for sharing data on market arrivals as well as other inputs needed for the study.

I congratulate the project team comprising of **Mr. Mangesh Tyagi**, Principal Advisor, and **Dr. Anitha Govindaraj,** Advisor, both at the IGG's Centre for NRM & Decentralised Governance, and **Mr. Vikram Sarbhajna**, Machine Learning Consultant for successfully completing the study.

We are hopeful that the Mandi Board shall be able to disseminate the information collected as an outcome of this project to the state's farmers to help them make informed selling decisions for getting a remunerative price for their produce.

R. Parasuram
Director General, IGG

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EXECUTIVE SUMMARY

Price volatility is one of the major risks that a farmer faces today. Yet, there are limited means available to the farmer to mitigate this risk.

In today's world, price volatility is not only a function of domestic production and demand but international (trade) dynamics too. Within this context, reliable price predictions can help farmers anticipate price movements and plan their marketing accordingly.

During Kharif 2018-19, The Madhya Pradesh Mandi board together with Atal Bihari Vajpayee Institute of Good governance and policy analysis (AIGGPA) collaborated to pilot the use of machine learning models to predict (short-term) prices of Soyabean.

The algorithm was created to predict modal prices at 14-day intervals across the major mandis in MP. It achieved an accuracy rate of 95%.

The high accuracy rate for Soyabean resulted in a further pilot with 6 crops for Rabi 2018-19 and Kharif 2019-20 seasons. The crops were, Bengal Gram (Chana), Mustard and Lentil (Masur) for Rabi 2018-19. Maize, Red gram (Arhar), and Black gram (Urad) were selected for the Kharif 2019-20 season.

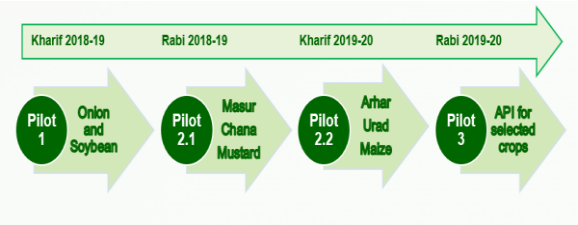


Figure 1 Phases of pilots

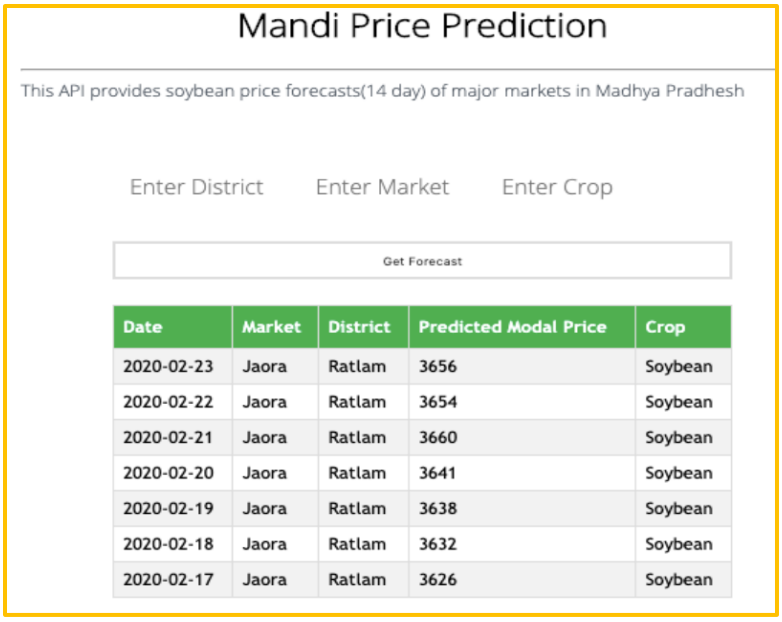
Rabi 2018-19 phase was completed **with accuracy of 94% for Masur, 96% for Chana and 97% for Mustard.**

For Kharif 2019-20 an accuracy of **91% for Maize and 87% for Urad** was achieved.

Dissemination of the prediction is just as important as their accuracy.
Observations from field visits to major mandis suggest that predictions need to be provided through both analog (newspapers and radio) as well as digital (websites, apps) channels. As a follow-up an API-based strategy is being adopted to support multiple dissemination channels.

API and Front end

As stated,the API for Soyabean has been created and a front end to check the actual versus predicted has been created . Below is the snap shot of the API



Date	Market	District	Predicted Modal Price	Crop
2020-02-23	Jaora	Ratlam	3656	Soybean
2020-02-22	Jaora	Ratlam	3654	Soybean
2020-02-21	Jaora	Ratlam	3660	Soybean
2020-02-20	Jaora	Ratlam	3641	Soybean
2020-02-19	Jaora	Ratlam	3638	Soybean
2020-02-18	Jaora	Ratlam	3632	Soybean
2020-02-17	Jaora	Ratlam	3626	Soybean

Selection to be made for District, Market and Crop

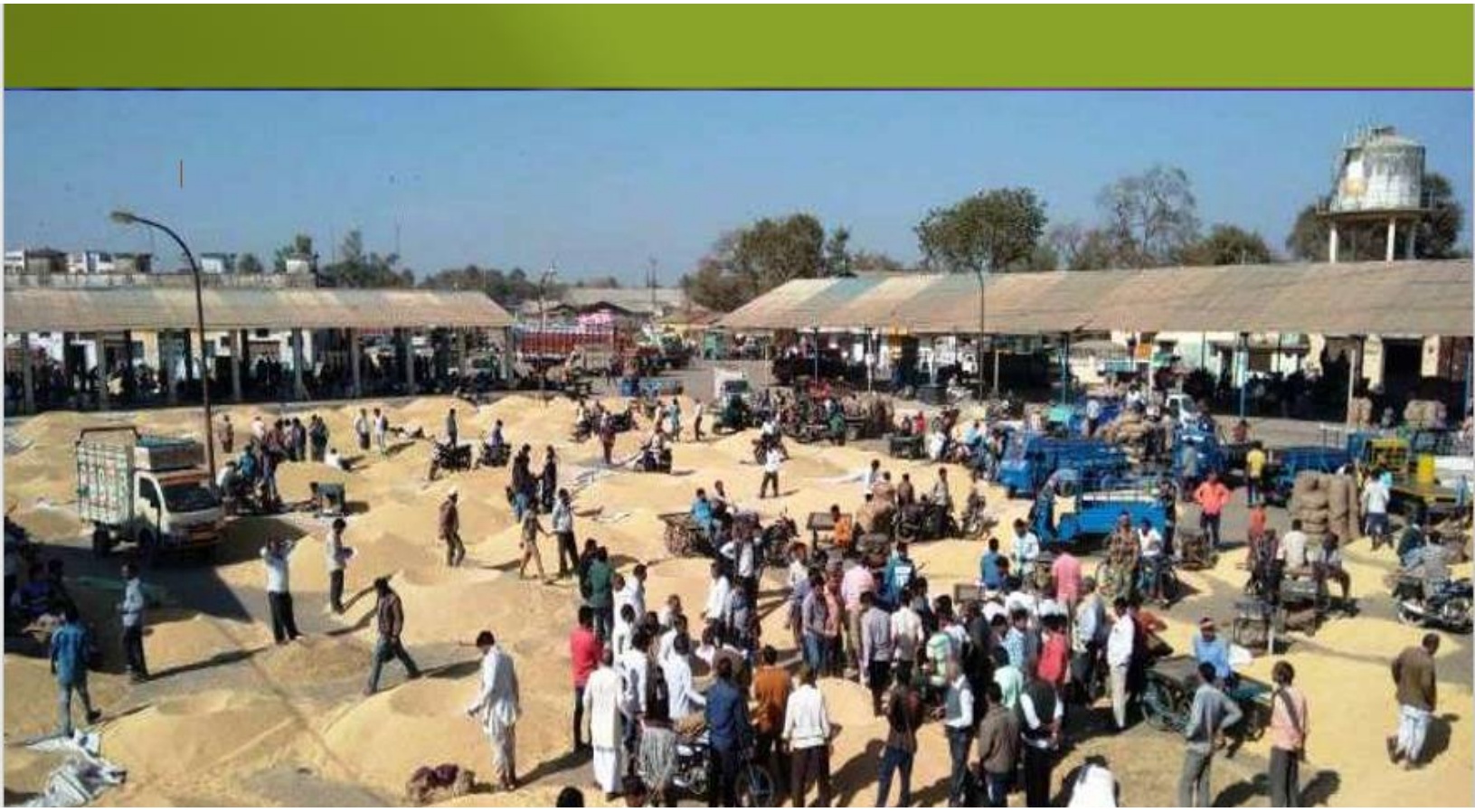
Predicted price will be displayed for 14 days in advance of the current date

Date	Market	District	Current Modal Price	Crop
09-02-2020	Jaora	Ratlam	3600	Soybean
08-02-2020	Jaora	Ratlam	3600	Soybean
07-02-2020	Jaora	Ratlam	3710	Soybean
06-02-2020	Jaora	Ratlam	3710	Soybean
05-02-2020	Jaora	Ratlam	3710	Soybean
04-02-2020	Jaora	Ratlam	3760	Soybean

Download CSV

The Current Modal price will be the last updated price on agmarknet portal.

The predicted prices can be downloaded in excel.



1. INTRODUCTION

Agriculture produce is subjected to various risks, which are not only confined to production risk pertaining to weather, pest but also the demand and supply of various countries, other policy and economic factors. With restricted knowledge to understand and comprehend the information, farmers can incur huge losses by selling their produce in distress. Farmers no longer have to contend with just local markets. They also have to account for competition from the world over.

High price volatility has been a major concern in past few years both for farmers and consumers.

Higher price volatility has driven the search for reliable and accurate price forecasting techniques for agricultural commodities. The main purpose of price prediction is to help producers manage their price risk and take informed decisions. Machine Learning has proved to be better than the traditional time series method of price prediction, using many linear and non-linear forecasting models.

Machine learning driven price predictions differ in two main aspects from traditional approaches:

- It can account for multiple price determinants thus improving accuracy
- It provides localized (mandi-level) predictions thus increasing their usability

Machine Learning based price prediction provides a unique way of combining technical and fundamental analysis methods. While technical analysis solely looks at historical

price, fundamental analysis consists of understanding external and internal factors that influence the prices of a certain commodity. Individually technical analysis can be useful for providing accurate short-term prediction while fundamental analysis can help in long term forecast. By combining the two, higher accuracy in predictions can be achieved.

During the Kharif season of 2018-19, a pilot was undertaken for predicting the prices of Soyabean and Onion for a period of 14 days and 30 days. The results for Soyabean were promising and hence the second pilot was initiated with new set of crops (Mustard, Chana and Masur) for Rabi 2018-19 and (Maize, Arhar and Urad) for Kharif 2019-20.

Also, a need for an API has arisen mainly to automate the dissemination of prices to the farmers.

This document summarizes the methodology, results and observations of the crops identified for Kharif 2019-20 as well as Rabi 2018-19. A reading guide, Chapter 2 will provide the Scope and objective of the pilot. Chapter 3 provides the methodology. Details on algorithm training is covered in Chapter 4. Finally, project results and conclusions are covered in Chapter 11 and Chapter 12. Weekly details of predictions as a part of project results are a part of Annexure C.

2. OBJECTIVES

To conduct a pilot to examine whether machine learning can be used for:

1. Forecasting the modal price of the selected crops in advance using machine learning at 14 and 30 days intervals at the selected Mandis across Madhya Pradesh.

2. Estimate the accuracy of price forecasts at various time intervals and determine confidence levels for the accuracy of the same.

Selection of crops for Price predictions:

The following crops were chosen for the price prediction considering various factors such as area under the crop, crop production and the price volatility. Paddy and Wheat crops were consciously avoided due its low-price volatility and MSP being the deciding factor of their prices.

Chana **Mustard** **Masur**

Arhar **Urad** **Maize**

3. PROJECT APPROACH

A general approach for machine learning projects has been adopted for this project. The following phases were followed:

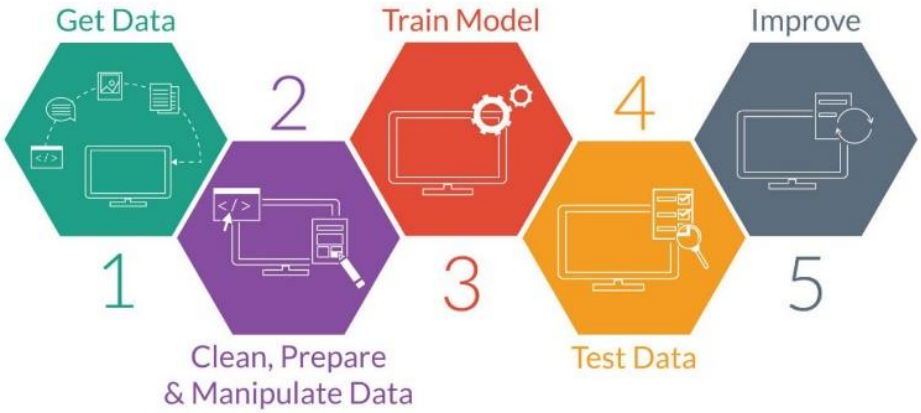


Figure 2 An overview of machine learning project steps

- Identify determinants and acquire data: Interviews with domain experts, identification of influencing factors and delivery of historical data from key stakeholders.
- Prepare data: Clean and transform the downloaded data into a machine-readable format.
- Train model: Developing multiple price prediction algorithms.
- Test model: Testing the output of the algorithms and shortlisting best performing algorithms.
- Deploy and live testing: Deploy the algorithm for live testing over a period and further improvement using key learnings.

The steps followed in price forecasting includes, identifying price determinants, data collection, data cleaning and formatting, algorithm training, testing and evaluation followed by giving live predictions. On an average it takes around three months to complete the process and give prediction of mandi specific prices. The most time-consuming steps are that of data collection, cleaning and formatting (almost 30% of the total project time

The identified price determinants along with their sources are provided in the following tables (Table 1 & 2)

Table 1 Identified general price determinants of commodities and their data sources

Crops	Data	Frequency of availability	Data source
All Crops	Arrivals and prices at Mandis of MP	Daily	Agmarknet
	Area, Yield, Production in MP (district-wise)	Yearly	Commissioner of Land Records MP
	Currency exchange rates for major exporting and importing countries	Daily	Investing.com
	Minimum Support Price (MSP)	Yearly	CACP
	Trade value (Import/Export)	Monthly	Ministry of Commerce and Industry website
	Weather data	Daily	World Weather Online
	APY of other major producing state of India.	Yearly	Department of Agriculture website of state Govt.
	APY in major producing countries.	Yearly	USDA, agricultural websites of respective countries
	Consumption of major consuming countries	Yearly	USDA
	Spot Prices	Daily	NCDEX

As stated in previous reports, identification of price determinants is an ongoing process. New determinants were added besides the general list (Table 1) that was used for last kharif and rabi season predictions. These have been mentioned in the crop specific part of Table 2.

Table 2 Identified Crop Price determinants and their data source

Crops	Data	Frequency of availability	Data source
Soyabean	Commodity Futures	Daily	NCDEX, investing.com
	Spot prices of Derived products (Soymeal and Refined Soyabean Oil)	Daily	NCDEX
Maize	Commodity Futures	Daily	NCDEX
	US Corn and Corn Starch Futures	Daily	Investing.com
	Domestic Consumption of India	Daily	USDA
	MSP of Soyabean	Yearly	CACP
	Estimated Opening Stock of Maize	Yearly	USDA
Urad	MSP of Moong and Urad	Yearly	CACP
Arhar	MSP of Moong and Urad	Yearly	CACP
Mustard	Production and consumption of ● Rapeseed - oilseed ● Rapeseed - meal ● Rapeseed - oil* In European Union and China.	Yearly	USDA
	Commodity Futures	Daily	Investing.com

An overview of the timelines that were followed for the pilot of both Kharif and Rabi is represented in the following figures:

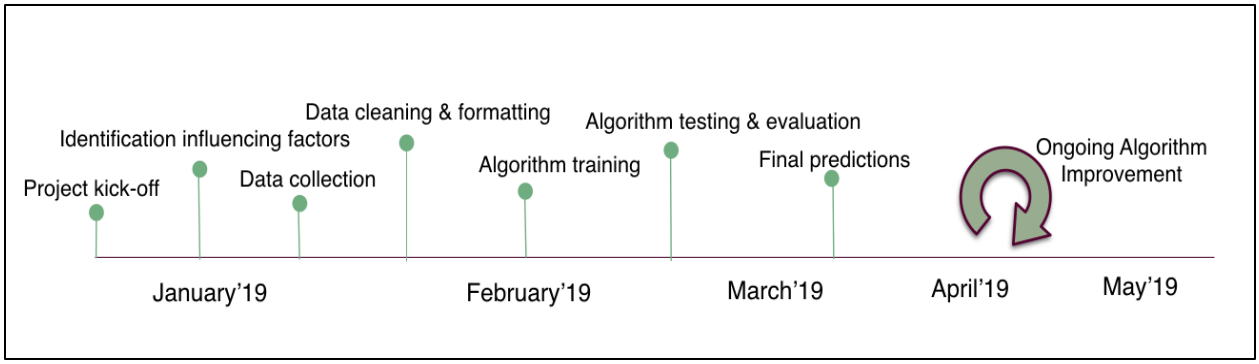


Figure 3 Timelines followed for Rabi pilot

In Rabi 2018-19, January was utilized to identify the price determinants and collect the corresponding data. February was used to create the models (experimentation and various algorithms). The first "live" prediction was provided on 16th March 2019 (for prices on the 30th March 2019). The live prediction was provided till the 18th of June which covers approximately 3 months of prediction.

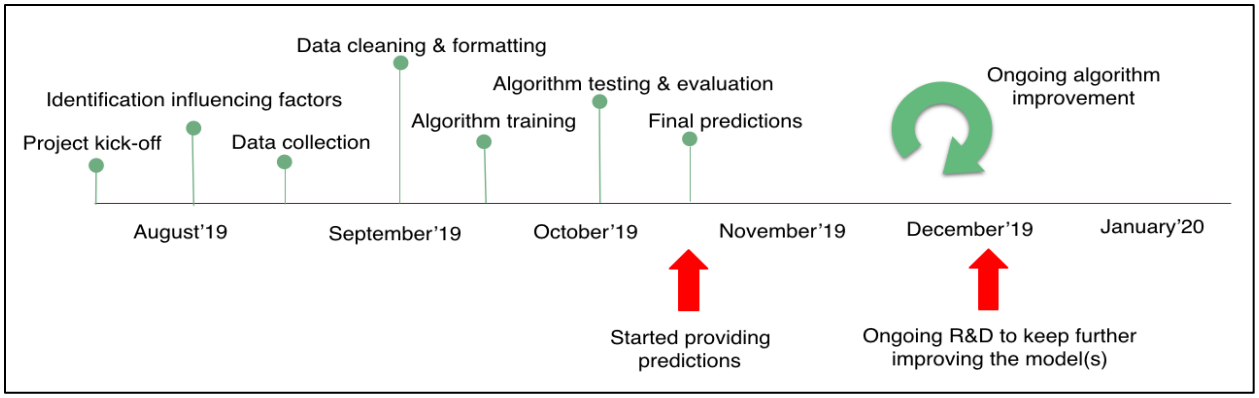
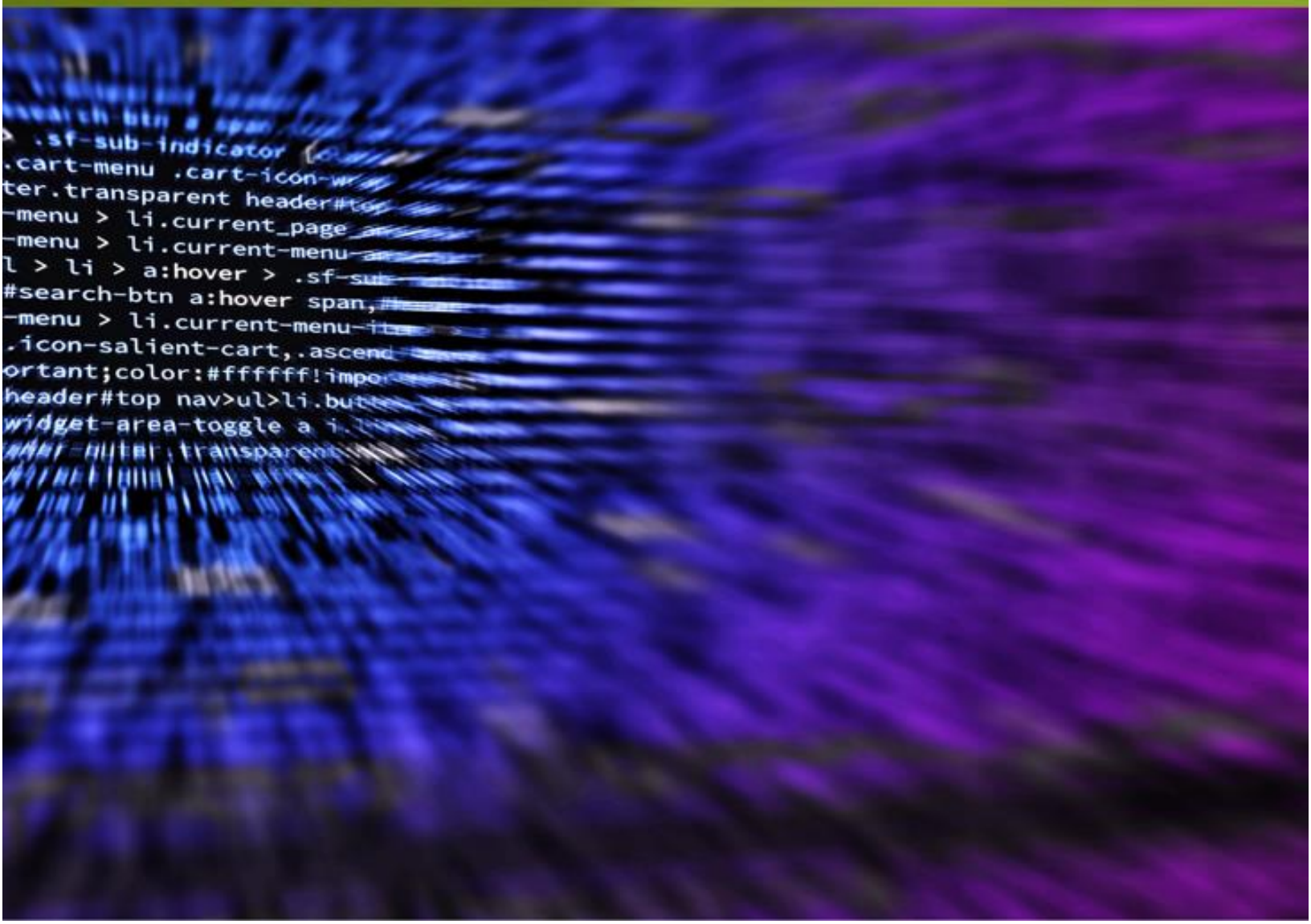


Figure 4 Timelines followed for the Kharif pilot

For Kharif 2019-20, the month of August was utilized in identifying new price determinants and collect their corresponding data. September was used in training the algorithm on these additional variants and improve predictions.

The 'live' predictions for Kharif 2019 started from 11th October'19 (for 25th October 2019) as the arrivals were late due to delay in onset of monsoon.



4. Algorithm Training

4. ALGORITHM TRAINING

The performance of different ML algorithms strongly depend on the size and structure of the input data. Thus, the correct choice of algorithm often remains unclear unless we test out our algorithms through plain old trial and error.

Our trials consisted of different combinations of the following three parameters:

1. **Class of algorithms**: Time series forecasting, decision trees and advanced regression algorithms
2. **Number of price determinants included while training**: Ranging from using 1 to 14 determinants
3. **Data from number of mandis for training**: Training the algorithm on data ranging from 1 to 30 mandis

Four major classes of machine learning algorithms were tested to select the best suited one for each crop. These were:

Random forest (RF)

Support vector machines (SVM)

Least absolute shrinkage and selection operator (LASSO)

Generalized linear model (glm)

The choice for the classes of algorithms was based on a literature review for price forecasting methods. For time series forecasting, we selected ARIMA (Auto Regressive Integrated Moving Average), for decision trees we applied Random forest and LASSO (least absolute shrinkage and selection operator), SVM (Support vector machine) and GLM (generalized linear model) for Regression. The explanation of the various algorithms is provided in appendix A.

The Root Mean Square Error (RMSE) was calculated during the training and testing of each algorithm. **RMSE is a standard way to measure the error of a model in predicting quantitative data.** It is the standard deviation of the residuals (prediction errors).

$$RMSE = \sqrt{(f-o)^2}$$

Residuals are a measure of how far from the regression line data points are; In other words, it tells us how concentrated the data is around the line of best fit. Where f = forecasted prices and o = observed prices or actuals.

Besides RMSE, for the benefit of the reader we have calculated accuracy percentages for each prediction. The formula for which was,

$$\frac{actual\ modal\ price - predicted\ modal\ price}{actual\ modal\ price}\ x\ 100$$

Data quality and pre-processing

As mentioned in the Table 1, the data collection process involves a wide variety of sources. This resulted in a time-consuming data pre-processing step as all sources have their own format and frequency of reporting. These datasets needed to be converted into a uniform 'machine readable' format.

Some of the challenges faced during this phase were:

Many datasets such as MSP, area, yield and production (APY) of other states and countries are provided in a pdf format hence data entry cannot be automated. Additionally, the unit of measurement differs in different sources, APY can vary from district, state to a country level. Finally, the reporting frequency varies from yearly (MSP and APY) to monthly (imports and exports) and daily (currency exchange rates).

There were a few instances concerning data discrepancies in agmarknet. The types of anomalies are stated at length in the previous Kharif and Rabi pilot reports. The main challenges were:

1. Identical modal prices being reported for a prolonged period.

In the following figure we can see that same prices i.e. max price, min price and modal has been reported same for 3 months in Deori market in Sagar District

state	district	market	variety	group	arrivals	min.price	max.price	modal.price	date
		Deori							
Madhya Pradesh	Sagar	Deori	Other	Pulses	18.00	3900	4620	4620	2019-04-09
Madhya Pradesh	Sagar	Deori	Other	Pulses	19.00	3900	4620	4620	2019-04-10
Madhya Pradesh	Sagar	Deori	Other	Pulses	19.00	3800	4620	4620	2019-05-05
Madhya Pradesh	Sagar	Deori	Other	Pulses	13.00	3900	4620	4620	2019-05-06
Madhya Pradesh	Sagar	Deori	Other	Pulses	11.00	3900	4620	4620	2019-05-07
Madhya Pradesh	Sagar	Deori	Other	Pulses	39.00	3900	4620	4620	2019-05-08
Madhya Pradesh	Sagar	Deori	Other	Pulses	47.00	3900	4620	4620	2019-05-09
Madhya Pradesh	Sagar	Deori	Other	Pulses	18.00	3900	4620	4620	2019-05-10
Madhya Pradesh	Sagar	Deori	Other	Pulses	49.00	3900	4620	4620	2019-05-11
Madhya Pradesh	Sagar	Deori	Other	Pulses	11.00	3900	4620	4620	2019-05-12
Madhya Pradesh	Sagar	Deori	Other	Pulses	98.00	3900	4620	4620	2019-05-14
Madhya Pradesh	Sagar	Deori	Other	Pulses	121.00	3900	4620	4620	2019-05-15
Madhya Pradesh	Sagar	Deori	Other	Pulses	157.00	3900	4620	4620	2019-05-16
Madhya Pradesh	Sagar	Deori	Other	Pulses	89.00	3900	4620	4620	2019-05-18
Madhya Pradesh	Sagar	Deori	Other	Pulses	11.00	3900	4620	4620	2019-05-19
Madhya Pradesh	Sagar	Deori	Other	Pulses	98.00	3800	4620	4620	2019-05-20
Madhya Pradesh	Sagar	Deori	Other	Pulses	93.00	3900	4620	4620	2019-05-21
Madhya Pradesh	Sagar	Deori	Other	Pulses	87.00	3900	4620	4620	2019-05-22
Madhya Pradesh	Sagar	Deori	Other	Pulses	29.00	3900	4620	4620	2019-06-01
Madhya Pradesh	Sagar	Deori	Other	Pulses	24.00	3800	4620	4620	2019-06-02
Madhya Pradesh	Sagar	Deori	Other	Pulses	17.00	3900	4620	4620	2019-06-03
Madhya Pradesh	Sagar	Deori	Other	Pulses	18.00	3900	4620	4620	2019-06-08
Madhya Pradesh	Sagar	Deori	Other	Pulses	13.00	3900	4620	4620	2019-06-09
Madhya Pradesh	Sagar	Deori	Other	Pulses	17.00	3900	4620	4620	2019-06-10
Madhya Pradesh	Sagar	Deori	Other	Pulses	19.00	3900	4620	4620	2019-06-11
Madhya Pradesh	Sagar	Deori	Other	Pulses	29.00	3900	4620	4620	2019-06-12
Madhya Pradesh	Sagar	Deori	Other	Pulses	19.00	4100	4620	4620	2019-06-13
Madhya Pradesh	Sagar	Deori	Other	Pulses	17.00	3900	4620	4620	2019-06-19
Madhya Pradesh	Sagar	Deori	Other	Pulses	17.00	3900	4620	4620	2019-06-20
Madhya Pradesh	Sagar	Deori	Other	Pulses	19.00	4100	4620	4620	2019-06-21

Figure 5 Constant prices reported for 3 months for Deori market (Sagar District)

The accuracy of the predictions increases with good quality historical data. Special attention should be given to the quality of historical prices provided by agmarknet portal.

2. Sudden and significant shocks in prices reported

state	district	market	group	arrivals	min.price	max.price	modal.price	date
All	All	Neem	All	All	All	All	All	
Madhya Pradesh	Neemuch	Neemuch	Pulses	9.30	3551	3900	3700	2019-05-01
Madhya Pradesh	Neemuch	Neemuch	Pulses	146.10	3400	4081	3800	2019-05-02
Madhya Pradesh	Neemuch	Neemuch	Pulses	4.50	3500	3900	3700	2019-05-03
Madhya Pradesh	Neemuch	Neemuch	Pulses	3.20	3500	3911	3781	2019-05-04
Madhya Pradesh	Neemuch	Neemuch	Pulses	9.80	3750	4004	3850	2019-05-06
Madhya Pradesh	Neemuch	Neemuch	Pulses	10.40	3650	4004	3700	2019-05-08
Madhya Pradesh	Neemuch	Neemuch	Pulses	7.30	3906	4061	3950	2019-05-09
Madhya Pradesh	Neemuch	Neemuch	Pulses	4.70	3800	4215	3900	2019-05-13
Madhya Pradesh	Neemuch	Neemuch	Pulses	6.80	3800	4025	3900	2019-05-14
Madhya Pradesh	Neemuch	Neemuch	Pulses	0.30	1851	1851	1851	2019-05-15
Madhya Pradesh	Neemuch	Neemuch	Pulses	11.30	4008	4573	4331	2019-05-16
Madhya Pradesh	Neemuch	Neemuch	Pulses	5.80	3950	4211	4150	2019-05-17
Madhya Pradesh	Neemuch	Neemuch	Pulses	0.50	4001	4260	4150	2019-05-21
Madhya Pradesh	Neemuch	Neemuch	Pulses	5.70	4000	4251	4150	2019-05-23

Figure 6 Sharp fall and recovery within 1 day

In Neemuch market we have seen sharp fall of prices on 15th May 2019 while the prices were normalized on 16th May 2019. This can be attributed to inferior quality of produce arrived in the market on a day. Adding a quality parameter could have explained this drop in prices at the market.

3. Unavailability or delayed reporting of modal prices.

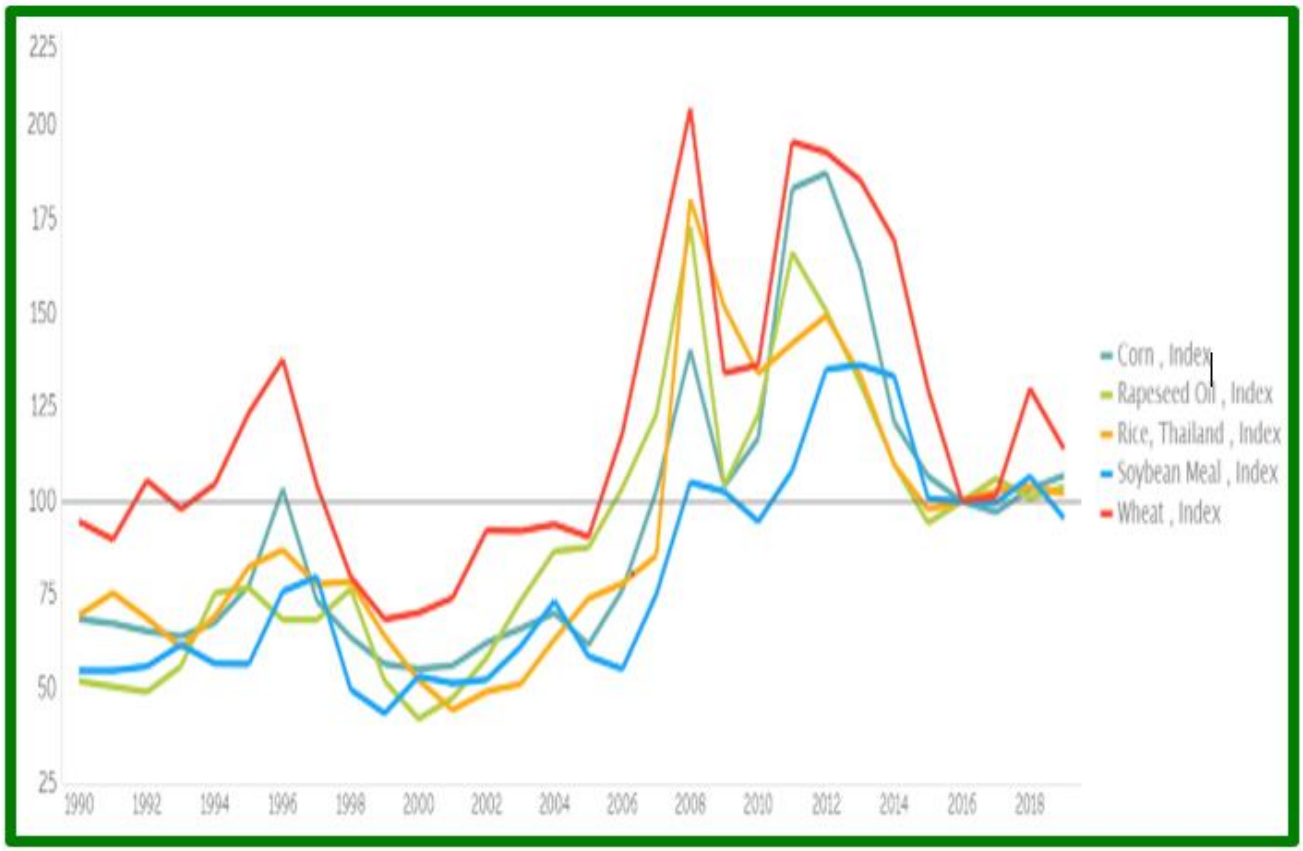
There have been periods when agmarknet portal was not functional for more than one day. For example, in December 2019 the portal was down for more than a week which led to a break in providing price predictions. Additionally, not all markets are consistently reported.

Three key aspects need immediate attention namely:

Data entry: there should be in-built checks to prevent identical price entries for a prolonged period.

Data availability: agmarknet portal is frequently down and all markets are not equally covered.

Data granularity: quality of the crop dictates the price and this parameter should be added as one of the standard features of the reporting.



5.Analysis of price movement

5. ANALYSIS OF PRICE MOVEMENT FOR PAST 3 YEARS

Kharif 2019-20

The volatility for the selected crops (both for Kharif and Rabi) was analyzed using historical data for the past 3 years. Standard deviation and mean price movements were used as basis for the volatility measures. Figure 7 shows the price movements of Soyabean for the major mandi Indore. From the below figure we deduct that prices were more volatile in current season. The exact volatility measures for the past 3 years have been provided in Table 3 below.

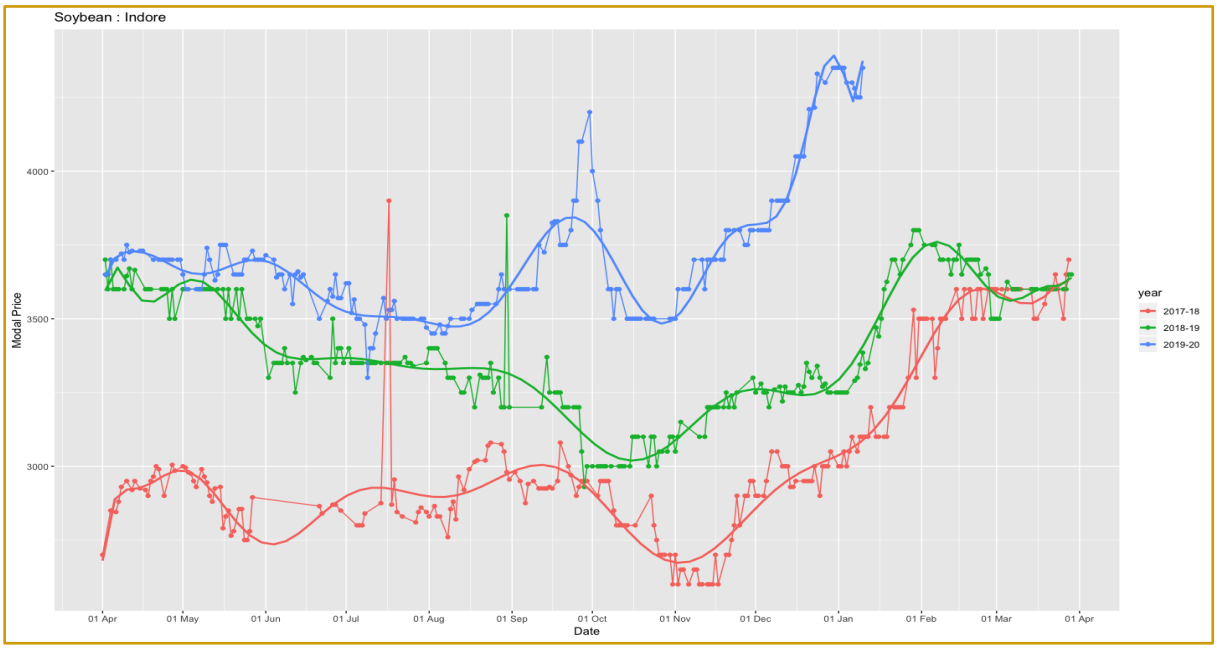


Figure 7 Price movements for Soyabean for 3 years

Table 3 : Volatility measures for Soyabean during peak arrival

Season	Standard deviation	Mean	Coefficient of Variation (CV)
KHARIF-2017-18	203.62	2918.02	0.070
KHARIF- 2018-19	203.62	3253.75	0.063
KHARIF-2019-20	285.75	3835.21	0.075

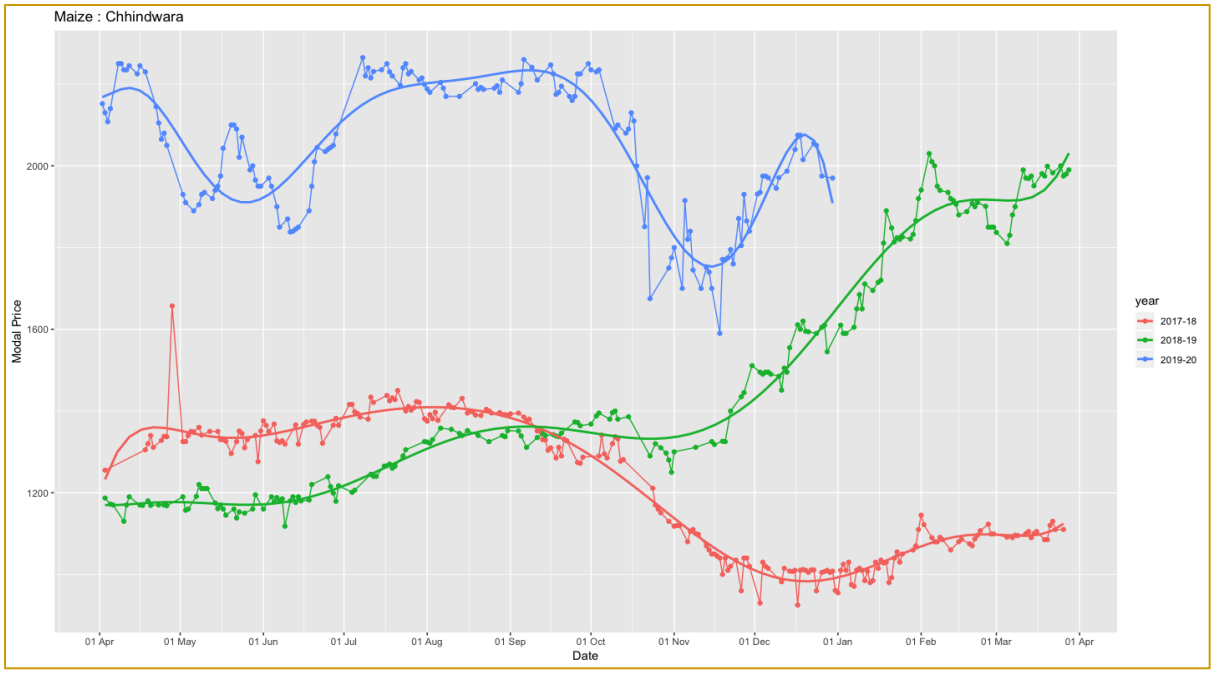


Figure 8 Price movements for Maize for 3 years

Table 4 Volatility measures for Maize during peak arrival

Season	Standard Deviation	Mean	Coefficient of Variation (CV)
KHARIF 2017-18	98.04	1060.93	0.092
KHARIF 2018-19	183.54	1543.92	0.119
KHARIF 2019-20	156.68	1918.29	0.082

From Figure 8, we can deduce that the prices for Maize were the most volatile in 2018-19 season. Prices in 2018-19 showed a steep increase mainly due to lower production. This can be further established with higher standard deviation for 2018-19. Volatility continues for 2019-20 due to delayed monsoons and sowing.

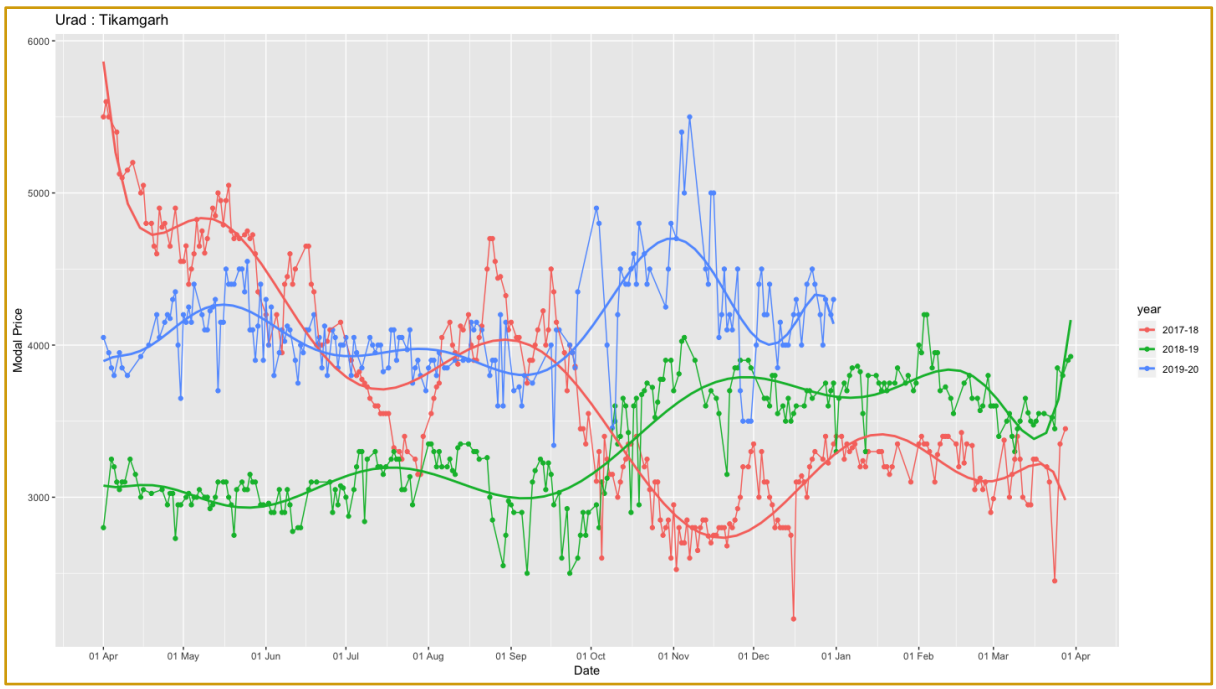


Figure 9 Price movements for Urad for 3 years

Table 5 Volatility measures for Urad during peak arrival

Season	Standard Deviation	Mean	Coefficient of Variation (CV)
KHARIF 2017-18	254.58	3030.85	0.084
KHARIF 2018-19	251.23	3630.88	0.069
KHARIF 2019-20	422.60	4320.61	0.098

Figure 9 depicts the prices movement of 3 years for Urad. It can be inferred that volatility of prices is higher in 2019-20. From the Table 5 it can be inferred that 2019-20, the mean price is higher and so is the standard deviation.

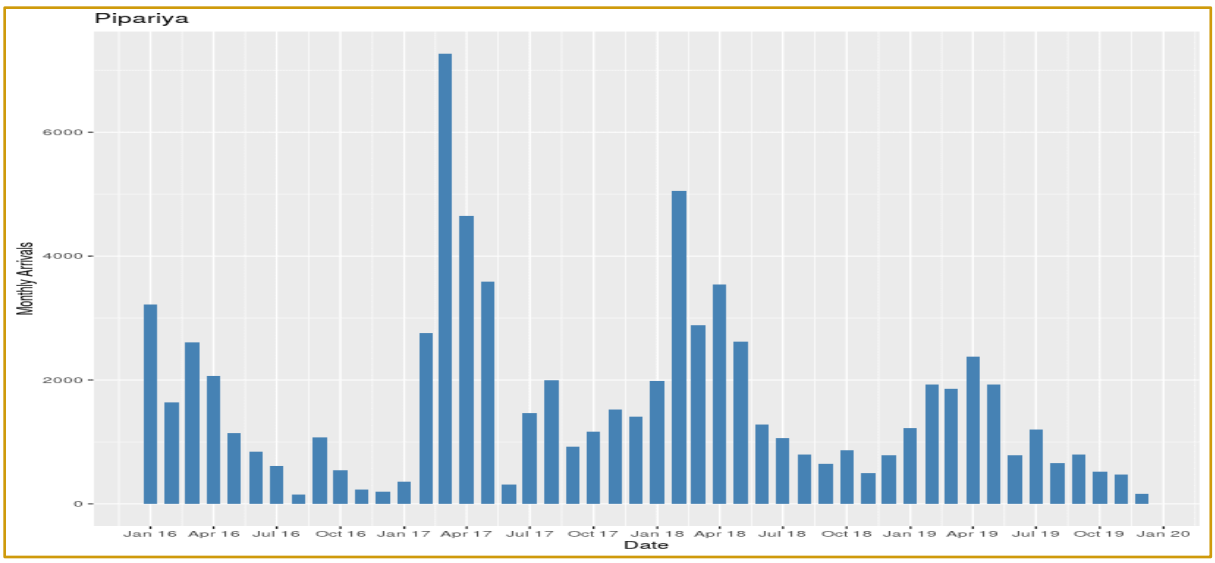


Figure 10 Arrivals of Arhar for 3 years

In case of Arhar, we will not be predicting the prices as the arrivals begins in March (Refer to figure 10 for peak arrivals mainly in March). Hence, Arhar will be treated as a Rabi crop.

Rabi 2018-19

Figure 11 below shows the price movements for Masur at a major mandi (Ganjbasoda). From the graph we can deduce that prices were relatively more volatile in the year 2016-17. We arrive at a similar conclusion when we calculated the standard deviation and the coefficient of variance for the three years (16-17, 17-18 and 18-19). Table 6 provides an overview of the volatility for Masur.

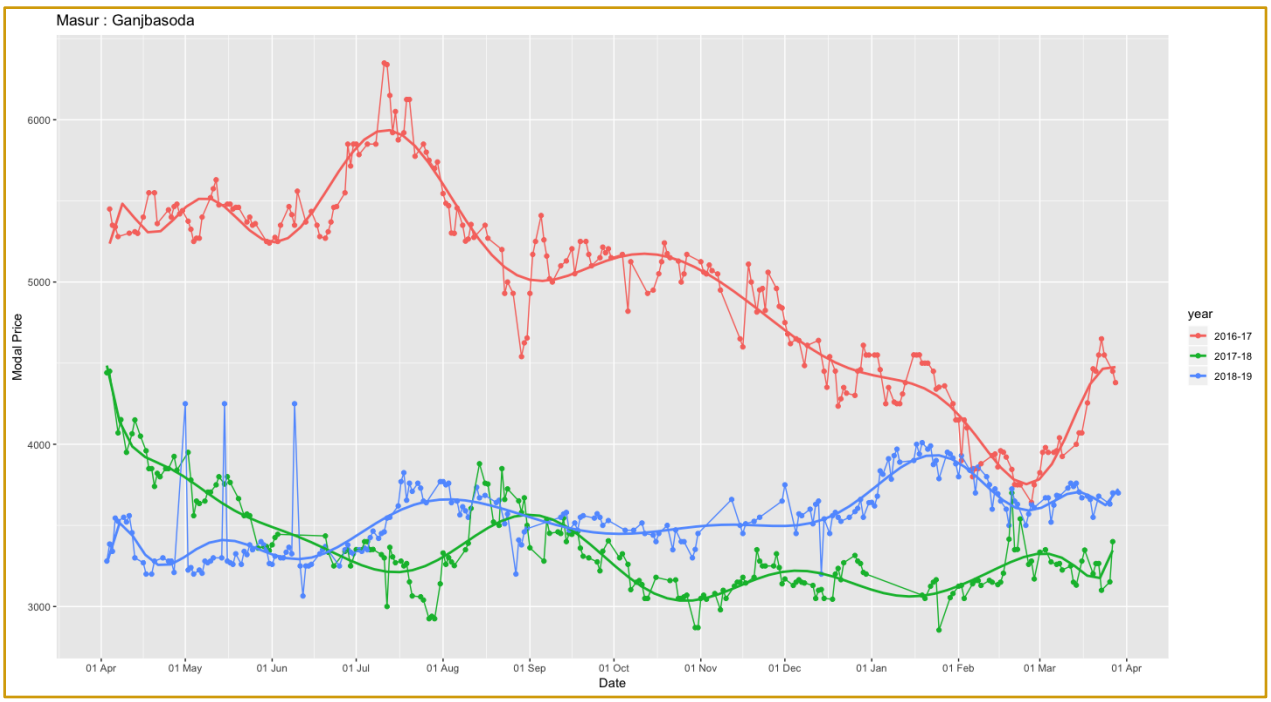


Figure 11 Price movements for Masur for 3 years

Table 6 Volatility measures for Masur during peak arrival

Season	Standard Deviation	Mean	Coefficient of Variation
RABI 2017-2018	352.91	3847.75	0.092
RABI 2018-2019	202.44	3335.12	0.061
RABI 2019-2020	219.90	3913.82	0.056

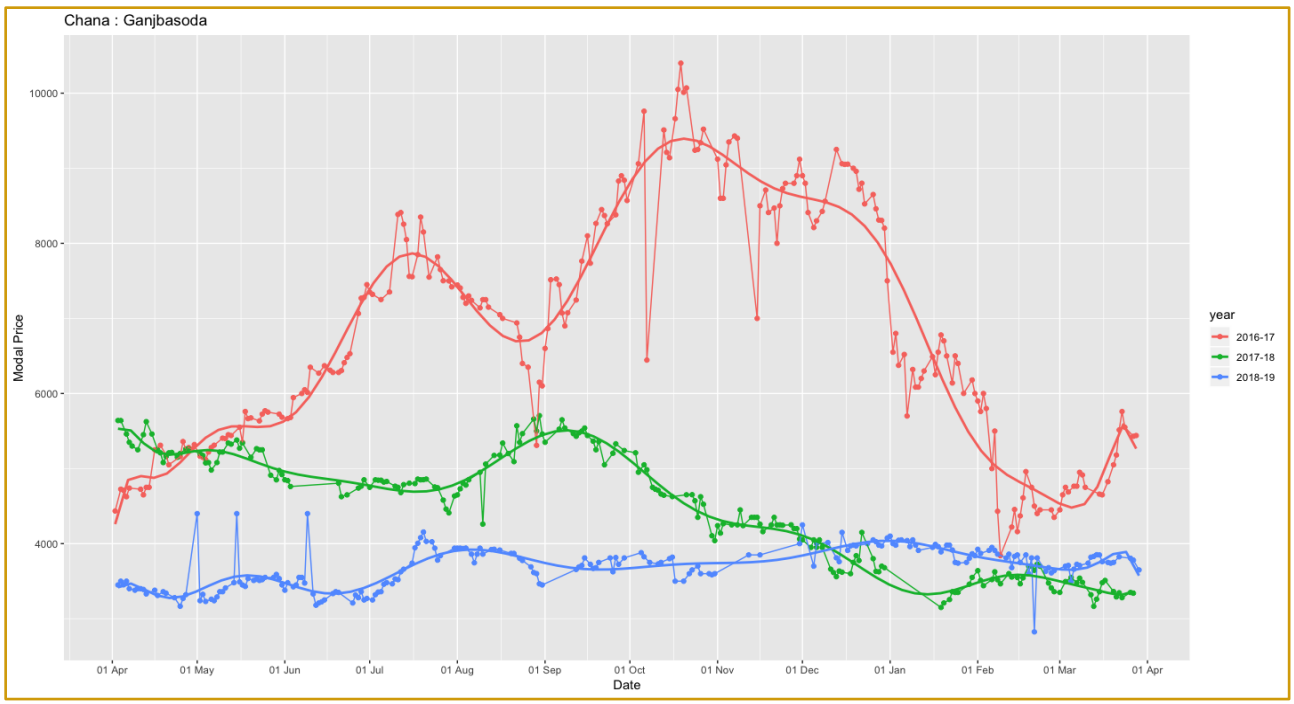


Figure 12 Price movements for Chana for 3 years

Table 7 Volatility measures for Chana during peak arrival

Season	Standard Deviation	Mean	Coefficient of Variation
RABI 2017-2018	297.96	5103.78	0.058
RABI 2018-2019	218.97	3420.08	0.064
RABI 2019-2020	228.92	4009.99	0.057

Figure 12 depicts the price movements for Chana for the past 3 years. In 2016-17 the mean price was significantly higher but the volatility (in terms of standard deviation) was also higher. The Rabi-season of 2019 seemed to be stable.

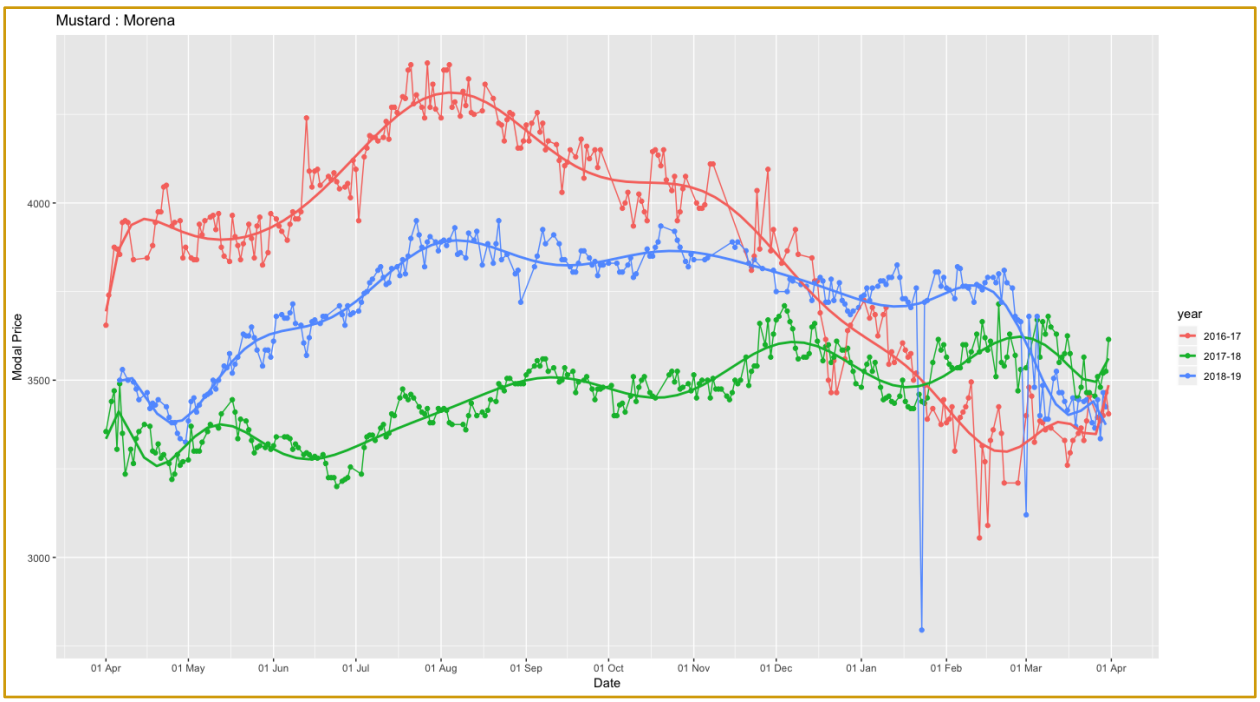


Figure 13 Price movements for Mustard for 3 years

Table 8 Volatility measures for Mustard during peak arrival

Season	Standard Deviation	Mean	Coefficient of Variation
RABI 2017-2018	65.07	3328.23	0.020
RABI 2018-2019	101.88	3550.70	0.029
RABI 2019-2020	145.96	3530.35	0.041

In case of Mustard maximum volatility was seen in year 2016-17. Prices have been relatively stable for past two years which can be also established from the mean of last two years.

Overall our analysis showed that for Kharif 2019-20 season, the prices of Soyabean have been volatile. Maize has been relatively less volatile in the current season; however, its prices have increased compared to previous season. Urad has shown the highest volatility amongst all the shortlisted crops. For Rabi 2018-19, all the three crops namely, Masur, Chana and Mustard have been relatively stable compared to previous seasons.

6. Price variations across major mandis

6. PRICE VARIATIONS ACROSS MAJOR MANDIS

We have analyzed intra- mandi prices and discovered that prices keep varying during the entire peak season with significant changes recorded in modal prices within different mandis. We have provided a few examples to showcase the differences in prices reported for different mandis on particular dates.

Kharif 2019-20

The difference in modal prices across mandis on a particular date can be seen in all three crops of Kharif. Arhar is not considered as arrivals will begin only from the month of March.

Table 9 Price variations across major mandis for Soyabean

Date	Ashta	Dewas	Indore	Ratlam	Ujjain
2019-10-04	**4100**	3850	3800	3742	**2851**
2019-10-17	**3600**	**2800**	3500	3125	3326
2019-10-30	**3651**	3300	3500	**3050**	3151
2019-11-02	3710	**3500**	3600	**3725**	3611
2019-11-20	**3840**	3550	3800	**3450**	3611
2019-11-29	**3850**	3550	3800	**3409**	3570
2019-12-04	**3900**	3600	3800	**3470**	3760
2019-12-19	**4230**	3900	4050	**3800**	3981
2019-12-27	**4350**	4100	4300	**3818**	4051
2020-01-02	**4450**	4200	4350	**3990**	3990
2020-01-10	**4420**	3900	4350	**3895**	3981

Table 10 : Price variations across major mandis for Maize

Date	Chhindwara	Dhamnod	Harda	Indore	Khargone
2019-10-03	2230	1750	**1310**	**2270**	1800
2019-10-10	**2091**	1685	**1425**	2013	1451
2019-10-18	**2000**	1676	**1340**	1947	1450
2019-10-30	1750	1660	**1150**	**1800**	1450
2019-11-06	1820	1585	**1480**	**1900**	1640

2019-11-20	1770	**1775**	**1600**	1600	1570
2019-11-27	**1930**	1865	1840	1855	**1800**
2019-12-03	**1935**	1851	**1785**	1800	1830
2019-12-17	**2075**	1905	**1831**	1900	1870
2019-12-24	**2050**	1940	**1830**	1900	1930
2019-12-30	**1970**	1940	**1820**	1900	1940

Table 11 Price variations across mandis for Urad

Date	Ashoknagar	Ganjbasoda	Jabalpur	Sagar	Tikamgarh
2019-10-10	**3390**	3682	**3705**	3615	3500
2019-10-22	3340	4200	**4550**	4265	4400
2019-10-31	**3200**	4530	**4850**	**4850**	4800
2019-11-02	4175	5200	**6570**	**3640**	4700
2019-11-14	5160	5000	**5635**	**4250**	4400
2019-11-21	5490	4400	**6850**	**3705**	4100
2019-11-29	**4665**	4120	4200	4605	**3500**
2019-12-03	**5950**	4600	4815	**4350**	4400
2019-12-17	**4899**	4305	4170	**3500**	4300
2019-12-23	4645	4300	**4175**	**5100**	4500
2019-12-30	**3595**	4800	4200	**4995**	4200

Rabi 2018-19

In Rabi 2018-19 there has been significant difference within the markets, for example Sagar market for Masur is always reported higher than other markets while Chana showed highest price in Pipariya. Such instances for each crop are highlighted below.

Table 12 Price variations across major mandis for Masur

Date	Ganjbasoda	Katni	Mandsaur	Piplya	Sagar	Satna
2019-03-26	3632	**3500**	3750	3600	**4050**	3550
2019-04-16	3770	3884	3880	3750	**4100**	**3700**
2019-04-25	3780	3730	3770	3750	**4200**	**3450**
2019-05-14	4060	4048	**3870**	3875	**4500**	4000
2019-05-30	4050	4080	4150	4000	**4200**	**3400**
2019-06-11	4050	3880	3860	3900	**4300**	**3350**
2019-06-27	4020	3838	3680	3900	**4300**	**3500**

Table 13 Price variations across major mandis for Chana

Date	Ashta	Begamganj	Ganjbasoda	Kalapipal	Pipariya	Vidisha
2019-03-26	3741	**3600**	3805	3800	**3880**	3720
2019-04-16	3980	3700	3950	**3450**	3950	**4095**
2019-04-24	3990	3850	3900	**3675**	**4050**	3920
2019-05-14	4150	**3800**	4180	3800	**4270**	3900
2019-05-30	4120	**3900**	4220	3850	**4620**	4260

2019-06-14	3900	3700	4060	**3475**	4120	**4130**
2019-06-21	3881	3700	4010	**3550**	4120	**4050**

Table 14 Price variations across mandis for Mustard

Date	Lahar	Lashkar	Morena	Piplya	Rewa	Satna
2019-03-26	3276	3275	**3365**	3250	**2880**	3120
2019-04-16	3362	**3460**	3360	3250	**3141**	3282
2019-04-25	3381	**3510**	3420	3325	**3145**	3400
2019-05-15	3524	3615	**3650**	3400	**3264**	3300
2019-05-29	3628	3690	**3690**	3450	**3305**	3600
2019-06-14	3705	**3760**	3740	**3400**	3400	3400
2019-06-28	3631	**3680**	3680	3450	**3282**	3500

7.Correlation of identified factors with prices

7. CORRELATION OF IDENTIFIED FACTORS WITH PRICES

We have calculated the correlation scores of the determinants in order to validate their relevance before training the algorithms for Rabi 2018-19 and Kharif 2019-20. Results of this analysis are presented in the form of top determinants (based on higher positive or negative scores) for each crop.

Kharif 2019-20

Correlation has been calculated for peak arrivals season for Kharif crops (between months October to January) for the past 5 years (for selected mandis). The influence of the past prices is generally observed in all cases. We shall follow up each table with a short explanation for the other highly corelated factors

Table 15 Determinants and correlation scores for Soyabean (Indore)

Price determinant	Correlation for the period 2014-19
Past Price	0.84
Past Futures	0.82
Past Soymeal Futures	0.8
Past Soya Oil Futures	0.78
Past_CNY	0.62
Past US Soymeal Futures	0.58
Past US SoyaOil Futures	-0.45

For Soyabean, the highest correlation is with past prices of Soyabean, followed by Soymeal, a derived product of Soyabean. Soya oil futures of the US have negative impact on the price prediction. MSP is not mentioned in the list as it did not appear to have a high correlation score.

Table 16 Determinants and correlation scores for Maize (Chhindwara)

Price determinant	Correlation for the period 2014-19
Past Price	0.93
MSP Maize	0.84
Past_USD	0.79
Past Futures	0.75
Domestic_consumption_India	0.73
MSP Soyabean	0.73
Value of Maize Imports - South Africa	0.72
Beginning_stocks_India	0.58

In case of Maize MSP is strongly correlated which can be validated by increase in prices corresponding to increase in MSP in 2018-19 from Rs 1425 to Rs 1700/Qtl.

Table 17 Determinants and correlation scores for Urad (Tikamgarh)

Price determinant	Correlation for the period 2014-19
Past Price	0.95
Past Mayanmar Import Value	0.38
Mean_temp_sowing	0.32
Mean_humid_sowing	-0.37
MSP Urad	-0.66

For Urad, past price is a strong determinant like other crops, however MSP is negatively correlated. One of the major importing countries Myanmar's import value showed a lower correlation. It may be attributed to import restriction since 2017.

Rabi 2018-19

During Rabi 2018-19 the correlation has been calculated for the peak arrivals period for Rabi crops (between the months of March and June) for the past 5 years (for selected Mandis).

Table 18 Determinants and correlation scores for Masur (Ganjbasoda)

Price determinant	Correlation for the period 2014-19
Past_price	0.96
Area Under Cultivation Bihar	0.74
Area under Cultivation Australia	-0.72
MSP	-0.72
Production in Australia	-0.66
Past Turkish Currency	0.59
Production estimates district wise	-0.46
Rainfall District wise	-0.43

For Masur, Bihar being one of the largest producers within India, has a positive correlation with area under cultivation, while production in Australia has a negative correlation with mandi prices. Production from previous year seems to be negatively correlated. The correlation for MSP for the past 5 years has also been negative (-0.72), however when calculated for a 10-year period it was significantly lower (0.23).

Table 19 Determinants and correlation scores for Chana (Gadarwada)

Price determinant	Correlation for the period 2014-19
Past _Price	0.92
District wise Mean temp	0.91
Area _ Rajasthan	-0.73
Yield _Districtwise	0.64
Past_ Australian Dollar	-0.64
Production_ District	0.57
Past_CAD Currency	-0.57
Past Import Value	0.52

For Chana, we observe that the area under cultivation in Rajasthan is negatively correlated and so are the currencies of major exporting countries such as Australia and Canada. Total production, yield and mean temperature during the sowing period for the district shows a positive correlation with the mandi prices. Additionally, the total import value for Chana is a positively correlated factor. Interestingly the correlation score for MSP for the past 5 years was 0.17 while the same for the past 10 years has been 0.72.

Table 20 Determinants and correlation scores for Mustard seed (Morena)

Price determinant	Correlation for the period 2014-19
NCDEX_mustard_future	0.89
Past_ Price	0.87
mean_humidity_sowing	-0.72
production_India.rapeseedmeal	-0.63
past_CNY_currency	0.58
consumption_India_rapeseed	-0.57
production_India_rapeseed	-0.54
mean_temp_sowing	0.53
US_soyaFutures	-0.46

For Mustard, the NCDEX futures quotes is observed to have the highest correlation score. The total Indian production of rapeseed meal and rapeseed seems to be negatively correlated to the mandi prices. Interestingly the mean humidity during sowing period (due to its relation is also negatively correlated while the mean temperature during the sowing period is positively correlated to the mandi prices. Chinese currency movements are also positively correlated.

8. Experiments to select the matching algorithm class

8. EXPERIMENTS TO SELECT THE MATCHING ALGORITHM CLASS

Performance of the algorithm depends on the quality of data and the determinants which are used as input. In order to choose the optimal ML algorithm class, we needed to test various algorithms in experimental setting. The experiments consisted of various combinations of the following parameters:

1. The type of algorithm classes
2. Number of determinants that were used

Classes of different ML supervised algorithms that were used in the experiments:

- **Ex-treme gradient boosting (XGBoost),** which is a special variety of gradient boosting algorithm that is constructed by building sequential trees. One tree is added at a time in order to optimize the objective further. This algorithm inherits the high fitting capability of ensemble trees, while being extremely efficient (at least ten times faster than random forest to train)

- **Least absolute shrinkage and selection operator (LASSO)** which is an acronym for least absolute shrinkage and selection operator. It is a regression analysis method that performs both variable selection and regularization in order to enhance the prediction accuracy and interpretability of the statistical model it produces.

- **Random forest (RF),** a group of decision trees which are trained independently. It creates an ensemble of decision trees using bagging and boosting. It is relatively more robust to noise. The final prediction is the average of predictions of individual trees.

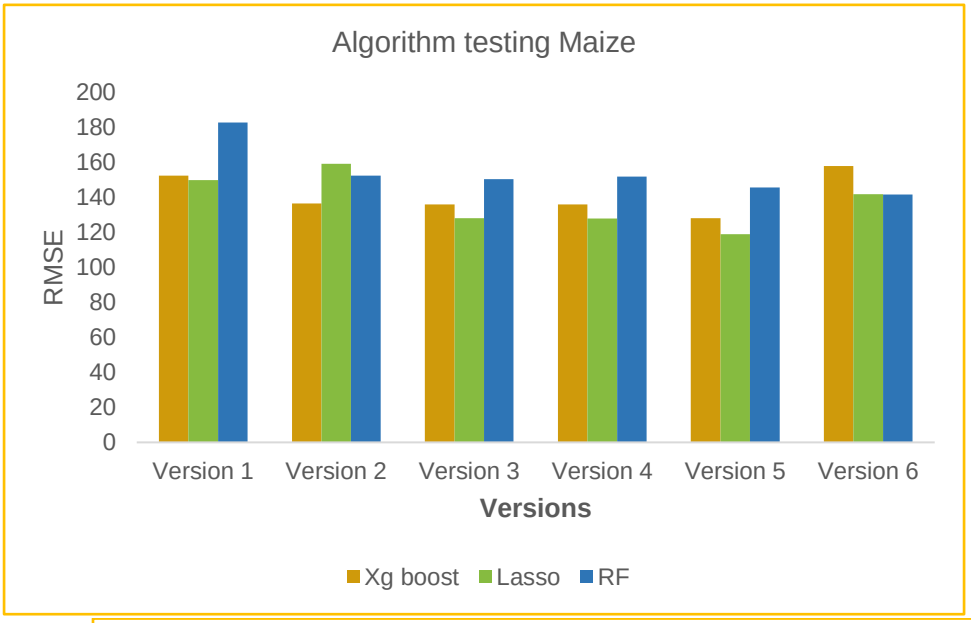
Ensemble, besides using independent machine learning algorithms, or picking one best performing algorithm for forecasting, we experimented with combining various algorithm classes together.

9.Testing results of various algorithms

9. TESTING RESULTS OF VARIOUS ALGORITHMS

The evaluation metric which we chose to test our trained model was RMSE (Root Mean Squared Error). The lower the RMSE, the better the performance of the respective algorithm.

Kharif 2019-20



The versions differed in two main aspects:

- Number of factors used
- Amount of historical data used

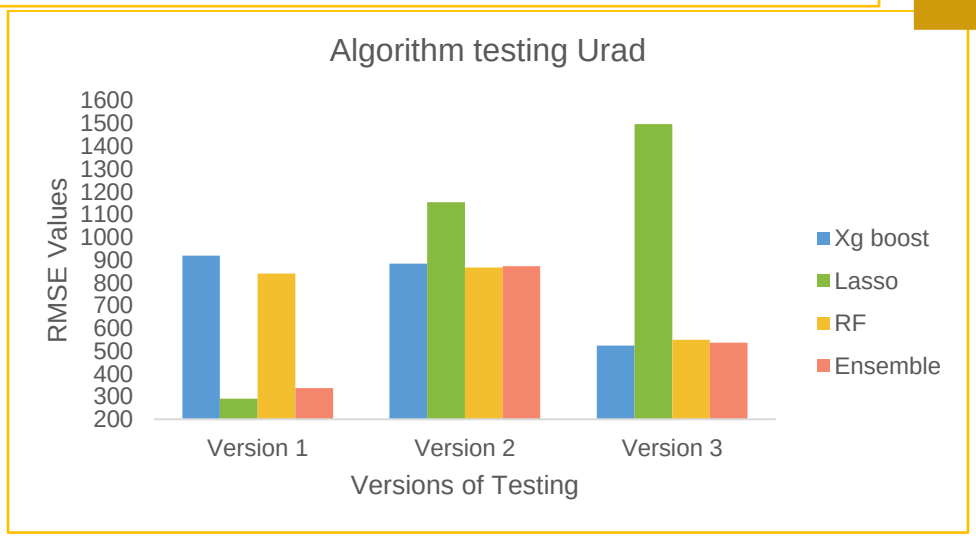


Figure 15 Testing Results for various algorithms Urad

During the experiments, we discovered that Lasso is better for Maize predictions while Random Forest proved to be important for Arhar and Urad.

For Urad, Maize and Soyabean, the period between October 2018 and January 2019 was used for testing various algorithms while for Arhar the algorithm had been tested between March to May 2019.

Rabi 2018-19

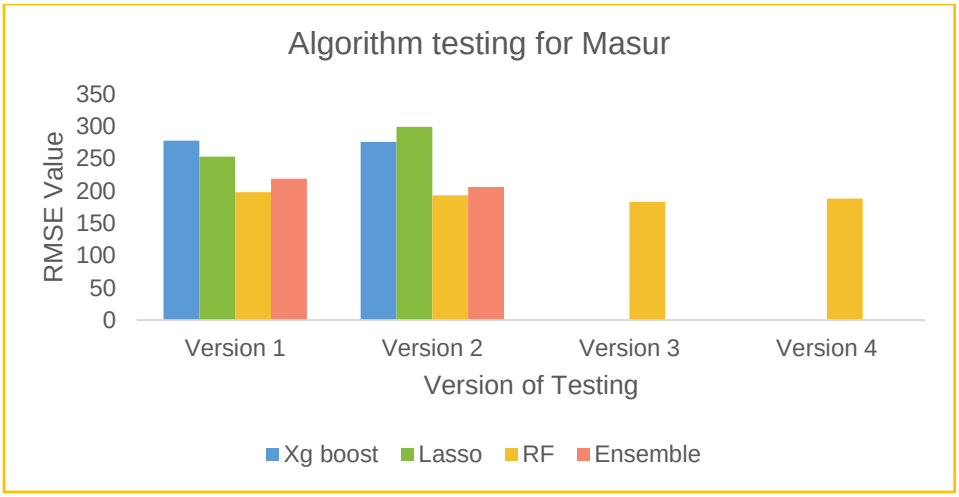


Figure 16 Testing Results for various algorithms Masur

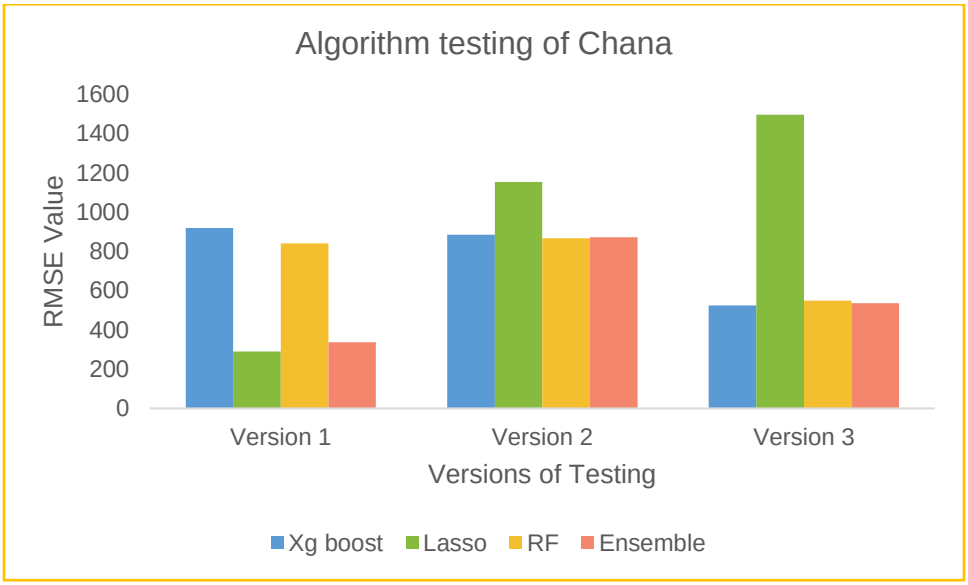


Figure 17 Testing results for various algorithms Chana

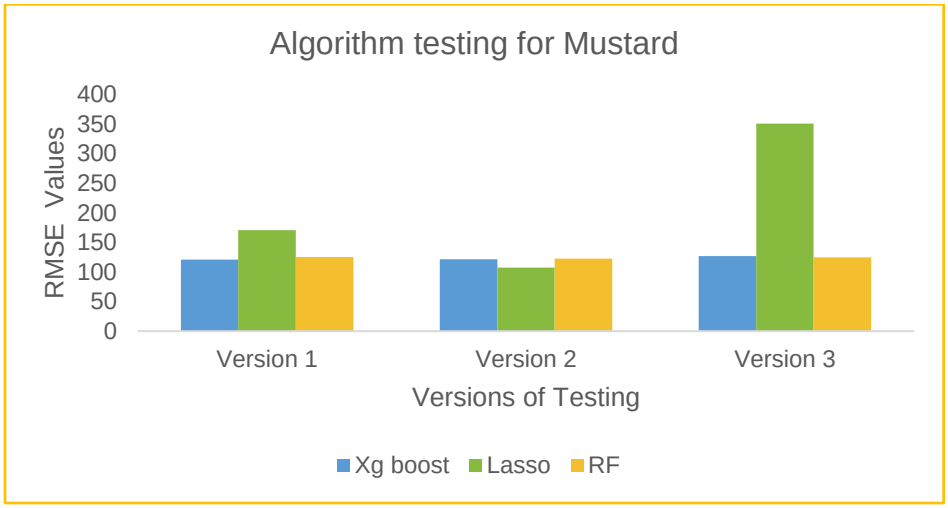


Figure 18 Testing results for various algorithms for Mustard

For Rabi crops in 2018-19, we found that Lasso provided the lowest error in case of Mustard and Chana, while Random Forest was effective for Masur. It can be thus inferred that different models are suitable for different crops.

10.Variable importance plots

10. VARIABLE IMPORTANCE PLOTS

After training and selecting the best performing algorithm, we created a plot of the determinants in their order of importance. For the right perspective, correlation of determinants is something we do before machine learning while variable importance is something which is done after the algorithm has been trained.

Kharif 2019-20

The following diagrams show the plots for each crop:

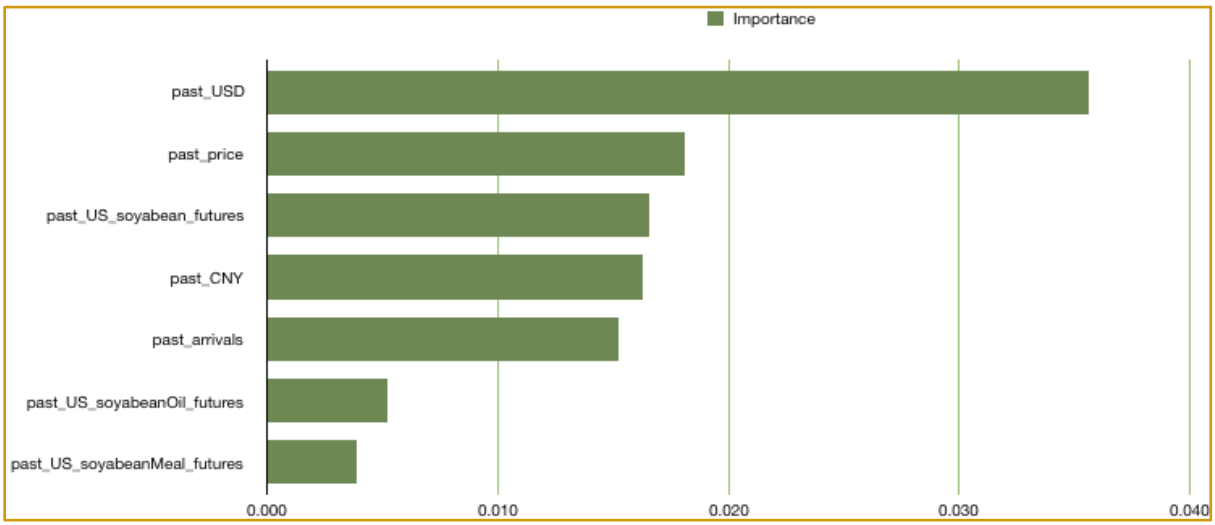


Figure 19 Variable importance plot for Soyabean

For Soyabean, variable importance does not show similar results as correlation factors. Past USD is an important factor in variable importance but does not feature in the list of highly correlated determinant. Past price (min, max, modal) are both highly correlated and variable importance is high as well. In Kharif 2018, variable importance of Soyabean was slightly different from the current one.

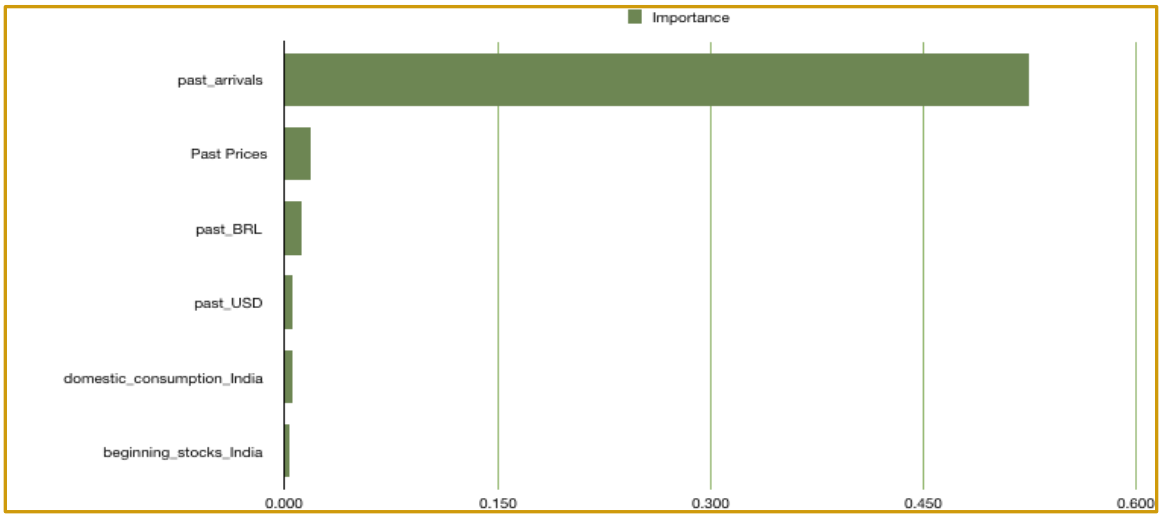


Figure 20 Variable importance plot for Maize

For Maize, market arrivals are determined as a very strong factor in price prediction while historical prices were high on correlation.

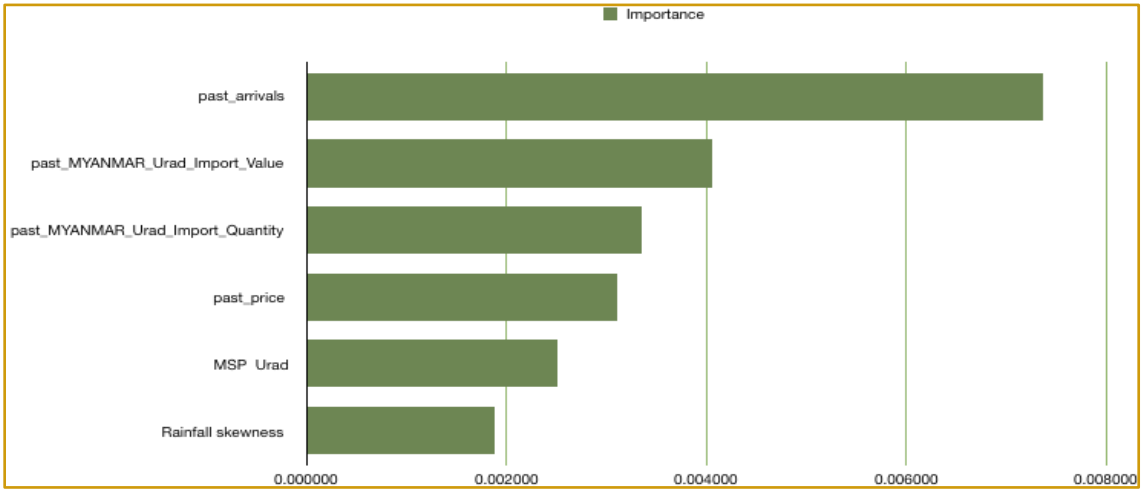


Figure 21 Variable importance plot for Urad

For Urad, the past arrivals and prices are important variables. Myanmar import value did not show a strong correlation but are high on variable importance list.

We have not covered Arhar as a part of this report as the arrivals generally start in March and hence it will be treated as a Rabi crop.

Rabi 2019-20

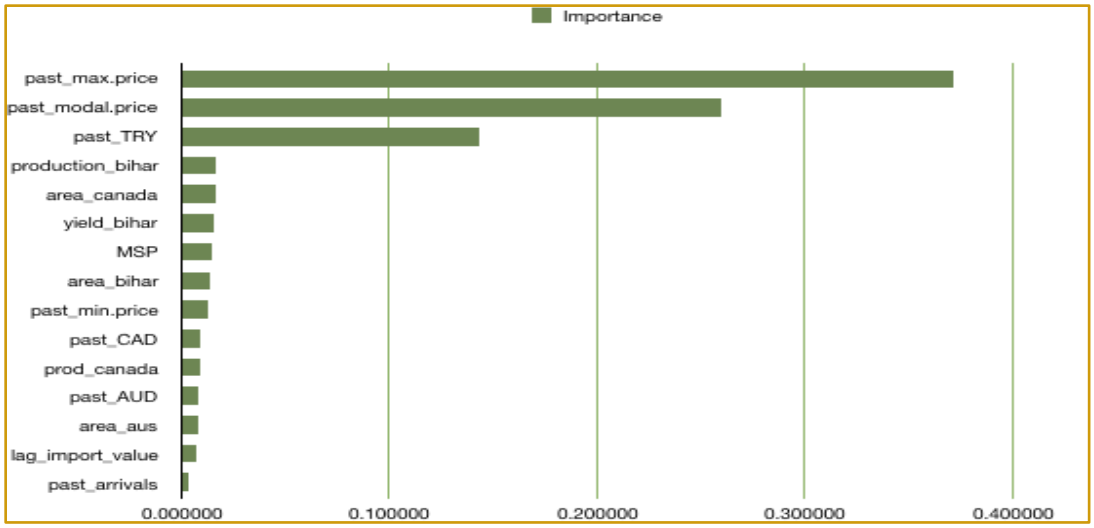


Figure 22 Variable importance plot for Masur

The variable importance plot for Masur is comparable to the correlation scores for the determinants, the difference being that the algorithm has also picked up an additional factor of area under cultivation for Canada.

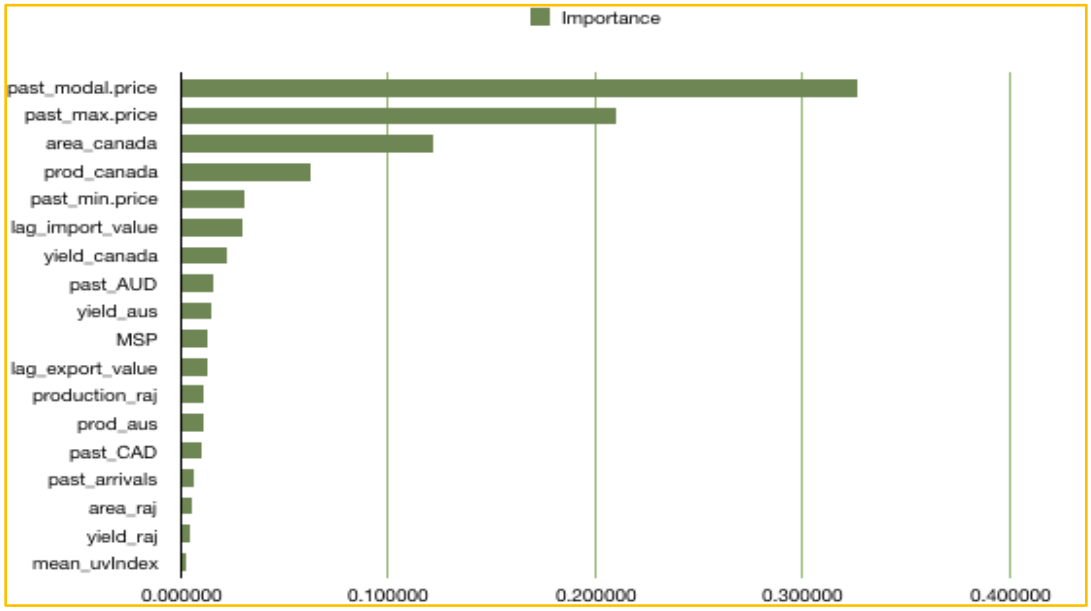


Figure 23 Variable importance plot for Chana

For Chana we see a similar picture where additional factors regarding the area under cultivation and total production of Canada shows up as important factors. We also notice that the importance of total value of imports in Chana is rated relatively higher in correlation according to the algorithm.

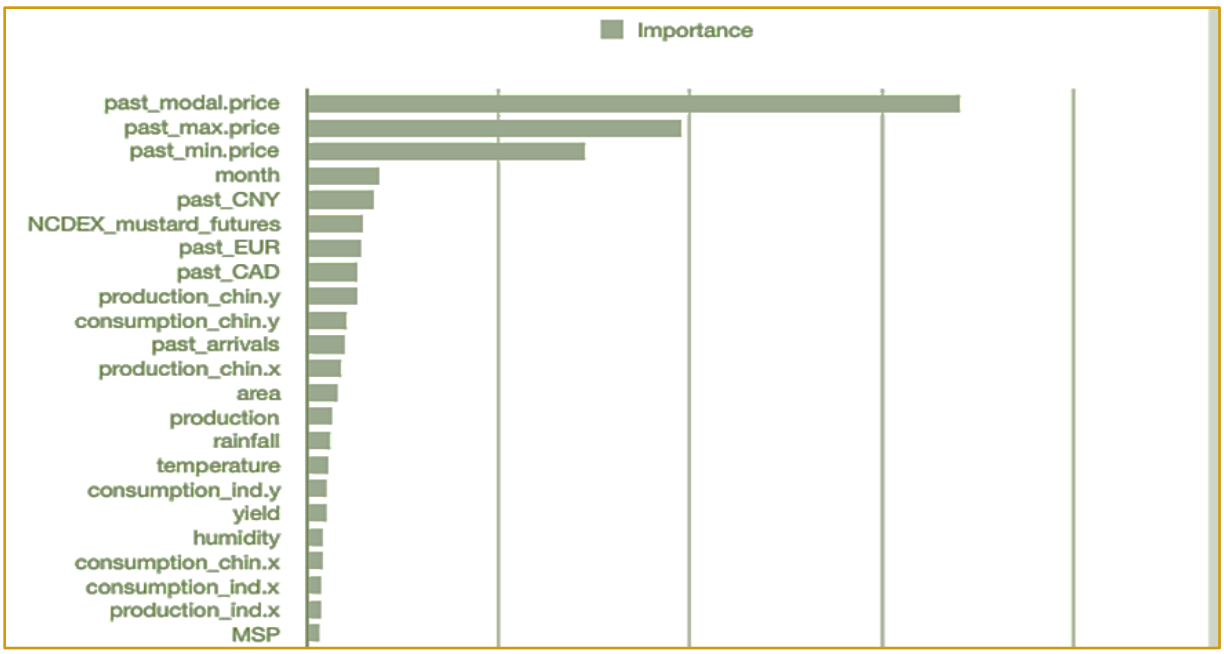


Figure 24 Variable importance plot for Mustard

The variable importance plot for mustard seed largely coincides with the correlation scores. The low or negligible correlation of MSP is reflected in variable importance as it did in correlation scores. The variable importance plot also demonstrates the influence of the of the Chinese market on the prices of mustard seeds. All the particulars of the Chinese market such as movements of the Chinese yen, production and consumption of China come up as important factors.

The variable importance plots showed mixed results, while Mustard was aligned to correlation scores, Chana and Masur showed additional factors. However, in case of Maize the variable factors showed a skewed result leaning more towards the past prices and MSP.

Variable Importance of different crops show different results. For Maize market arrivals stood as the most important factor, while variables of mustard are similar to correlation scores. Chana and Masur showed additional factors as important determinants of price.

11. Project results

11. PROJECT RESULTS

In the following tables we have provided a subset of the predicted modal prices together with the actual prices for that date for both Kharif and Rabi. An overview of the remaining predictions of Kharif 2019-20 and Rabi 2018-19 has been provided in Appendix C.

In the following table Soyabean prediction is not mentioned as it is available through API. The number of markets that are given in the tables below are a subset of the entire list of markets predicted.

Kharif 2019-20

Table 21 : Predictions of Maize for 13th November 2019

Market	Predicted Modal Price	Actual Modal Price	Error %
Indore	1614	1900	15.05
Khilchipur	1656	1700	2.56
Kumbhraj	1568	1775	11.68
Mandsaur	1667	1740	4.22
Neemuch	1668	1750	4.70

Table 22 Predictions of Maize for 12th December 2019

Market	Predicted Modal Price	Actual Modal Price	Error %
Mandsaur	1780.98	1940	8.20
Neemuch	1790.46	1990	10.03
Indore	1728.67	1800	3.96
Kumbhraj	1726.87	1980	12.78
Khilchipur	1649.65	1900	13.18

Table 23 Predictions of Maize for 21st January 2020

Market	Predicted Modal Price	Actual Modal Price	Error %
Betul	1882.38	1800.00	4.58
Chaurai	1885.38	1825.00	3.31
Indore	1898.88	1767.00	7.46
Khandwa	1825.13	1720.00	6.11
Khilchipur	1953.51	1950.00	0.18
Mandsaur	1981.45	1895.00	4.56
Neemuch	1958.63	1900.00	3.09
Segaon	1931.13	1800.00	7.28

Table 24 Predictions of Urad for 13th November 2019

Market	Predicted Modal Price	Actual Modal Price	Error %
Mandsaur	3409	3880	12.13
Neemuch	3902	4140	5.74
Sheopurkalan	4203	4115	2.14

Table 25 Predictions of Urad for 19th December 2019

Market	Predicted Modal Price	Actual Modal Price	Error %
Mandsaur	3766.7	3250	15.90
Neemuch	4593.04	4550	0.95
Sheopurkalan	4100.94	4235	3.17

Table 26 Predictions of Urad for 14th January 2020

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashoknagar	4512.41	4040.00	11.69
Bina	3733.86	3375.00	10.63
Ganjbasoda	4248.80	4510.00	5.79
Harda	4547.92	4800.00	5.25
Kolaras	3546.24	3365.00	5.39
Mandsaur	3586.49	3700.00	3.07
Tikamgarh	4228.18	4300.00	1.67
Timarni	3677.82	3699.00	0.57

Rabi 2018-19

Table 27- Predictions for 10th April for Masur

Market	Predicted Modal Price	Actual Modal Price	Error %
Berasia	3600.85	3500	2.88
Guna	3535.04	3650	3.15
Mandsaur	3654.19	3790	3.58
Piplya	3598.93	3750	4.03
Gadarwada	3666.64	3676	0.25
Manasa	3613.90	3738	3.32
Neemuch	3620.63	3700	2.15
Rewa	3637.15	3763	3.34
Satna	3512.55	3760	6.58
Susner	3768.50	3800	0.83
Ganjbasoda	3797.18	3750	1.26
Vidisha	3581.27	3781	5.28

Table 28 Predictions for 28th of May for Chana

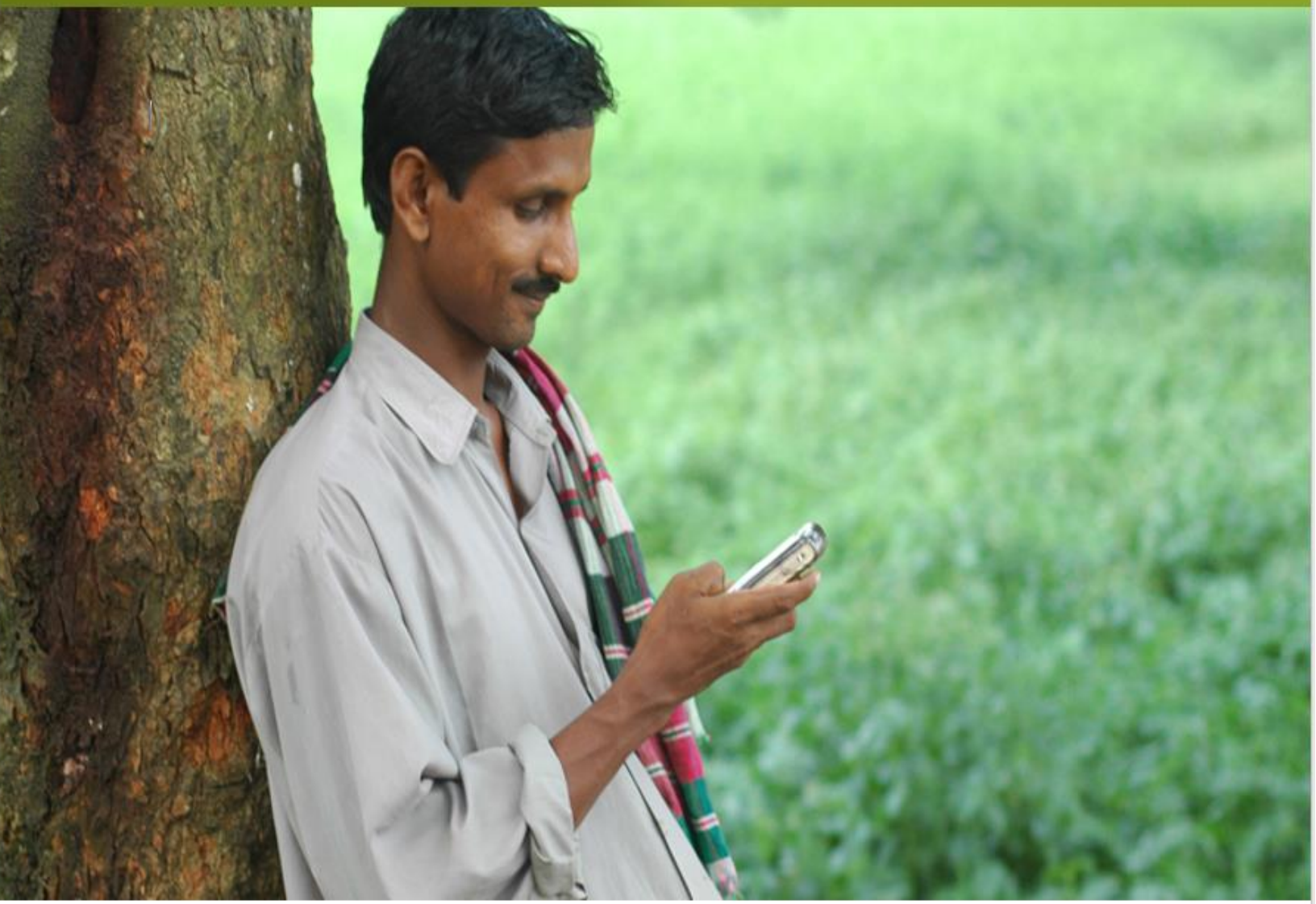
Market	Predicted Modal Price	Actual Modal Price	Error %
Ashta	4150.01	4161	0.26
Damoh	4112.04	4190	1.86
Khilchipur	4128.58	4200	1.70
Khujner	4197.89	4130	1.64
Kurawar	4184.99	4250	1.53
Sanawad	4233.79	4250	0.38
Sendhwa	4602.24	4640	0.81
Shajapur	4132.80	4182	1.18
Shamshabad	3983.12	4165	4.37
Bamora	4084.64	4220	3.21
Haatpipliya	3990.26	3945	1.15
Jabalpur	4059.42	4050	0.23
Kareli	4144.27	4150	0.14
Katni	4039.23	4150	2.67
Kumbhraj	4121.49	4165	1.04
Mungawali	4116.36	4160	1.05
Sihora	4189.38	4235	1.08

Table 29 Predictions for 22nd of April for Mustard

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashoknagar	3242.99	3280	1.13
Banda	3263.29	NA	NA
Chhapiheda	3185.42	3250	1.99
Dabra	3338.80	3325	0.42
Datia	3338.53	3375	1.08
Kailaras	3341.11	3350	0.27
Kurawar	3299.87	3400	2.95
Morena	3355.79	3420	1.88

Neemuch	3330.35	3365	1.03
Piplya	3297.16	3275	0.68
Rewa	3203.04	3031	5.68
Sabalgarh	3292.36	3320	0.83
Sagar	3248.16	3225	0.72
Satna	3254.26	3250	0.13

As a part of Rabi 2018-19, we achieved 94% accuracy for Masur, for Chana and Mustard we achieved 96% and 97% respectively. While for Kharif 2019-20, Maize accuracy was at 94% while Urad accuracy was lower at 83%.



12. API development

12. API DEVELOPMENT

Field visits to the mandis established the existence of an information gap between farmers and traders. Traders seemed to be aware of the price movements across mandis through channels such as WhatsApp groups. Farmers however lacked such organization.

Farmers expressed radio programs and newspapers as preferred information channels. However, farmers are a very diverse group as far as information dissemination is concerned. Keeping this diversity in mind, the proposed strategy is to provide the **predictions in a channel agnostic fashion**. The predictions shall be provided in the form of an API (application programming interface), which can be subsequently utilized by any consuming channel of choice by the mandi board.

API stands for **Application Programming Interface**. An API is a software intermediary that allows two applications to talk to each other.

In other words, an API is the messenger that delivers your request to the provider that you're requesting it from and then delivers the response back to you.

The API provides two main advantages for the Mandi board, firstly it **automates the entire process of delivery of the predictions**. During the pilot this was done through a regular email from the prediction provider to the Mandi board. This however is not scalable. Secondly, the maintenance of the algorithm (monitoring results and updating determinants) can be automated. Figure 21 provides an overview of how such an API can be deployed by the Mandi Board.

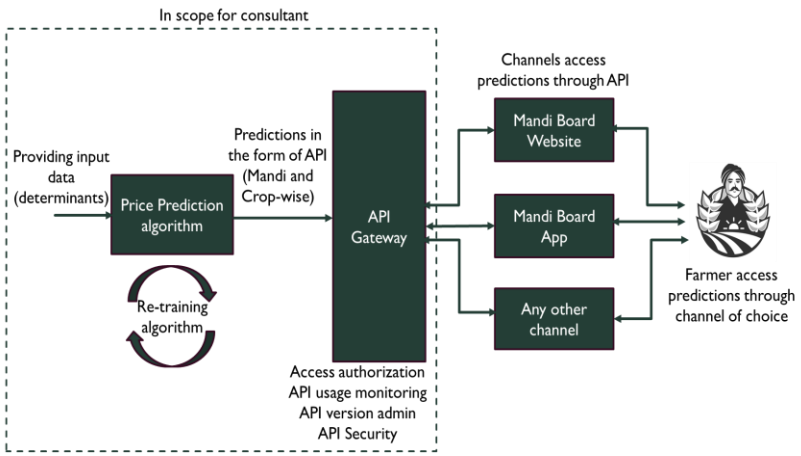


Figure 25 Channel agnostic information dissemination

By following such an architecture, the mandi board is free to provide the farmers with the prediction by **SMS, radio program, an app or the renewed mandi board website**.

13. CONCLUSION

The first pilot during Kharif 2018-19 for the Soyabean crop had already established that machine learning techniques can be successfully applied to predict prices of agricultural commodities at a mandi level. In general, the models were trained using historical data for the past 5 years (2014-2019). For Kharif 2019-20, we had attempted predicting prices for Soyabean, Maize, Urad and Arhar. Since arrivals of Arhar begin in March, the predictions have been postponed matching the Rabi-arrival calendar.

The accuracy achieved for Soyabean during the ongoing season is 94%, compared to 95% in the previous season. It demonstrates that the algorithm performs reliably despite higher price volatility in Kharif 2019-20. The accuracy achieved for Maize is 91%. Urad predictions had the lowest accuracy at 87%. Lack of data concerning produce quality and variety can be attributed to the lower accuracy.

During Rabi 2018-19, we achieved 94% accuracy for Masur, for Chana and Mustard we achieved 96% and 97% respectively. From our research, we can state that the choice of algorithm varies according to the crop and season. Certain price determinants seem to be important regardless of the crop type, such as, area under production in MP, production of major exporting countries and major production states in India.

The data quality and reliability of agmarknet continues to remain a challenge. Instances of modal prices not being regularly updated, frequent downtime of the portal and huge price variations in intra-day prices affects the quality of predictions. Measures such as automation of data entry and frequent training for staff will further improve the data quality.

As previously mentioned, the field visits validated the need of farmers to receive information on market prices. Lack of access to local market prices puts farmers at a distinct disadvantage to traders who are generally far better informed. During the field visit farmers mentioned a preference for receiving the price predictions on radio or local newspapers. However, given the diversity in the farmer preferences, it is advisable to adopt a flexible information dissemination strategy. Keeping this in mind the Mandi board has decided to take an API-based approach. APIs can be used for both analog channels such as radio programs and newspapers and completely digital channels such as websites, government apps and digital screens at selected mandis.

At present an API for Soyabean API has already been created and it provides ongoing daily predictions. As a follow-up to this project, the mandi board had selected the following crops for the creation of APIs: Maize, Chana and Masur.

The work done during the course of this project was presented at the joint workshop on AI for social good at the Conference on Neural Information Processing Systems (NeurIPS) in Vancouver, Canada 2019.

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APPENDIX A: A BRIEF EXPLANATION OF MODELS TESTED

ARIMA: It is an acronym that stands for Auto Regressive Integrated Moving Average. It is a class of model that captures a suite of different standard temporal structures in time series data.

Random Forest: These are an ensemble learning method for classification, regression and other tasks, that operate by constructing a multitude of decision trees at training time and outputting the class that is the mode of the classes (classification) or mean prediction (regression) of the individual trees.

Lasso: It is an acronym for least absolute shrinkage and selection operator. It is a regression analysis method that performs both variable selection and regularization in order to enhance the prediction accuracy and interpretability of the statistical model it produces.

SVM: Support Vector Machine is a supervised machine learning algorithm which can be used for both classification or regression challenges. However, it is mostly used in classification problems. In this algorithm, each data item is plotted as a point in n-dimensional space (where n is number of features) with the value of each feature being the value of a coordinate. Then, classification is performed by finding the hyper-plane that differentiate the two classes very well.

GLM: the generalized linear model (GLM) is a flexible generalization of ordinary linear regression that allows for response variables that have error distribution models other than a normal distribution. The GLM generalizes linear regression by allowing the linear model to be related to the response variable via a link function and by allowing the magnitude of the variance of each measurement to be a function of its predicted value.

APPENDIX B: ABBREVIATION OF FACTORS AND MEANING

ABBREVIATIONS	
MSP	Minimum Support Price
past_price	Past Price
APY	Area Production Yield
past_arrivals	Past Arrivals of particular commodity in mandi.
past_CNY, past_USD, past_BRL	Past Chinese, American & Brazilian foreign exchange currency value to INR respectively.
past_US_soyabean_futures,	Past CBOT Soyabean, Soymeal & Soyabean oil futures.
past_US_soyabeanMeal_futures,	
past_US_soyabeanOil_futures	
past_MYANMAR_Urad_Import_Value, past_MYANMAR_Urad_Import_Quantity	Past Myanmar Import Value & Quantity.
mean_humid_sowing, mean_temp_sowing	Aggregated humidity value for a Rabi season.
	Aggregated temperature value for a Rabi season.
domestic_consumption_India	Estimated domestic consumption for particular commodity in India.
beginning_stocks_India	Carry Forward Stock of particular commodity in India.
area_bihar, yield_bihar	Area sown, yield in Bihar state for a particular crop
past_TRY, past_AUD, past_CNY, past_EUR, past_CAD	Past Turkish, Australia, China, European Union, Canada foreign exchange currency value to INR respectively
Past_production,past_import_value,past_export_value	Past Production value of India for a particular crop Import value of India for a particular crop Export value of Inda for a particular crop

APPENDIX C: PREDICTION TABLES FOR THE ALL THE DATES

Kharif 2019-20

Table 30 Predictions of Maize for 20th November 2019

Market	Predicted Modal Price	Actual Modal Price	Error %
Mandsaur	1665.31	1740	4.29
Neemuch	1655.52	1775	6.73
Indore	1662.11	1600	3.88
Kumbhraj	1637.28	1800	9.04
Khilchipur	1685.25	1750	3.70

Table 31 Predictions of Maize for 4th December 2019

Market	Predicted Modal Price	Actual Modal Price	Error %
Mandsaur	1681.25	1840	8.63
Neemuch	1670.92	2000	16.45
Indore	1578.51	1800	12.31
Kumbhraj	1676.46	1905	12.00
Khilchipur	1620.26	1720	5.80

Table 32 Predictions of Maize for 19th December 2019

Market	Predicted Modal Price	Actual Modal Price	Error %
Mandsaur	1953.02	1870	4.44
Neemuch	1886.9	2050	7.96
Indore	1818.97	1900	4.26
Kumbhraj	1874.23	1925	2.64
Khilchipur	1796.31	1950	7.88

Table 33 Predictions of Maize for 7th January 2020

Market	Predicted Modal Price	Actual Modal Price	Error %
Indore	1904.42	1900	0.23
Khilchipur	1966.49	1750	12.37
Kumbhraj	1986.86	1915	3.75
Mandsaur	1948.6	1860	4.76
Neemuch	1986.26	1975	0.57

Table 34 Predictions of Maize for 14th January 2020

Market	Predicted Modal Price	Actual Modal Price	Error %
Chaurai	1967.21	1940.00	1.40
Indore	1923.54	1871.00	2.81
Khandwa	1915.07	1842.00	3.97
Khilchipur	1979.96	1800.00	10.00
Manasa	1938.31	1880.00	3.10
Saunsar	1957.53	1850.00	5.81
Timarni	1877.35	1751.00	7.22

Table 35 Predictions of Maize for 28th January 2020

Market	Predicted Modal Price	Actual Modal Price	Error %
Timarni	1787.97	1550.00	15.35
Segaon	1871.85	1800.00	3.99
Khilchipur	1850.37	1750.00	5.74
Indore	1878.17	1793.00	4.75

Table 36 Predictions of Maize for 2nd February 2020

Market	Predicted Modal Price	Actual Modal Price	Error %
Bhikangaon	1908.89	1632.00	16.97
Chaurai	1944.73	1650.00	17.86
Manawar	1905.20	1706.00	11.68
Segaon	1971.86	1700.00	15.99
Timarni	1816.49	1441.00	26.06

Table 37 Predictions of Urad for 20th November 2019

Market	Predicted Modal Price	Actual Modal Price	Error %
Mandsaur	4105.75	3050	34.61
Neemuch	5503.11	5300	3.83
Sheopurkalan	5007.16	4201	19.19

Table 38 Predictions of Urad for 4th December 2019

Market	Predicted Modal Price	Actual Modal Price	Error %
Mandsaur	3618.6	3770	4.02
Neemuch	5268.02	4401	19.70
Sheopurkalan	4216.6	4650	9.32

Table 39 Predictions of Urad for 12th December 2019

Market	Predicted Modal Price	Actual Modal Price	Error %
Mandsaur	3281.37	3120	5.17
Neemuch	4439.84	5020	11.56
Sheopurkalan	3871.42	3712	4.29

Table 40 Predictions of Urad for 7th January 2020

Market	Predicted Modal Price	Actual Modal Price	Error %
Mandsaur	2879.74	3570	19.34
Neemuch	4521.94	5700	20.67
Sheopurkalan	3993.3	4150	3.78

Table 41 Predictions of Urad for 21st January 2020

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashoknagar	4300	4495	4.34
Ganjbasoda	4349	4120	5.56
Jabalpur	4750	4495	5.67
Kolaras	3574	3300	8.31
Mandsaur	3604	3730	3.37
Sagar	4106	4050	1.38
Sheopurkalan	4132	3051	35.43
Timarni	3801	3480	9.21

Table 42 Predictions of Urad for 28th January 2020

Market	Predicted Modal Price	Actual Modal Price	Error %
Harda	4037	3651	10.57
Jabalpur	4518	4855	6.94
Kolaras	3439	3800	9.50
Mandsaur	3454	3560	2.97
Sagar	4558	4100	11.17

Table 43 Predictions of Urad for 2nd February 2020

Market	Predicted Modal Price	Actual Modal Price	Error %
Katni	3709	3100	19.66
Sheopurkalan	3653	4256	14.17

Rabi 2018-19

Table 44 Predictions for 28th May for Masur

Market	Predicted Modal Price	Actual Modal Price	Error %
Berasia	3302.39	3825	13.66
Betul	3656.71	3600	1.58
Gadarwada	3886.57	4000	2.84
Ganjbasoda	4095.73	4025	1.76
Jabalpur	4036.56	3910	3.24
Jaora	3889.31	3800	2.35
Katni	3923.00	3800	3.24
Khatora	3967.43	3953	0.37
Manasa	3781.43	3951	4.29
Mandsaur	3862.34	4100	5.80
Neemuch	3836.04	4112	6.71
Piplya	3880.89	4000	2.98
Rewa	3932.61	3786	3.87
Sagar	4374.84	4150	5.42
Vidisha	3991.89	4000	0.20

Table 45 Predictions for 18th of June for Masur

Market	Predicted Modal Price	Actual Modal Price	Error %
Betul	3666.72	3250	12.82
Gadarwada	3929.94	3800	3.42
Ganjbasoda	4126.16	3920	5.26
Guna	3909.53	3805	2.75
Jabalpur	4091.59	3990	2.55
Katni	4000.79	4015	0.35
Khatora	4017.08	3900	3.00
Mandsaur	3895.68	3450	12.92
Neemuch	3981.49	3850	3.42

Piplya	4013.86	3871	3.69
Rewa	4021.57	3916	2.70
Satna	3591.23	3300	8.83
Vidisha	4090.29	3950	3.55

Table 46 Predictions for 30th March for Masur

Market	Predicted Modal Price	Actual Modal Price	Error %
Katni	3583.46	3800	5.70
Gadarwada	3657.48	3900	6.22
Satna	3568.12	3250	9.79

Table 47 Predictions for 23rd April for Masur

Market	Predicted Modal Price	Actual Modal Price	Error %
Gadarwada	3757.16	3691	1.79
Jaora	3773.35	3800	0.70
Mandsaur	3776.52	3790	0.36
Neemuch	3759.94	3900	3.59
Piplya	3786.01	3810	0.63
Rahatgarh	3754.66	3575	5.03
Rewa	3767.16	3745	0.59
Satna	3765.22	3700	1.76
Susner	3753.13	4000	6.17
Vidisha	3919.68	3850	1.81

Table 48 Predictions for 30th April for Masur

Market	Predicted Modal Price	Actual Modal Price	Error %
Berasia	3561.98	3550	0.34
Gadarwada	3684.14	3860	4.56
Ganjbasoda	3759.19	3800	1.07
Guna	3622.12	3765	3.79

Jaora	3705.25	3800	2.49
Khatora	3689.33	3730	1.09
Mandsaur	3715.17	3720	0.13
Neemuch	3682.51	3650	0.89
Piplya	3679.61	3800	3.17
Rahatgarh	3641.08	3720	2.12
Sagar	3985.81	4200	5.10
Satna	3642.27	3350	8.72
Susner	3741.24	3900	4.07
Vidisha	3754.21	3750	0.11

Table 49 Predictions for 15th May for Masur

Market	Predicted Modal Price	Actual Modal Price	Error %
Ganjbasoda	4112.56	4475	8.10
Jabalpur	3654.71	3970	7.94
Jaora	3640.54	4100	11.21
Katni	3732.62	4135	9.73
Mandsaur	3657.34	4000	8.57
Piplya	3651.2	3900	6.38
Rahatgarh	3613.04	4000	9.67
Vidisha	4052.16	3900	3.90

Table 50 Predictions for 22nd of May for Masur

Market	Predicted Modal Price	Actual Modal Price	Error %
Berasia	3629.13	3985	8.93
Betul	3487.97	3800	8.21
Gadarwada	3765.21	4200	10.35
Ganjbasoda	3826.25	4180	8.46
Guna	3675.15	4025	8.69
Jabalpur	3735.78	4280	12.72

Jaora	3699.11	4000	7.52
Manasa	3727.16	4071	8.45
Mandsaur	3750.27	4080	8.08
Piplya	3714.55	4100	9.40
Rahatgarh	3722.5	4140	10.08
Rewa	3753.62	4212	10.88
Satna	3494.97	3820	8.51
Susner	3899.08	4550	14.31
Vidisha	3952.25	4250	7.01

Table 51 Predictions for 28th of May for Masur

Market	Predicted Modal Price	Actual Modal Price	Error %
Berasia	3330.26	3825	12.93
Betul	3586.28	3600	0.38
Gadarwada	3882.43	4000	2.94
Ganjbasoda	4062.89	4025	0.94
Jabalpur	3943.06	3910	0.85
Jaora	4001.65	3800	5.31
Katni	3956.11	3800	4.11
Khatora	3974.48	3953	0.54
Manasa	3888.62	3951	1.58
Mandsaur	3943.58	4100	3.82
Neemuch	3866.96	4112	5.96
Piplya	3870.86	4000	3.23
Rewa	3938.28	3786	4.02
Sagar	4264.02	4150	2.75
Vidisha	3996.59	4000	0.09

Table 52 Predictions for 4th June for Masur

Market	Predicted Modal Price	Actual Modal Price	Error %
Betul	3387.83	3551	4.60
Gadarwada	3537.28	3800	6.91
Ganjbasoda	3563.11	4050	12.02
Guna	3530.88	3900	9.46
Jabalpur	3557.82	3955	10.04
Katni	3566.36	4060	12.16
Khatora	3557.88	4017	11.43
Mandsaur	3583.31	3970	9.74
Neemuch	3547.93	4050	12.40
Piplya	3585.07	4000	10.37
Rahatgarh	3554.63	3960	10.24
Sagar	3773.02	4215	10.49
Satna	3568.96	3400	4.97
Vidisha	3600.62	3980	9.53

Table 53 Predictions for 11th of June for Masur

Market	Predicted Modal Price	Actual Modal Price	Error %
Gadarwada	3502.88	3900	10.18
Ganjbasoda	3524.11	4050	12.98
Guna	3514.5	3950	11.03
Jabalpur	3519.04	3955	11.02
Jaora	3442.66	3750	8.20
Katni	3445	3880	11.21
Khatora	3500.14	3950	11.39
Mandsaur	3576.86	3860	7.34
Piplya	3527.27	3900	9.56

Rewa	3430.22	3967	13.53
Sagar	3630.59	4300	15.57
Satna	3219.98	3350	3.88
Vidisha	3530.18	3900	9.48

Table 54 Predictions for 16th of May for Chana

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashta	4078.35	3980	2.47
Bina	3937.68	3933	0.12
Chanderi	3913.06	3900	0.33
Kurawar	3997.63	4100	2.50
Sarangpur	3905.79	3715	5.14
Shajapur	4113.51	4098	0.38
Bamora	3918.88	3960	1.04
Bhopal	4056.24	3921	3.45
Haatpipliya	3919.09	3755	4.37
Jabalpur	4169.98	4040	3.22
Kareli	4314.65	4150	3.97
Katni	4091.28	3851	6.24
Kumbhraj	4056.79	3850	5.37
Mungawali	3952.05	3960	0.20
Sihora	3871.76	4051	4.42

Table 55 Predictions for 18th of June for Chana

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashta	4092.09	3880	5.47
Biaora	4034.05	3840	5.05
Chanderi	4057.80	3810	6.50
Chhapiheda	4034.79	3695	9.20
Damoh	4148.78	3975	4.37

Khilchipur	4024.57	3900	3.19
Kurawar	4105.08	3900	5.26
Sarangpur	3949.35	3600	9.70
Shajapur	3945.34	3760	4.93
Bhopal	4118.92	3891	5.86
Jabalpur	4035.70	3850	4.82
Kareli	4272.51	3950	8.16
Katni	4154.47	3900	6.52
Kumbhraj	4110.31	3935	4.46
Mungawali	4084.03	3890	4.99
Sihora	4075.81	3899	4.53

Table 56 Predictions for 22nd April for Chana

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashta	3907.45	3860	1.23
Bina	3844.62	3810	0.91
Chanderi	3859.05	3700	4.30
Chhapiheda	3572.46	3800	5.99
Damoh	3985.82	3805	4.75
Kurawar	3880.64	4000	2.98
Shajapur	3894.45	3970	1.90
Bamora	3878.23	3860	0.47
Bhopal	4056.81	3864	4.99
Haatpipliya	3850.89	3728	3.30
Jabalpur	3953.38	3850	2.69
Katni	4111.53	3875	6.10%
Mungawali	3977.97	3880	2.53%

Table 57 Predictions for 30th of April for Chana

Market	Predicted Modal Price	Actual Modal Price	Error %
Alampur	3874.2	3940	1.67
Ashta	3902.38	3875	0.71
Biaora	3529.28	3740	5.63
Bina	3855.89	3850	0.15
Khujner	3887.72	3925	0.95
Kurawar	4133.19	3950	4.64
Sarangpur	3777.57	3865	2.26
Sendhwa	4126.11	4620	10.69
Shajapur	3897.24	3865	0.83
Shamshabad	3793.26	3815	0.57
Bamora	3812.97	3770	1.14
Bhopal	3740.52	3970	5.78
Haatpipliya	3697.32	3790	2.45
Kareli	3862.11	4100	5.80

Table 58 Predictions for 14th of May for Chana

Market	Predicted Modal Price	Actual Modal Price	Error %
Alampur	3860.91	4150	6.97
Ashta	3936.9	4150	5.13
Biaora	3761.37	3980	5.49
Bina	3826	4150	7.81
Damoh	3890.71	4110	5.34
Jeerapur	3730.21	3900	4.35
Khilchipur	3886.11	4200	7.47
Khujner	3938.12	4180	5.79
Kurawar	3983.66	4200	5.15
Sanawad	4032.76	4275	5.67
Sarangpur	3819.11	4000	4.52

Sendhwa	4584.37	4622	0.81
Shajapur	3861.41	4180	7.62
Shamshabad	3805.59	4080	6.73

Table 59 Predictions for 15th of May for Chana

Market	Predicted Modal Price	Actual Modal Price	Error %
Bhopal	3915.2	4240	7.66
Jabalpur	3971.51	4205	5.55
Kareli	4529.72	4022	12.62
Katni	3946.28	4000	1.34
Kumbhraj	3849.88	4100	6.10
Mungawali	3832.56	4180	8.31
Sihora	3947.18	4111	3.98

Table 60 Predictions for 22nd of May for Chana

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashta	3761.53	4300	12.52
Biaora	3899.35	4010	2.76
Chhapiheda	3798.19	4100	7.36
Kurawar	3937.97	4400	10.50
Sanawad	4010.26	4265	5.97
Shajapur	3946.35	4204	6.13
Shamshabad	3867.08	4130	6.37
Bhopal	3988.13	4360	8.53
Haatpipliya	3782.12	4265	11.32
Jabalpur	4006.59	4235	5.39
Kareli	4121.68	4422	6.79
Kumbhraj	3956.22	4300	7.99
Mungawali	3921.98	4300	8.79
Sihora	4036.15	4276	5.61

Table 61 Predictions for 28th of May for Chana

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashta	4150.01	4161	0.26
Damoh	4112.04	4190	1.86
Khilchipur	4128.58	4200	1.70
Khujner	4197.89	4130	1.64
Kurawar	4184.99	4250	1.53
Sanawad	4233.79	4250	0.38
Sendhwa	4602.24	4640	0.81
Shajapur	4132.8	4182	1.18
Shamshabad	3983.12	4165	4.37
Bamora	4084.64	4220	3.21
Haatpipliya	3990.26	3945	1.15
Jabalpur	4059.42	4050	0.23
Kareli	4144.27	4150	0.14
Katni	4039.23	4150	2.67
Kumbhraj	4121.49	4165	1.04
Mungawali	4116.36	4160	1.05
Sihora	4189.38	4235	1.08

Table 62 Predictions for 4th of June for Chana

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashta	4209.07	4150	1.42
Biaora	3935.85	4120	4.47
Chanderi	4185.37	4100	2.08
Khilchipur	4152.36	4100	1.28
Kurawar	4520.84	4150	8.94
Sanawad	4227.69	4175	1.26
Sarangpur	4084.51	4050	0.85

Shajapur	4254.88	3970	7.18
Shamshabad	4145.06	4025	2.98
Bamora	4164.7	4175	0.25
Bhopal	4273.14	4074	4.89
Jabalpur	4257.99	3990	6.72
Kareli	5277.91	4250	24.19
Kumbhraj	4271.14	4120	3.67
Mungawali	4238.29	4135	2.50
Sihora	4189.25	4090	2.43

Table 63 Predictions for 11th of June for Chana

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashta	4145.82	3800	9.10
Chhapiheda	4036.77	3645	10.75
Khilchipur	4123.78	3970	3.87
Khujner	4150.93	3895	6.57
Sarangpur	3938.62	3815	3.24
Shajapur	4111.15	3875	6.09
Shamshabad	3954.81	3957	0.06
Bamora	4137.43	4010	3.18
Haatpipliya	3883.78	3788	2.53
Jabalpur	4068.24	3955	2.86
Kareli	4206.85	4000	5.17
Katni	4126.79	4000	3.17
Kumbhraj	4131.41	3965	4.20
Mungawali	4063.65	4045	0.46
Sihora	4175.28	4050	3.09

Table 64 Predictions for 18th of June for Chana

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashta	4092.09	3880	5.47
Biaora	4034.05	3840	5.05
Chanderi	4057.8	3810	6.50
Chhapiheda	4034.79	3695	9.20
Damoh	4148.78	3975	4.37
Khilchipur	4024.57	3900	3.19
Kurawar	4105.08	3900	5.26
Sarangpur	3949.35	3600	9.70
Shajapur	3945.34	3760	4.93
Bhopal	4118.92	3891	5.86
Jabalpur	4035.7	3850	4.82
Kareli	4272.51	3950	8.16
Katni	4154.47	3900	6.52
Kumbhraj	4110.31	3935	4.46
Mungawali	4084.03	3890	4.99
Sihora	4075.81	3899	4.53

Table 65 Predictions for 28th of May for Mustard

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashoknagar	3458.13	3600	3.94
Kailaras	3532.18	3640	2.96
Kurawar	3238.36	3295	1.72
Morena	3597.25	3670	1.98
Piplya	3415.61	3410	0.16
Rewa	3241.25	3308	2.02
Sabalgarh	3517.11	3600	2.30
Sagar	3366.44	3475	3.12
Ashoknagar	3458.13	3600	3.94

Kailaras	3532.18	3640	2.96
Kurawar	3238.36	3295	1.72

Table 66 Predictions for 17th of June for Mustard

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashoknagar	3517.16	3674	4.27
Kailaras	3646.24	3661	0.40
Lashkar	3760.53	3740	0.55
Morena	3712.75	3775	1.65
Neemuch	3629.62	3650	0.56
Piplya	3486.83	3415	2.10
Rewa	3321.96	3400	2.30
Sabalgarh	3572.35	3665	2.53

Table 67 Predictions for 30th of March for Mustard

Market	Predicted Modal Price	Actual Modal Price	Error %
Lashkar	3393.36	3310	2.52
Morena	3441.11	3425	0.47
Sabalgarh	3425.67	3100	10.51
Satna	3378.51	3420	1.21

Table 68 Predictions for 22nd of April for Mustard

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashoknagar	3242.99	3280	1.13
Chhapiheda	3185.42	3250	1.99
Dabra	3338.8	3325	0.42
Datia	3338.53	3375	1.08
Kailaras	3341.11	3350	0.27
Kurawar	3299.87	3400	2.95

Morena	3355.79	3420	1.88
Neemuch	3330.35	3365	1.03
Piplya	3297.16	3275	0.68
Rewa	3203.04	3031	5.68
Sabalgarh	3292.36	3320	0.83
Sagar	3248.16	3225	0.72
Satna	3254.26	3250	0.13

Table 69 Predictions for 30th of April for Mustard

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashoknagar	3242.98	3200	1.34
Banda	3108.69	3035	2.43
Dabra	3362.64	3415	1.53
Kailaras	3321.51	3340	0.55
Kurawar	3278.24	3300	0.66
Lashkar	3391.7	3445	1.55
Morena	3374.88	3425	1.46
Neemuch	3383.15	3275	3.30
Piplya	3284.67	3250	1.07
Sabalgarh	3315.65	3310	0.17
Sagar	3215.58	3265	1.51
Satna	3282.39	3250	1.00

Table 70 Predictions for 6th of May for Mustard

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashoknagar	3301.64	3300	0.05
Chhapiheda	3276.91	3350	2.18
Datia	3351.96	3370	0.54
Kailaras	3368.05	3441	2.12
Kurawar	3344.99	3200	4.53

Lashkar	3439.68	3460	0.59
Morena	3442.23	3385	1.69
Neemuch	3366.27	3351	0.46
Piplya	3277.71	3250	0.85
Sabalgarh	3354.03	3370	0.47

Table 71 Predictions for 14th of May for Mustard

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashoknagar	3295.43	3500	5.84
Banda	3076.88	3155	2.48
Dabra	3446.71	3575	3.59
Datia	3399.44	3550	4.24
Kailaras	3385.51	3600	5.96
Kurawar	3323.08	3190	4.17
Morena	3459.39	3660	5.48
Piplya	3305.73	3470	4.73
Sabalgarh	3338.02	3550	5.97
Sagar	3300.66	3400	2.92
Satna	3307.4	3300	0.22

Table 72 Predictions for 22nd of May for Mustard

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashoknagar	3354.35	3525	4.84
Datia	3370.59	3650	7.65
Kurawar	3254.97	3250	0.15
Morena	3440.92	3570	3.62
Neemuch	3352.2	3500	4.22
Piplya	3305.57	3610	8.43
Rewa	3221.56	3236	0.45

Sabalgarh	3359.76	3530	4.82
Satna	3274.54	3280	0.17

Table 73 Predictions for 28th of May for Mustard

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashoknagar	3458.13	3600	3.94
Kailaras	3532.18	3640	2.96
Kurawar	3238.36	3295	1.72
Morena	3597.25	3670	1.98
Piplya	3415.61	3410	0.16
Rewa	3241.25	3308	2.02
Sabalgarh	3517.11	3600	2.30
Sagar	3366.44	3475	3.12

Table 74 Predictions for 3rd of June for Mustard

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashoknagar	3463.94	3455	0.26
Banda	3194.2	3217	0.71
Datia	3489.05	3725	6.33
Kailaras	3575.76	3650	2.03
Lashkar	3606.4	3780	4.59
Morena	3627.9	3675	1.28
Sabalgarh	3523.85	3550	0.74
Sagar	3413.18	3425	0.35
Satna	3353.71	3400	1.36

Table 75 Predictions for 10th of June for Mustard

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashoknagar	3583.6	3500	2.39
Dabra	3675.05	3677	0.05
Lashkar	3702.89	3790	2.30
Morena	3630.19	3730	2.68
Neemuch	3547	3550	0.08
Piplya	3570.83	3200	11.59
Rewa	3322.36	3314	0.25
Sabalgarh	3662.13	3600	1.73
Sagar	3403.99	3250	4.74
Satna	3632.18	3300	10.07

Table 76 Predictions for 17th of June for Mustard

Market	Predicted Modal Price	Actual Modal Price	Error %
Ashoknagar	3517.16	3674	4.27
Kailaras	3646.24	3661	0.40
Lashkar	3760.53	3740	0.55
Morena	3712.75	3775	1.65
Neemuch	3629.62	3650	0.56
Piplya	3486.83	3415	2.10
Rewa	3321.96	3400	2.30
Sabalgarh	3572.35	3665	2.53
Satna	3388.57	3500	3.18