

1 **“Modeling and forecasting of potato production in Rajasthan and their yield**
2 **sustainability”**

Commented [A1]: makes the title more concise

3
4 **Abstract**

5 This study analyzed trends, sustainability, and forecasted potato area, production, and
6 productivity in India and Rajasthan from 1970 to 2030. Annual potato production data was
7 modeled with an autoregressive integrated moving average (ARIMA). The models were trained
8 on 1970–2020 data and evaluated on a 2021–2023 validation set. On the training set, a box
9 showed the best performance. The ARIMA models produced the lowest forecast errors. The top-
10 performing models forecast potato production up to 2030. The production of potato in Rajasthan
11 and India in 2023 was 260.50 and 61250.50 thousand tonnes. Rajasthan and India are predicted
12 in 2030 to produce 301.31 and 63318.26 thousand tonnes thousand tons. The forecasts can assist
13 food security planning and agricultural policymaking in the region. Rajasthan and India are
14 highly sustainable in the yield of potato in period-2 (1998–2023).

Commented [A2]: Redundant phrase

Commented [A3]: The abstract is comprehensive but repetitive, especially regarding numerical forecasts for 2023 and 2030. It would be better to streamline the results.

15 **Keywords:** Trend, Sustainability, ARIMA, Time Series, Policy.

16 **Introduction:** - **Potato** (*Solanum tuberosum*) is an annual herbaceous tuber crop belonging to
17 the family Solanaceae, one of the most horticulture crops that have the highest nutrition and dry
18 matter production per unit area and time of any major food crop. It is the world’s most significant
19 crop for food, with a 78% water content and a 22% dry matter content. 20% fat, 2.1% protein,
20 1.1% dietary fiber, 0.9% ash, and 0.3% carbs. Potato is another important source of raw materials
21 for the extraction of starch, with starch extraction typically ranging from 9% to 25%. According
22 to the total amount of mineral compounds accumulated in potatoes, they exceed many types of
23 fruits and vegetables, 18 amino acids are found in potato proteins. Potatoes are characterized by
24 high nutritional value and are a source of vitamins C, A, (carotene), group B, and K. By eating an
25 average of 300 g (about 10.58 oz) of boiled potatoes every day, we provide ourselves with the
26 necessary carbohydrates, phosphorus, vitamin 8 %, 10-12%, amino acids 30-40%, vitamin C 40-
27 50%, vitamin B- 20-25%, potassium 55-60%, calcium and iron-25-30% and carotene 1-2%.
28 Sustainable agriculture" is defined as "agriculture that, over the long term, improves the
29 environment quality and the resource base on which agriculture depends; provides for the basic
30 needs of human food and fiber; is economically viable; and enhances the quality of life for
31 farmers and society as a whole. Farming has always been characterized by large and irregular

32 changes in location, demand, and yield; this makes forecasting beneficial to farmers,
33 governments, and the agribusiness sector. Due to the critical role that food production plays in a
34 nation's stability, governments are becoming major providers and users of agricultural prediction
35 (Mishra *et al.*,2015).The area of potato production in India during 2022-23 is 2332Thousand ha,
36 withproduction of 61250.50 MT (Metric ton) anda yield of 257 q/ha.The total area, production,
37 and productivity of potato in Rajasthanin 2021 is about 13.59 Thousand ha,256.00thousand
38 tonnes, and 188.33 q/ha (Ministry of Agriculture and Farmer Welfare, Govt. of India,2023).
39 Mishra *et. al.*, (2024) utilized ARIMA (Auto Regressive Integrated Moving Average) and ETS
40 (Error-Trend-Seasonality) forecast models to predict potato production. Kumari *et. al.*, (2024)
41 This study focuses on the crucial requirement for precise prediction of potato price, which is
42 essential for optimizing production, marketing tactics, and inventory management. Yadav *et al.*,
43 (2024) utilized autoregressive integrated moving average (ARIMA) models, state space models,
44 and gradient-boosting machine learning approaches to analyze the annual potato production data
45 from 1967 to 2020.Sahu *et al.*, (2024) utilized time series data on area, production, productivity,
46 market prices, export quantity, and export value in the primary cultivating states, markets, and
47 importing nations, respectively. Devi *et al.*, (2021) study looked at the sustainability and
48 instability of wheat production in Haryana.

49 MATERIAL AND METHODS

50 Source of data

51 In the present investigation,secondary data has been gathered. A glance at Agricultural
52 Statistics (2022) provided the area, production, and yield data on potato for the years 1970–
53 2023 for Rajasthan and Whole India.

54 Descriptive Statistics

55 Descriptive statistics are frequently used to make numerical data easily understandable. We
56 have the option of using one or more criteria to assess a large sample of people. We can make
57 sense of very large datasets by using descriptive statistics.The three categories of descriptive
58 statistics are central tendency (CT), dispersion, and association measures.

59 Trend models

60 A (Mishra *et. al.* 2015) model is a way to illustrate a system or process. Statistical models often
61 follow the course of the process together with its statistical characteristics and implications.

62 i. **Linear Model:** $Y_t = b_0 + b_1t$

Commented [A4]: The methodology is robust, particularly the application of ARIMA models for forecasting.

- 63 ii. **Quadratic Model:** $Y_t = b_0 + b_1t + b_2t^2$
 64 iii. **Compound Model:** $\ln(Y_t) = \ln(b_0) + t \ln(b_1)$
 65 iv. **Cubic Model:** $Y_t = b_0 + b_1t + b_2t^2 + b_3t^3$
 66 v. **Exponential Model:** $Y_t = b_0 e^{(b_1)^t}$
 67 vi. **Logarithmic Model:** $Y_t = b_0 + b_1 \ln(t)$
 68 vii. **Growth Model:** $\ln(Y_t) = b_0 + b_1t$
 69 viii. **Inverse Model:** $Y_t = b_0 + \frac{b_1}{t}$
 70 ix. **Power Model:** $Y_t = b_0 t^{b_1} +$
 71 x. **S Type Model:** $Y_t = e^{(b_0 + \frac{b_1}{t})}$
 72 xi. **Logistic Model:** $Y_t = \frac{K}{(1 + e^{b_0 + b_1t})}$

73 **Randomness Test**

74 The current non-parametric test for randomization is based on the quantity of turning points. The
 75 method is to tally the series' peaks and troughs. A value that is higher than its two neighbors is
 76 referred to as a "peak," and a value that is lower than its two neighbors is referred to as a
 77 "trough." The series' highs and lows are regarded as pivotal moments. Therefore, one requires at
 78 least those data points to identify a turning moment. There are fewer turning points in the series
 79 than there are ups and downs.

80 Let us consider now a set of values $\mu_1, \mu_2, \dots, \mu_n$, and let us define a "marker" variable X_i by

81
$$X_i = \begin{cases} 1 & \left\{ \begin{array}{l} \mu_i < \mu_{i+1} > \mu_{i+2} \\ \mu_i > \mu_{i+1} < \mu_{i+2} \end{array} \right. \\ 0 & \text{otherwise; } i = 1, 2, \dots, n-2 \end{cases}$$
 The number of turning points p is then simply

$$p = \sum_{i=1}^{n-2} X_i$$

Then,

$$E(p) = \sum E(X_i) = \frac{2}{3}(n-2)$$

82 $E(p^2) = E\left(\sum_{i=1}^{n-2} X_i\right)^2$ on simplification,

$$E(p^2) = \frac{40n^2 - 144n + 131}{90} \text{ and}$$

$$V(p) = \frac{16n - 29}{90}$$

83 Measures of sustainability

84 According to Devi et al. (2021) and Vishwajith et al. (2018), sustainability is a complicated,
85 multifaceted phenomenon that has been described in a variety of ways. While highly divisive it is
86 widely accepted that it is complex and needs many evaluations. It can be evaluated by taking into
87 account its biophysical, social, and economic characteristics in its most basic form.

88 Sustainability Index (SI)

89 For the sustainability index will divide the potato productivity data into two periods.

- 90 • Period -1 (1970 -1997)
- 91 • Period -2 (1998 - 2023)
- 92 • Whole Period (1970 – 2023)

93 (a) According to **Singh et al.**, (1990), the sustainability measure is as follows.

$$94 \text{ Sustainability Index (SI)} = \frac{\bar{Y}-s}{Y_{max}}$$

95 (b) According to **Sahu et al.**, (2005) A sustainability index value that is closer to zero is a
96 desirable value.

$$97 \text{ SI} = \frac{Y_{max}-\bar{Y}}{\bar{Y}}$$

98 (c) According to **Pal and Sahu** (2007), sustainability increases when the sustainability index
99 value decreases.

$$100 \text{ SI} = \frac{S_i}{\bar{Y}_i} \cdot \frac{1}{S_{max}}$$

101

102

103 Modeling and forecasting

104 The plan looks like a flowchart for time series analysis-based potato production forecasts. The
105 flow is described as follows:

- 106 1. Start The procedure's first action.
- 107 2. Data on potato production: This appears to be the initial step in which the pertinent data on
108 potato production is recognized as a process input by using SPSS23.
- 109 3. Input Potato Production Data (India and Rajasthan): This stage indicates that data on potato
110 production will originate from India and Rajasthan.
- 111 4- Training data: After the information is acquired, it is categorized as training data, which is
112 what the forecasting models are fitted to.

Commented [A5]: he sustainability indices (SI-1, SI-2, SI-3) require clearer explanations. Discuss why different indices were used and their practical implications

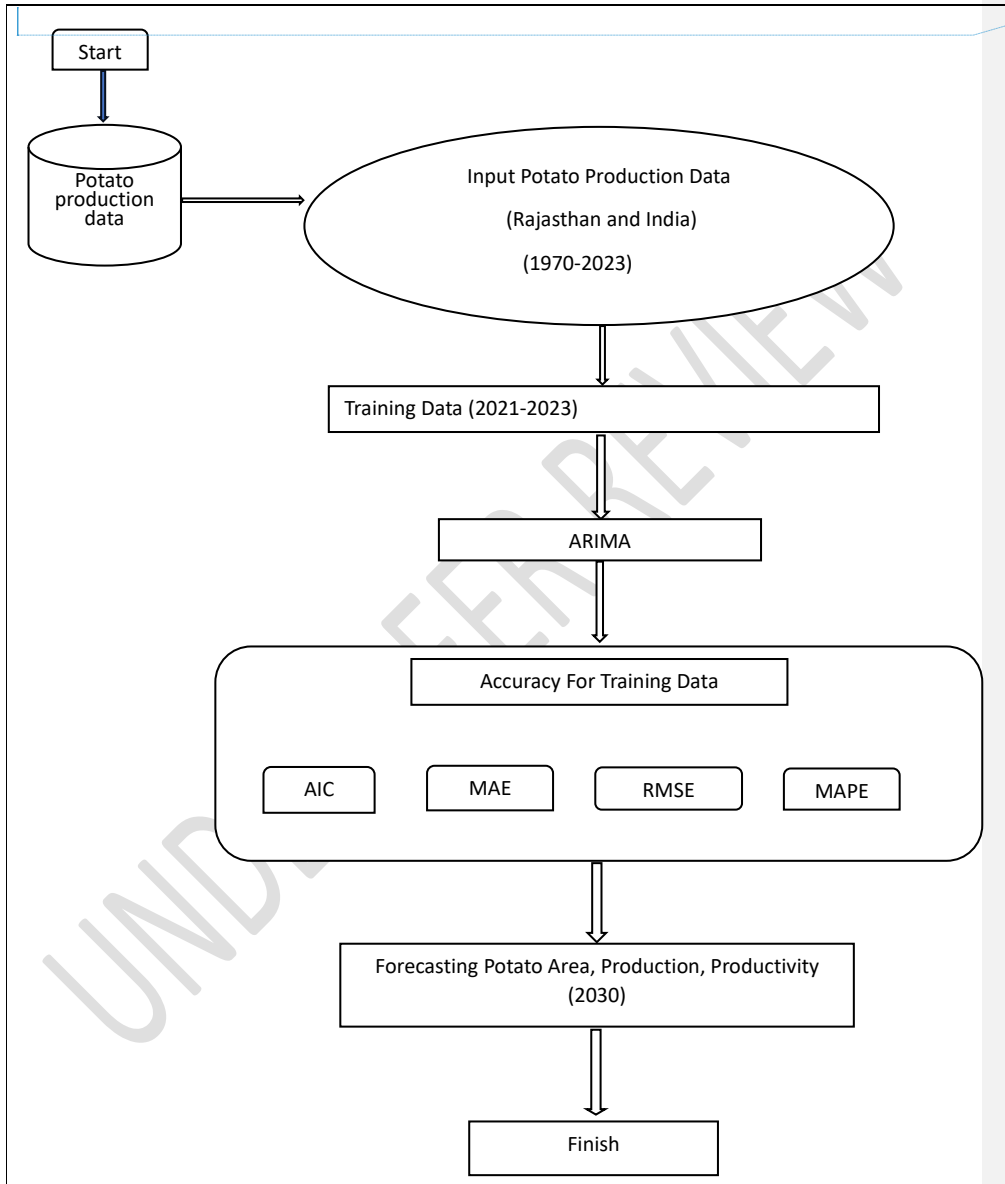
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113 5. The training data splits into two routes, signifying the application forecasting techniques:
114 The statistical technique known as Autoregressive Integrated Moving Average (ARIMA) is
115 widely used in time series forecasting.
116 6. Accuracy for training data: A number of accuracy metrics are used.
117 MAE: Mean Absolute Error, a measure of errors between paired observations expressing the
118 same phenomenon;
119 RMSE: Root Mean Square Error, a measure of the differences between values predicted by a
120 model and the values observed;
121 BIC: Bayesian Information Criterion, a measure of the relative quality of statistical models for a
122 given set of data.
123 Mean Absolute Error (MAE): A measurement of inaccuracies between two observations that
124 represent the same occurrence.
125 Root Mean Square Error (RMSE): a measurement of the discrepancies between data observed
126 and values projected by a model.
127 Autocorrelation Function at Lag 1 (ACF1): A measure of the correlation between time series
128 observations separated by a single time period.
129 Mean Absolute Percentage Error (MAPE): A measure of forecasting model prediction accuracy.
130 7. Projecting potato production: The more accurate forecasting model is probably chosen to
131 project future potato production based on the evaluations.

132

133

134 • **Flow chart forecasting**



Commented [A7]: Too much big figure .Flow Diagram needs to be reduce

137 **Autoregressive Moving Average (ARMA)**

138 The model containing p autoregressive terms and q moving average terms is denoted by the
139 notation ARMA (p, q). The AR(p) and MA(q) models are contained in this model.(Mishra et al
140 2023)

141
$$X_t = c + \varepsilon_t + \sum_{i=1}^p p_i X_{t-i} + \sum_{i=1}^q \theta_i \varepsilon_{t-i}$$

142 **RESULT & DISCUSSION**

143 According to the purpose of the analysis, the secondary source data was evaluated and
144 interpreted.

145 **Performance of Potato in India and Rajasthan during 1970-2023**

146 In this section, descriptive statistics such as maximum, minimum, mean, median, skewness, and
147 kurtosis are employed to elucidate the series' pattern and generate a consensus that is examined
148 in Table-1The data Platykurtic structure of potato under area, production, and yield in India and
149 Rajasthan.Rajasthan and India have an average area of 5.59 and 1291.31 thousand ha of potato
150 annually. Rajasthan and India produce an average of 74.69 and 24714.96 thousand tons of potato
151 annually. Rajasthan and India have an average yield of 99.07 and 172.65 q/ha of potato annually.
152 Skewness of 0.41 and 0.94 suggest that the area under potato in India and Rajasthan has been
153 changing over time. positive skewness scores of 1.38 and 0.72 indicate that output increased at
154 the start of the study and stayed almost constant for the duration of the investigation in Rajasthan
155 and India. The positive skewness score was 0.03 and 0.27 in Rajasthan and India.

156 **Table1: Performance of Potato area, production, and yield in India and Rajasthan during**
157 **1970-2023**

India			
	Area ('000 ha)	Production ('000 t)	Yield (q/ha)
Mean	1291.319	24714.596	172.650
Standard Error	79.023	2277.440	6.483
Median	1206.900	20709.060	167.700
Kurtosis	-1.181	-0.737	-0.571

Skewness	0.414	0.729	0.273
Minimum	482.000	4451.000	88.200
Maximum	2345.400	61250.500	277.460
Rajasthan			
Mean	5.592	74.69557	99.077
Standard Error	0.649	12.812	8.040
Median	2.752	27.151	110.835
Kurtosis	-0.809	0.570	-1.083
Skewness	0.946	1.383	0.039
Minimum	1.3	3.1	13.3
Maximum	15.985	337,991	211.442

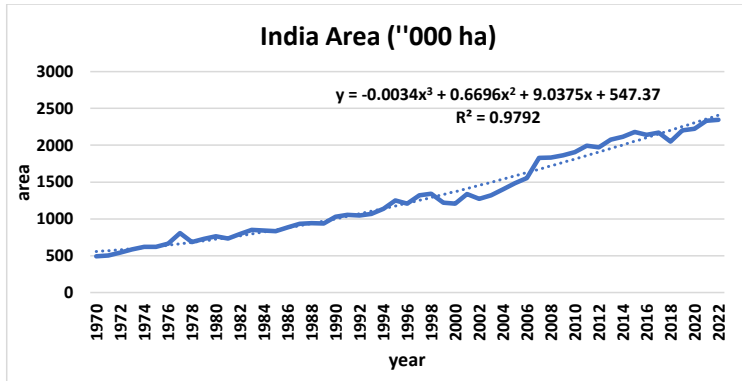
158 **Trend Analysis of Potato in India and Rajasthan**

159 The trend analysis shows (table-2) that there are cubic trends in potato area, yield, and
 160 production throughout India and Rajasthan. Suggesting that in the recent past, most likely, the
 161 series have reached their maximum values and then either remained constant or decreased, which
 162 is concerning. As can be seen from the data, the area dedicated to potato has grown annually in
 163 India and Rajasthan. Figures 1 to 6, show the non-linear patterns in India and Rajasthan.

164 **Table-2: Trends of Potato in India and Rajasthan**

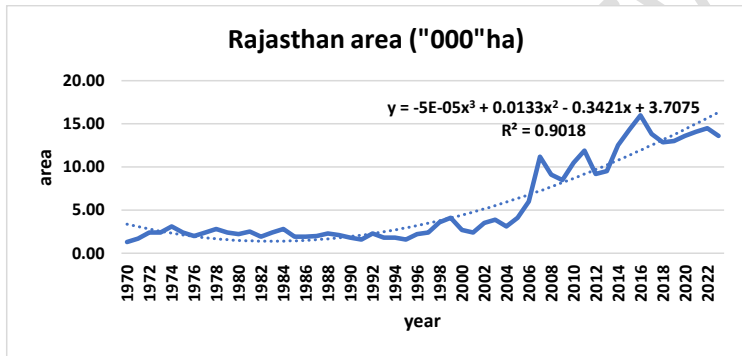
India							
	Model summary			Parameter Estimates			
	equation	R ²	Sig.	constant	B ₁	B ₂	B ₃
Area	Cubic	0.980	0.000	519.639	10.237	0.588	-0.002
production	Cubic	0.976	0.000	4046.793	504.577	-5.371	0.298
Yield	Cubic	0.936	0.000	79.466	6.563	-0.188	0.002
Rajasthan							
Area	Cubic	0.902	0.000	3.708	-0.342	0.013	-4.859E-05
production	Cubic	0.902	0.000	8.613	-0.125	-0.047	0.003
Yield	Cubic	0.752	0.000	-6.880	6.541	-0.143	0.002

165 **Figure-1: Trends of Area under Potato in India**



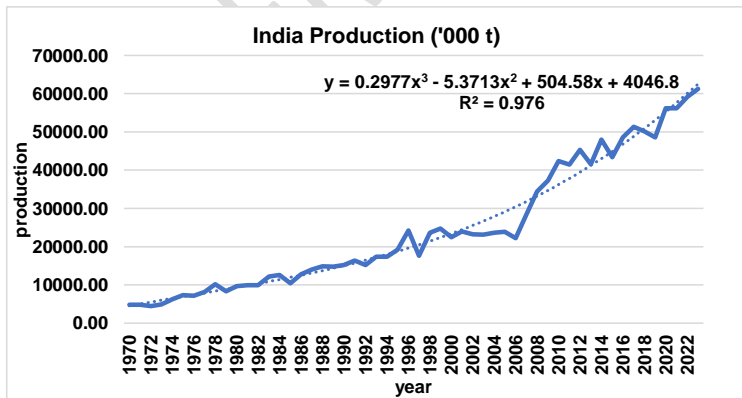
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167 **Figure-2: Trends of Area under Potato in Rajasthan**



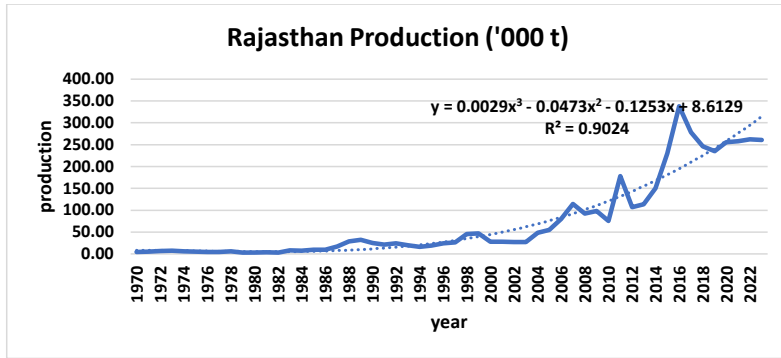
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169 **Figure-3: Trends of production under Potato in India**



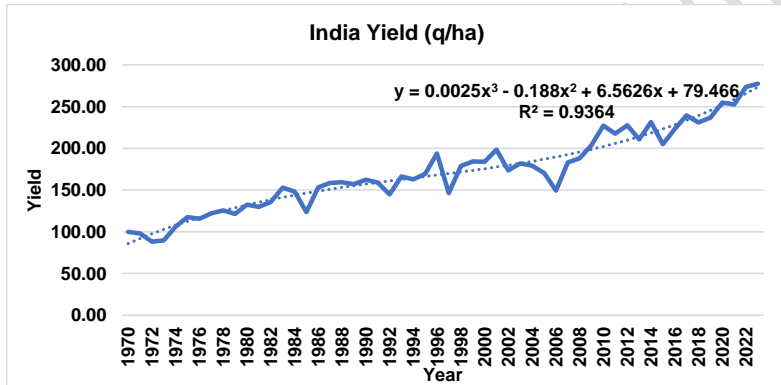
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171 **Figure-4: Trends of production under Potato in Rajasthan**



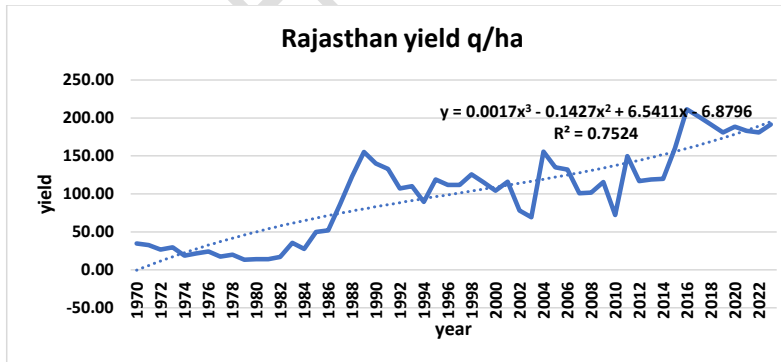
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173 **Figure-5: Trends of yield under Potato in India**



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175 **Figure-6: Trends of yield under Potato in Rajasthan**



176

177 **Randomness Test:** -In table-3shows, that Rajasthan and India exhibit distinct trends in the area,
 178 production and yield of potato, as demonstrated by the randomization test.

179 **Table-3** : That Rajasthan And India Exhibit Distinct Trends In The Area, Production And
 180 Yield Of Potato, As Demonstrated By The Randomization Test

Test of randomness	India			Rajasthan		
	Area	Prod	yield	Area	Prod	yield
No. of Observation	54	54	54	54	54	54
No. of Point (p)	21	27	29	24	17	27
E (P)	38.67	38.67	38.67	38.67	38.67	38.67
V(P)	10.34	10.34	10.34	10.34	10.34	10.34
t _{cal}	-5.49	-3.63	-3.01	-4.56	-6.74	-3.63
Inference	Trend	Trend	Trend	Trend	Trend	Trend
outliers Test	NO	NO	NO	NO	NO	NO

181

182 **Sustainability analysis**

183 Table-4 presents the results of measuring sustainability in the productivities of potato in
 184 Rajasthan and India using sustainability measurement.

India			
Sustainability Index	Period 1 (1970-1997)	Period 2 (1998-2023)	Whole Period (1970-2023)
SI 1	0.570	0.640	0.451
SI 2	0.414	0.316	0.607
SI 3	0.004	0.003	0.006
Rajasthan			
SI 1	0.092	0.459	0.189
SI 2	1.505	0.520	1.134
SI 3	0.013	0.005	0.010

185 **Table-4: Sustainability potato yield measurement**

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193 According to indexes provided by SI-1 (Singh et al., 1990), SI-2 (Sahu et al., 2005), and SI-3
194 (Pal and Sahu, 2007), as measured by various formulas for accuracy, it is evident the entire
195 country of India is highly sustainable in yield of potato in period-2 (1998-2023) and Rajasthan is
196 highly sustainable in yield of potato in period-2 (1998-2023).

197 **Modeling and forecasting**

198 We used the Box-Jenkins methodology for this. The model was built using data from 1970 to
199 2020, and it was validated using data from 2020 to 2023. Future series predictions are made
200 using the models that suit the data the best. None of them are stable in nature, as the ACF and
201 PACF graphs from the original series make abundantly evident, and first-order differencing is
202 enough to make them so. It was found that ARIMA models, starting with the model-building
203 procedure given in the material and method section, ranging from (0, 1, 0) to (1, 1, 5) are
204 appropriate for forecasting and predicting the production behavior of potato. using data from
205 1970 to 2023, the study then uses the differenced series to estimate ARIMA equations for all
206 parameters. It then produces predictions up to 2030. However, ACF and PACF graphs are also
207 used to perform diagnostic checks on residuals.

208 Figures-10 displays the ACF and PACF plot of the first difference, or the area under potato, for
209 Rajasthan and India. These plots indicate that $p=1$ and $q=5$ for Rajasthan and $p=1$ and $q=5$ for
210 India would be a reasonable range for the area under potato. Consequently, Table-5 demonstrates
211 the ARIMA (1,1,5) areas under potato have the highest R^2 value and the lowest RMSE, MAPE,
212 MaxAE, and MAE values in India. butthe ARIMA (1,1,5) areas under potato have the highest R^2
213 value and the lowest MAPE and MAE values in Rajasthan.The projected areas for potato in
214 Table-6demonstrateRajasthan and India in 2023 were 13.51 thousand hectares and 2423
215 thousand hectares, respectively, while the actual areas were 13.60 thousand hectares and 2345.40
216 thousand hectares. India is predicted to have 2620 thousand hectares and Rajasthan will have
217 15.54 thousand hectares in 2030 respectively.Figure-11displays the ACF and PACF plot of the
218 first difference, or the value of production under potato in Rajasthan and India.The ARIMA

219 (0,1,5) and ARIMA (0,1,5) were therefore determined to be appropriate for the Production of
 220 potato in Rajasthan and India. Table-5 further shows that India has the highest R² value along
 221 with the lowest values of MAPE, MaxAPE, and MAE, however, Rajasthan ARIMA (0,1,5)
 222 potato production has the highest value of R² along with the lowest values of RMSE, MAE, and
 223 MaxAE. In Table-7 contrast to the predicted 274.22 thousand tons and 63318.26 thousand tons,
 224 the production of potato in Rajasthan and India in 2023 was 260.50 thousand tons and 61250.50
 225 thousand tons, respectively. Rajasthan is predicted to produce 301.31 thousand tons, while India
 226 is forecast to produce 69806.76 thousand tons in 2030. The yield under potato in Rajasthan and
 227 India, as indicated by the ACF and PACF plot of the first difference Figures-12. It may be
 228 concluded that ARIMA (1,1,3) and ARIMA (1,1,5) are the ARIMA models that are most suited
 229 for yield under potato in Rajasthan and India. Moreover, Table-5 examination showed that while
 230 Rajasthan had the highest R² value and the lowest MAE value, India yielded potato highest R² and
 231 lowest MAPE, MAE and Normalized BIC values across all of India. In Table-8 contrast to the
 232 predicted 264.13 q/ha and 191.33q/ha, the yields of India and Rajasthan in 2023 and yield in 2023
 233 were 277.46 q/ha and 191.54q/ha, respectively. Rajasthan is anticipated to receive 209.25q/ha,
 234 while India is expected to receive 274.09 q/ha in 2030.

Table 5: Different ARIMA Model for area (“000”ha), production (“000”tons), and yield(q/ha) under potato in India and Rajasthan

India								
	ARIMA	R ²	RMSE	MAPE	MAE	MaxAPE	MaxAE	Normalized BIC
Area	(1,1,5)	0.990	62.696	3.577	42.235	16.938	189.079	8.876
Production	(0,1,5)	0.978	2600.236	9.818	1902.447	39.111	7002.540	16.176
Yield	(1,1,5)	0.922	13.916	5.962	9.633	27.145	40.554	5.790
Rajasthan								
Area	(1,1,5)	0.946	1.186	16.608	0.741	61.810	5.120	0.865
Production	(0,1,5)	0.930	26.366	55.422	14.353	276.300	91.400	6.994
Yield	(1,1,3)	0.852	23.616	24.279	15.962	106.590	71.750	6.698

Table-6: Model Validation and forecasting of Area (000’ha) under potato in India and Rajasthan

India			
year	Observed	Predicted	Prediction error percentage

2021	2225.75	2276.36	-2.27
2022	2332.05	2352.92	-0.89
2023	2345.41	2422.88	-3.30
2024		2413.99	
2025		2487.86	
2026		2474.06	
2027		2559.1	
2028		2547.16	
2029		2628.77	
2030		2620.14	
Rajasthan			
2021	14.10	14.71	-4.32
2022	14.50	14.45	0.34
2023	13.60	13.51	0.66
2024		14.32	
2025		14.62	
2026		14.59	
2027		14.86	
2028		15.08	
2029		15.31	
2030		15.54	

Table-7: Model Validation and forecasting of Production ('000' tons) of potato in India and Rajasthan

India			
year	Observed	Predicted	Prediction error percentage
2021	56175.75	57521.81	-2.39
2022	59160.34	60571.58	-2.38
2023	61250.50	63318.26	-3.37
2024		63527.71	

2025		65419.16	
2026		65502.66	
2027		67459.86	
2028		67654.86	
2029		69589.11	
2030		69806.76	
Rajasthan			
2021	258.20	264.65	-2.49
2022	262.50	270.85	-3.18
2023	260.50	274.22	-5.26
2024		281.81	
2025		280.31	
2026		285.88	
2027		286.75	
2028		291.61	
2029		296.46	
2030		301.31	

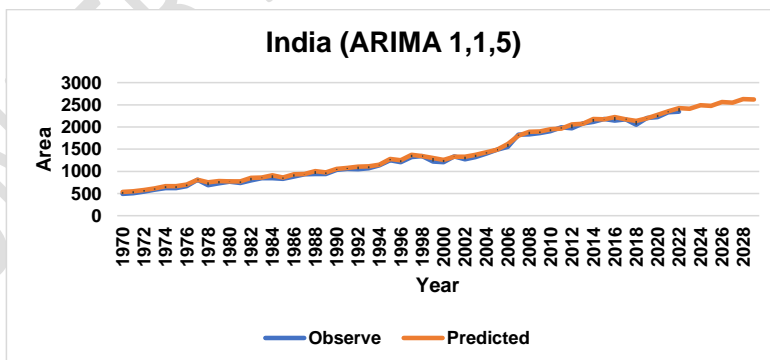
239 Table-8: Model Validation and forecasting of Yield (q/ha) under potato in India and Rajasthan

India			
year	Observed	Predicted	Prediction error percentage
2021	252.40	249.62	1.10
2022	273.56	265.24	3.04
2023	277.46	264.13	4.80
2024		267.81	
2025		261.24	
2026		262.94	
2027		264.48	
2028		268.45	

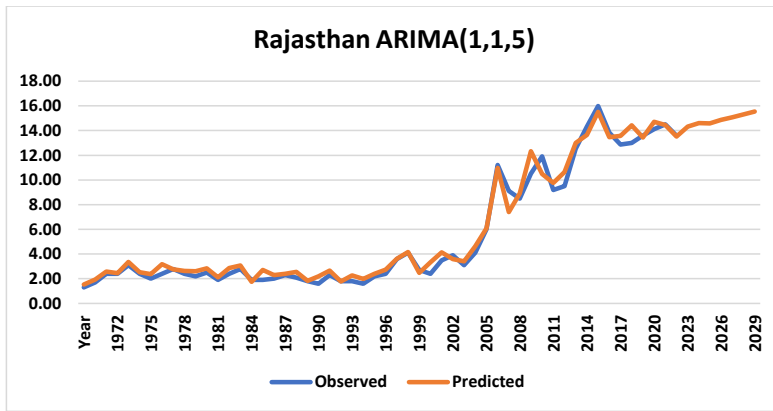
2029		270.55	
2030		274.09	
Rajasthan			
2021	183.12	185.62	-1.36
2022	181.03	183.85	-1.55
2023	191.54	191.33	0.10
2024		194.04	
2025		195.98	
2026		198.26	
2027		200.79	
2028		203.5	
2029		206.33	
2030		209.25	

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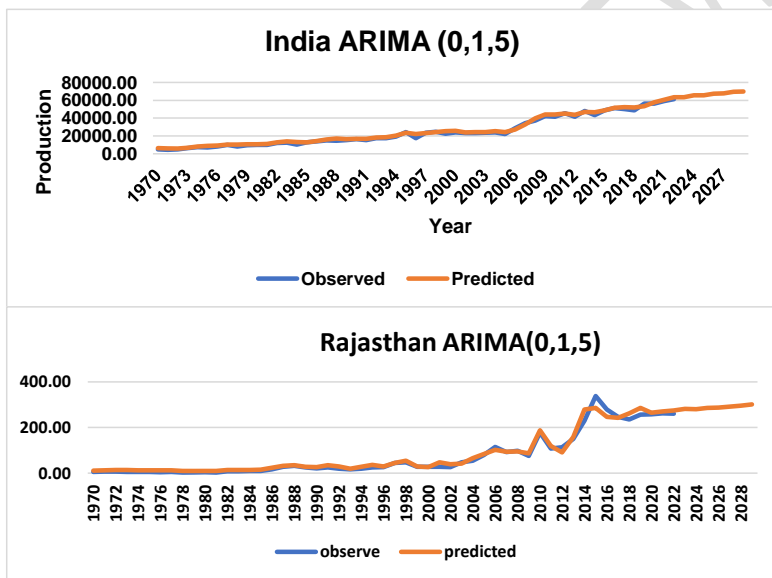
244 **Figure -7: Observed and Predicted Area (000'ha) under potato in India and Rajasthan**



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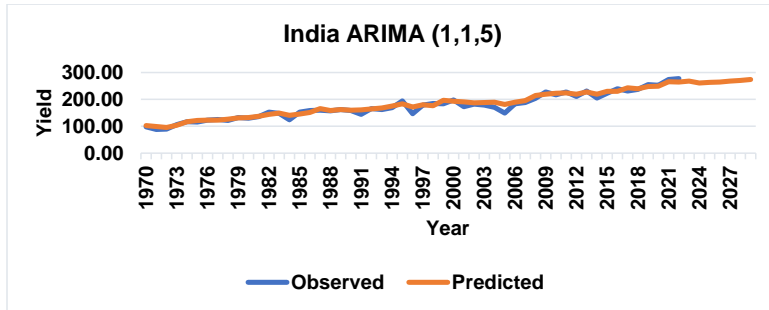


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247 **Figure-8: Observed and Predicted of Production ('000' tons)of potato in India and Rajasthan**

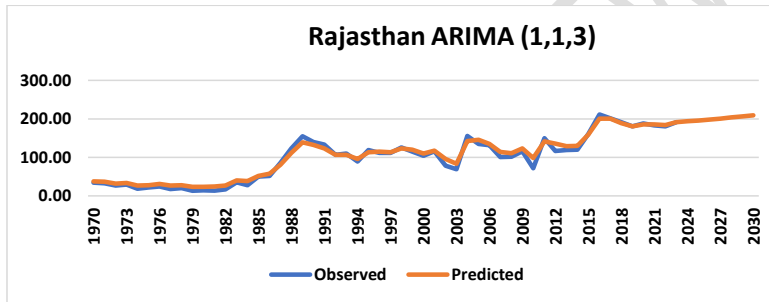


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250 **Figure-9: Observed and Predicted of Yield (q/ha) under potato in India and Rajasthan**

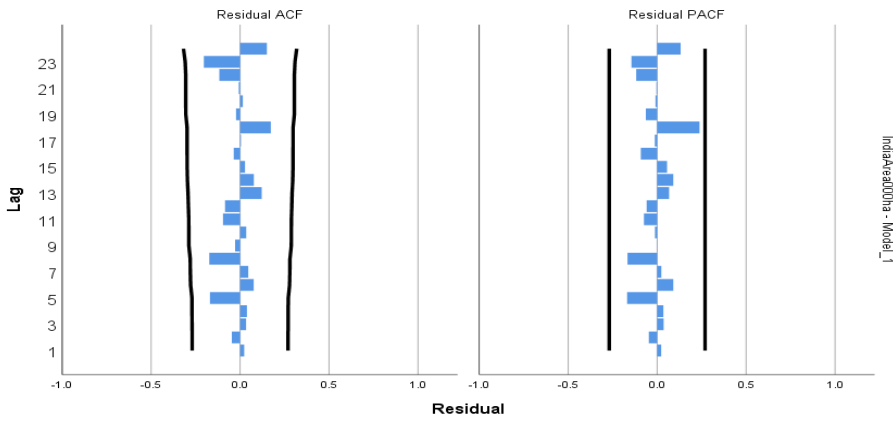
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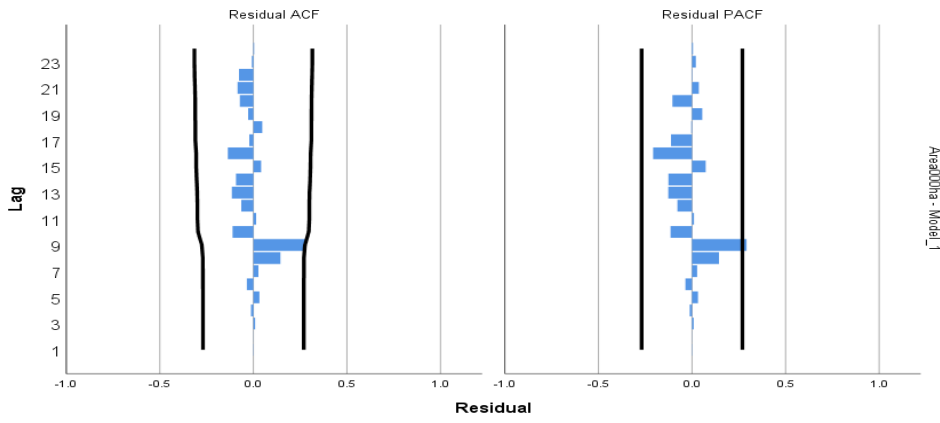
253 **Figure -10: ACF and PACF graphs of residuals for the best-fitted models of Area under**
 254 **Potato in India and Rajasthan**



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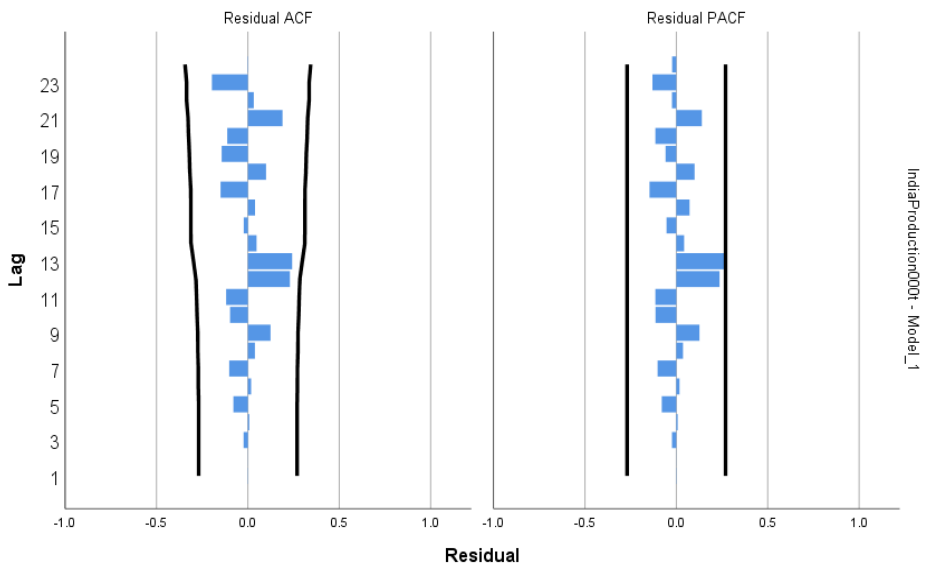
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259 **Figure-11: ACF and PACF graphs of residuals for the best-fitted models of Production**
 260 **under potato in India and Rajasthan**



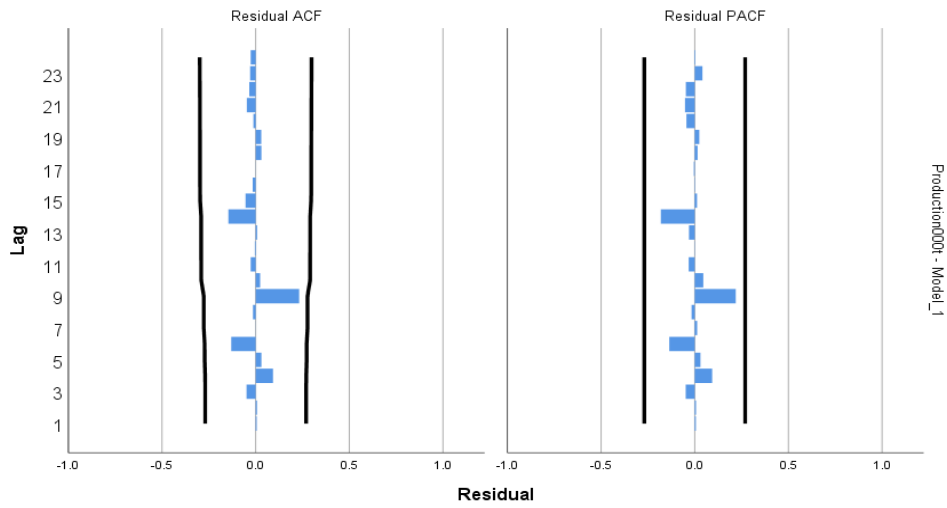
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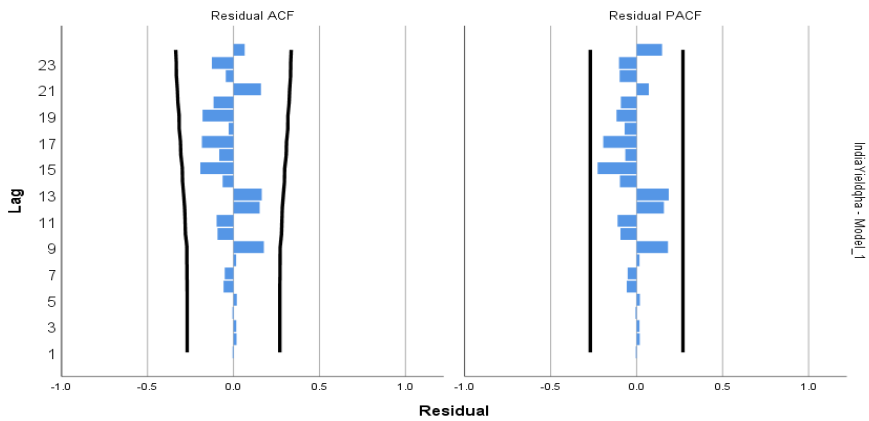
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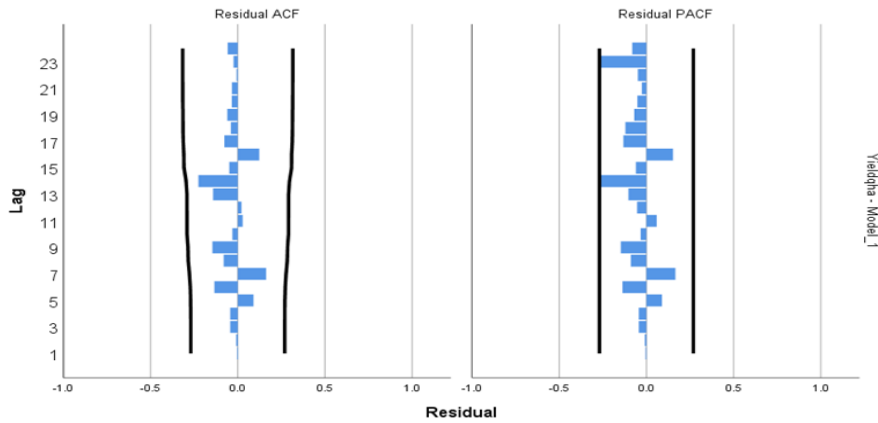


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 267 **Figure-12: ACF and PACF graphs of residuals for the best-fitted models of Area under**
 268 **potato in India and Rajasthan**
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279 Conclusion

280 Potato is the most important horticultural crops and has the maximum nutrition and dry matter
281 production per unit area and time. It is the most important crop in the world for food. This study
282 covering the period from 1970 to 2023, has analyzed potato area, production and productivity in
283 the Rajasthan and India employing forecasting based box-Jenkins methodology after analyzing
284 its trend for each individual series. Trend behavior of potato production there has been significant
285 growth in area, production, and productivity. Analysis shows the cubic trend in potato area,
286 production, and productivity in India and Rajasthan. Sustainability analysis is used for the future
287 plan of crop improvement. The ARIMA models that are most suited for yield under
288 potato Rajasthan would be anticipated to receive 209.25q/ha, while India would be expected to
289 receive 274.09 q/ha in 2030.

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Commented [A8]: •A thorough proofreading for grammar and formatting is recommended.
•Figures and tables are well-organized but ensure that all figures are referenced in the text.
•A stronger conclusion summarizing key findings and practical applications for policymakers and farmers would add value.

Commented [A9]: The references are recent and relevant to the topic. However, the following additional studies may strengthen the manuscript:
•Studies that compare ARIMA with machine learning models in agricultural forecasting.
•Sustainability assessments in other horticultural crops

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