

Original Research Article

Direction of Trade of Rice from India: Markov Chain Analysis

Abstract: Agriculture is the most important occupation in India. Rice ranks second globally and is one of the most significant and important food crops in India. More than fifty percent of the global population is fed by it. For the majority of people in Southeast Asia, it is a staple food. In this article we tried to find out the direction of trade of rice especially from India to the rest of the world by the Markov chain analysis after examining the compound annual growth rate of exports from India to the different regions of the world. The results of the study revealed that the compound annual growth rate of rice production was 2.26 per cent and Exports in terms of value increased by 16.8 per cent, CAGR of rice exports to Iraq was 58.6 per cent, Iran was 46.47 per cent, Whereas CAGR of rice exports in terms of quantity was increased by 10.82 per cent, Iraq was 44 per cent and Iran was 34 per cent. The Transitional Probability Matrix of rice exports in terms of value indicates that Africa retains 78 per cent of its trade and Asia retains 93.7 per cent of trade during the period 2001-2022 and in terms of quantity indicated that the Asia retains 92.6 per cent of its trade and Africa retains 89.1 per cent of trade during 2001-2022. It is suggested from the study that India had the potential to diversify the rice exports to other nations and to gain the competitive advantage. Government should also focus on improving the processing facilities, transportation facilities and quality maintenance.

Keywords: Direction of Trade, Export Performance, India, Markov Chain Analysis, Rice

Introduction: Agriculture is the most important occupation in India. A little over 58% of the populace is reliant on agriculture. It is the largest and oldest occupation in India and the backbone of the country's economy. It is the centre, around which the entire economy of the nation revolves. Despite its declining proportion in the state's domestic product, agriculture is still one of the key economic sectors in the state, especially in the rural areas. The government periodically plans and implements a number of initiatives and programmes to increase productivity. In terms of agriculture, rice ranks second globally and is one of the most significant and important food crops in India. More than fifty percent of the global population is fed by it. For the majority of people in Southeast Asia, it is a staple food. About 90 per cent and 91 per cent of the world's rice production and area, respectively, are found in Asia. India is the country with the largest area cultivated to rice worldwide, and it is positioned next to China in terms of production.

After the maize, rice is the second most significant cereal crop in the world. Around 510 million metric tonnes of milled rice were produced globally. Asia has traditionally produced the majority of the world's rice. According to FAO data the world's top producer of rice in 2021 was China, followed by India and Bangladesh. The major rice exporting nations include India, Vietnam, and Thailand. India had the highest export volume of rice worldwide, at 18.75 million metric tons as of 2021-2022. Vietnam was the second largest rice

exporter, with about 6.5 million metric tons of rice worldwide. The largest rice importers were the Philippines and China. The retail price of white rice has increased in recent years. Total global consumption of milled rice amounted to approximately 510.3 million metric tons in 2021-2022. China consumed almost 155 million metric tons of milled rice in 2021-22 and was by far the world's leading rice consumer. Following China, India is ranked second with 103.5 million metric tons of rice consumption in the same period (FAOSTAT, 2022).

There is problem of self-sufficiency in country, so it is difficult to decide what quantity of rice to be exported from the country looking at production of rice and consumption of rice in the country (Madhu *et. al*, 2023). In the recent incidents the countries were imposing the ban on exports of rice, so in this article we tried to find out the direction of trade of rice especially from India to the rest of the world by the Markov chain analysis after examining the compound annual growth rate of exports from India to the different regions of the world.

Materials and Methods:

Period of study: The Data pertaining to the analysis of direction of trade of rice from India both in value and quantities were taken from 2001-2002 to 2022-2023.

Nature and Sources of Data: The time series data pertaining to the Exports of rice from India to the rest of the world region wise was collected from the Ministry of Commerce and Industry, Government of India and APEDA.

Analytical Framework:

The compound annual growth rate (CAGR) was computed based on time series data on area, production and productivity of rice and exports of rice from India for 20 years of study period *viz.*, 2001 to 2022 using log-linear production function. Compound growth rate was estimated to study the percentage increase or decrease in the selected parameter. The following exponential growth function was used:

$$Y = ab^t u_t \text{ ----- (1)}$$

In the log form, the above function (1) was formulated as:

$$\text{Log } Y_t = \text{Log } a + t \text{ Log } b + \text{Log } u_t \text{ -----(2)}$$

Where,

- Y_t = Dependent variable for which growth was estimated (*i.e.* area, production, productivity)
- a = Intercept or constant
- b = Regression/Trend coefficient
- t = Periods in years (1, 2, 3...20)

u = Error terms with zero mean and constant variance

The compound growth rates “r” was computed using the following formula.

$$CAGR (r) = [Antilog (log b) - 1] \times 100 \text{ --- (3)}$$

Where,

r = Compound annual growth rate

The trade direction was examined by using Markov chain analysis. This method analyses structural change in any variable whose progress through time can be measured as of single variable outcome. Markov chain analysis involves developing a transitional probability matrix ‘P’, whose elements, P_{ij} indicate the probability of exports switching from country ‘i’ to country ‘j’ over time. The diagonal elements P_{ij} where $i=j$, measure the probability of a country retaining its market share or in other words, the loyalty of an importing country to a particular country’s exports. The transitional probabilities P_{ij} can be arranged in a (c*n) matrix.

In the context of current applications, structural changes were treated as a random process with the selected importing countries for the selected medicinal and aromatic plants under study. The assumption that the average export of each of the rice from India amongst importing countries in any period depends only on the export in the previous period and this dependence is same among all the periods. This is algebraically expressed as

$$E_{ij} = \sum_{i=1}^n [E_{i,t-1}] P_{ij} + e_{jt}$$

Where,

E_{ij} = exports from India to the j^{th} country in the year t, $E_{i,t-1}$ = exports of i^{th} country during year t-1

P_{ij} = the probability that exports were shift from i^{th} country to j^{th} country

e_{jt} = the error term which is statistically independent of $E_{i,t-1}$, n = the number of importing countries

The transitional probabilities P_{ij} which can be arranged in a (c*n) matrix, have the following properties.

$$\sum_{i=1}^n P_{ij} = 1 \text{ and } 0 \leq P_{ij} \leq 1$$

Thus, the expected export share of each country during period ‘t’ is obtained by multiplying the exports to those countries in the previous period (t-1) with the transitional matrix.

The transitional probability matrix (T) was estimated using linear programming (LP) framework by a method referred to as Minimization of Mean Absolute Deviation (MAD).

$$\text{Min, OP}^* + I e$$

Subject to

$$X P^* + V = Y$$

$$G P^* = 1$$

$$P^* \geq 0$$

Where,

P^* is a vector of the probabilities P_{ij} , O is the vector Zones

I is an appropriately dimensional vector of areas, E is the vector of absolute errors

Y is the proportion of exports to each country, X is block diagonal matrix of lagged valued of Y , V is the vector of errors, G is a grouping matrix to add the row elements of P arranged in P^* to unity

Prediction of quantity of selected Rice was made by using the Transitional Probability Matrix.

$$B_t = B_0 * T$$

$$B_{t+i} = B_{t+i-1} * T$$

Where,

B_0 = quantity exported in base year, B_t = quantity exported in next year (prediction)

T = Transitional Probability Matrix

The values in the transition probability matrix has different interpretations. The value of diagonal elements indicates the probability of retention of the previous year's values, while values in the columns reveal probability of gain of a particular country from other competing countries, values in row reveal probability that a country might lose to other competing countries in respect of rice exports.

Results and Discussion:

The compound annual growth rates of rice exports from India were calculated separately for both exports by quantity and exports by the value along with the Area, production and productivity of rice. Here in Table 1 represent that area under rice was increased by 0.35 per cent from 1967 to 2022 and it was 0.13 per cent during 1990-2022. The production and productivity increased by 2.26 per cent and 1.90 per cent respectively during 1967-2022 whereas between 1990-2022 its 1.64 and 1.50 per cent. Similarly, the CAGR of rice exports in terms of value during 1990-2022 were increased 16.84 per cent during the same period the exports to Africa were increased by 23.15 per cent next to Oceania by 24.21 per cent, Europe stands last by 12.32 increase among other regions.

Table 1: CAGR of Rice Area, Production and Productivity of rice in India:

CAGR	1967-2022	1990-2022
Area	0.358 %	0.130 %
Production	2.265 %	1.642 %
Productivity	1.901 %	1.509 %

Table 2: CAGR of rice exports of India from 1990-2022 in value

world	16.840 %
Africa	23.152 %
America	14.515 %
Asia	16.545 %
Europe	12.323 %
Oceania	24.213 %
others	-9.330 %

The major rice importing countries from India were Iran, Saudi Arabia, UAE, Iraq, Bangladesh, Nepal, Yemen and Kuwait. According to the table 3, the CAGR of rice Exports in terms of value to the top most countries which were selected based on the last ten years average of rice Exports by value from India, among which Iraq showed 58.46 per cent growth, Iran shows 46.47 per cent and Nepal showed 30.71 per cent during the time period 2001-2022.

Table 3: CAGR of rice exports of India from 2001-2022 in value

Iran	46.479 %
Saudi Arabia	10.369 %
UAE	15.869 %
Iraq	58.464 %
Bangladesh	10.192 %
Nepal	30.718 %
Yemen	21.147 %
Kuwait	11.364 %
Others	15.206 %

Here in Table 4, we calculated the Transitional Probability Matrix by using Markov Chain Analysis for the data on rice exports from India to the other regions of the world from 2001-2022, according to it the cells which are coincided with each other by the same region/country represents the retaining trade capacity of the particular region during the time period, if the value in that cell equals to 1 then it is said to be that the particular region is having the 100 per cent retention of the time period during the time period here in this case 2001-2022. Whereas the value 0 indicates the 0 per cent retention capacity, The horizontal rows represent the particular region/country loss to the country which is in the column

whereas the columns represent the potential gain in trade from the region/country which is in the rows. Here in this table Africa retains 78 per cent of trade during the time period 2001-2022 and lost remaining to the Asia, America and Europe by 16 per cent, 3.3 per cent and 1.8 per cent respectively. Similarly, Asia retains 93.7 per cent of its trade during the same period and lost 3.0 per cent each to America and Europe. America retained only 12.3 per cent lost 86.1 per cent to the Africa. Europe retained 58.8 per cent of its trade from India and lost 41.00 per cent to Africa in the same manner Oceanian also lost 50.8 per cent to Africa by retaining 49.2 per cent and in overall Africa gained the major trade from India which was lost by America, Europe and Oceania during the period 2001-2022 in terms of value of exports.

Table 4: Transitional Probability Matrix of rice region wise from 2001-2022 in Value

	Africa	America	Asia	Europe	Oceania	Others
Africa	0.781	0.033	0.166	0.018	0.001	0.000
America	0.861	0.123	0.000	0.000	0.016	0.000
Asia	0.000	0.030	0.937	0.030	0.004	0.000
Europe	0.410	0.000	0.000	0.588	0.000	0.003
Oceania	0.508	0.000	0.000	0.000	0.492	0.000
Others	0.000	0.000	0.000	0.952	0.000	0.048

The top eight countries which are importing rice from India in terms of export value based on the last decadal average were Iran, Saudi Arabia, UAE, Iraq, Bangladesh, Nepal, Yemen and Kuwait. It is evident from the table 5 and 6 that Iran retains 83.5 per cent of trade from India and lost 16.5 per cent to the Saudi Arabia during 2001-2010 whereas during 2011-2022 its retention capacity was 31 per cent and lost major portion to Saudi Arabia by 40.9 per cent. Whereas Saudi Arabia retains 57.6 per cent and 32.5 per cent during 2001-2010 and 2011-2022 respectively and lost to 30.5 per cent during 2001-2010 to others and more than 50 per cent to the UAE and Iraq together during 2011-2022. Iraq lost all its trade and Nepal lost 86.7 per cent, Yemen 66.1 per cent, and Kuwait 31.4 per cent to UAE which is at retention capacity of 67.8 per cent during the time period 2001-2010 whereas during 2011-2022 the retention capacity of UAE stands only 16.4 per cent and lost major part to Iran by 68.4 per cent. During 2011-2022 Bangladesh, Nepal and Yemen lost all of its trade which indicates These are most unstable markets for India. Bangladesh lost majorly to Iran, Nepal lost majorly to others, and Yemen lost to Nepal by 66.6 per cent, 79.00 per cent and 72.4 per cent respectively. Others retain 83.7 per cent of trade and only lost to 10 per cent to Saudi Arabia and small portion to the UAE and Bangladesh during 2011-2022 in terms of value of exports of rice from India.

**Table 5: Transitional Probability Matrix of rice exports from India to top 8 countries
2001-2010 in Value**

	Iran	Saudi Arabia	UAE	Iraq	Bangladesh	Nepal	Yemen	Kuwait	Others
Iran	0.835	0.165	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Saudi Arabia	0.000	0.576	0.000	0.000	0.000	0.000	0.055	0.064	0.305
UAE	0.081	0.000	0.678	0.004	0.000	0.000	0.000	0.237	0.000
Iraq	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000
Bangladesh	0.000	0.530	0.204	0.000	0.198	0.000	0.000	0.068	0.000
Nepal	0.000	0.000	0.867	0.000	0.000	0.000	0.000	0.133	0.000
Yemen	0.000	0.000	0.661	0.099	0.000	0.068	0.172	0.000	0.000
Kuwait	0.000	0.537	0.314	0.016	0.000	0.000	0.046	0.087	0.000
Others	0.000	0.088	0.000	0.000	0.239	0.024	0.007	0.000	0.642

**Table 6: Transitional probability Matrix of rice exports from India to top 8 countries
2011-2022 in Value**

	Iran	Saudi Arabia	UAE	Iraq	Bangladesh	Nepal	Yemen	Kuwait	Others
Iran	0.314	0.409	0.000	0.000	0.036	0.000	0.090	0.095	0.056
Saudi Arabia	0.000	0.325	0.276	0.309	0.000	0.000	0.000	0.073	0.017
UAE	0.684	0.052	0.164	0.000	0.000	0.000	0.077	0.023	0.000
Iraq	0.000	0.000	0.000	0.317	0.332	0.273	0.000	0.000	0.079
Bangladesh	0.666	0.171	0.074	0.010	0.000	0.002	0.072	0.005	0.000
Nepal	0.000	0.000	0.000	0.000	0.000	0.000	0.210	0.000	0.790
Yemen	0.000	0.000	0.000	0.000	0.000	0.724	0.000	0.000	0.276
Kuwait	0.646	0.000	0.000	0.000	0.000	0.000	0.076	0.149	0.129
Others	0.000	0.108	0.022	0.000	0.033	0.000	0.000	0.000	0.837

Table 7 represents the compound annual growth rate of rice exports from India by quantity which is to the world increased by 10 per cent whereas to Africa and Oceania increased by 17.33 per cent and 18.83 per cent respectively from 1990-2022 and from table 8 it is evident that exports to Iraq increased by 44.18 per cent and to Iraq by 34 per cent, for Bangladesh only 1.68 per cent increase in exports of rice from India in terms of quantity.

Table 7: CAGR of rice Exports from India by Quantity

CAGR	1990-2022	2001-2022
World	10.820 %	9.907 %
Africa	17.338 %	13.684 %
America	8.858 %	10.749 %
Asia	9.519 %	8.603 %
Europe	7.137 %	7.654 %
Oceania	18.832 %	16.382 %
Others	-	-15.670 %

Table 8: CAGR of Rice Exports from India by Quantity

CAGR	2001-2022
Iran	34.158 %
Saudi Arabia	3.569 %
Bangladesh	1.684 %
Nepal	22.779 %
UAE	8.780 %
Iraq	44.183 %
China	38.459 %
Yemen	12.590 %
Others	6.715 %

The transitional probability Matrix of rice exports from India in quantity to other regions were represented in table 9, according to which the Africa retains 89.1 per cent of trade from India during 2001-2022, whereas Asia retains 92.6 per cent of trade. Oceania lost all of its trade to Africa and America lost all of its trade to Asia during the same period. Europe retains 48.0 per cent of trade and lost 50.3 per cent to the Asia. Others retains only 5.7 per cent and lost 94.3 per cent to the Europe.

Table 10, represents the transitional probability Matrix of rice exports from India to top eight countries in terms of quantity which are taken by the last decadal average value of exports to the particular countries here the data taken from 2001-2022 and for convenience to identify the decadal losses and gains by the particular countries we have run Markov chain analysis separately two times from 2001-2010 and from 2011-2022 which were represented in table 10 and 11 separately. During 2001-2010 Iraq lost all its trade to UAE, China lost to Others and Yemen lost 91.9 per cent to UAE. Iran retains only 58.3 per cent of its trade and lost to Saudi Arabia by 41.00 per cent, Saudi retains less than half of its trade and lost that to the Others. UAE retains majority of its trade when compared to others by 71.4 per cent and lost the remaining to Iran

Table 9: Transitional Probability Matrix of rice exports in quantity from India to other regions from 2001-2022 by quantity

	Africa	America	Asia	Europe	Oceania	Others
Africa	0.891	0.012	0.067	0.029	0.001	0.000
America	0.000	0.000	1.000	0.000	0.000	0.000
Asia	0.024	0.024	0.926	0.021	0.004	0.000
Europe	0.503	0.000	0.000	0.480	0.017	0.000
Oceania	1.000	0.000	0.000	0.000	0.000	0.000
Others	0.000	0.000	0.000	0.943	0.000	0.057

Table 10: Transitional Probability Matrix of rice exports from India to top 8 countries in quantity from 2001-2010 in quantity

	Iran	Saudi Arabia	Bangladesh	Nepal	UAE	Iraq	China	Yemen	Others
Iran	0.583	0.410	0.000	0.000	0.000	0.007	0.000	0.000	0.000
Saudi Arabia	0.000	0.449	0.000	0.000	0.057	0.020	0.000	0.088	0.386
Bangladesh	0.000	0.532	0.341	0.000	0.125	0.000	0.000	0.002	0.000
Nepal	0.000	0.000	0.000	0.431	0.000	0.000	0.000	0.009	0.561
UAE	0.286	0.000	0.000	0.000	0.714	0.000	0.000	0.000	0.000
Iraq	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000
China	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000
Yemen	0.000	0.000	0.000	0.080	0.919	0.001	0.000	0.000	0.000
Others	0.000	0.000	0.296	0.029	0.000	0.000	0.001	0.011	0.664

According to table 11, China retains majority of its trade by 86.7 per cent and lost just 13.3 per cent to Others. Iraq and Yemen lost all of its trade during the period 2011-2022, Iran gains 43.7 per cent from Bangladesh, 59.6 per cent from UAE, Saudi Arabia gains 35.1 per cent from the Yemen, 19 per cent from Iran and 13 per cent from Bangladesh.

Table 11: Transitional probability Matrix of rice exports from India to top 8 countries in quantity from 2011-2022

	Iran	Saudi Arabia	Bangladesh	Nepal	UAE	Iraq	China	Yemen	Others
Iran	0.323	0.195	0.000	0.104	0.000	0.000	0.000	0.086	0.292
Saudi Arabia	0.000	0.368	0.000	0.000	0.290	0.342	0.000	0.000	0.000
Bangladesh	0.437	0.134	0.000	0.098	0.088	0.022	0.000	0.045	0.178
Nepal	0.000	0.000	0.000	0.551	0.016	0.188	0.010	0.033	0.201
UAE	0.596	0.000	0.000	0.015	0.344	0.000	0.000	0.045	0.000
Iraq	0.000	0.000	0.925	0.017	0.000	0.000	0.000	0.058	0.000
China	0.000	0.000	0.000	0.000	0.000	0.000	0.867	0.000	0.133
Yemen	0.000	0.351	0.000	0.649	0.000	0.000	0.000	0.000	0.000
Others	0.000	0.088	0.125	0.000	0.000	0.000	0.000	0.015	0.771

Conclusion:

The study was conducted to identify the direction of trade of rice, for which we have calculated CAGR and Transitional probability Matrix by Markov Chain Analysis by taking the time series data from the secondary sources like Ministry of Agriculture and farmers welfare, Ministry of Commerce and Industry and DGCI&S etc, and the results from the study indicated that the compound annual growth rate of rice production was 2.26 per cent and Exports in terms of value increased by 16.8 per cent, CAGR of Iraq was 58.6 per cent which is top among other countries, and Iran was 46.47 per cent, Whereas CAGR of rice exports in terms of quantity was increased by 10.82 per cent worldwide, Iraq was 44 per cent and Iran was 34 per cent. The Transitional Probability Matrix of rice exports in terms of value indicates that Africa retains 78 per cent of its trade and Asia retains 93.7 per cent of trade during the period 2001-2022, whereas for the to countries between 2001-2010, Iran retains 83.5 per cent of trade and Nepal lost 100 per cent of its trade o other countries, during 2011-

2022 Bangladesh, Nepal and Yemen lost all of its trade from India to other countries, and Iran retains only 31.4 per cent trade unlike during 2001-2010. Transitional probability Matrix for the rice exports from India in terms of quantity indicated that the Asia retains 92.6 per cent of its trade and Africa retains 89.1 per cent of trade during 2001-2022, in the same period Oceania, America lost 100 per cent of its trade. While in top countries Iran and UAE retains 58.3 per cent and 71.43 per cent respectively during 2001-2010, and Iraq, China and Yemen lost 100 per cent of its trade to other countries. Similarly, during 2011-2010 China retains 86.7 per cent of trade and Iran retains only 32 per cent, whereas Iraq, Yemen and Bangladesh lost 100 per cent of its rice exports from India. It is suggested from the study that India had the potential to diversify the rice exports to other nations and to gain the competitive advantage. Government should also focus on improving the processing facilities, transportation facilities and quality maintenance.

References:

- Angles, S., Sundar, A., & Chinnadurai, M. (2011). Impact of globalization on production and export of turmeric in India—An economic analysis. *Agricultural Economics Research Review*, 24(347-2016-16971), 301-308.
- Ashoka, N., Kuldeep, C., Ramachandra, V. A., & Yeledhalli, R. A. (2013). A study on growth, instability and direction of chilli trade in India. *Journal of Spices and Aromatic Crops*, 22(1).
- Beereraladinni, D., Loksha, H., & Deshmanya, J. B. (2016). Stability Analysis of India's Raw Cotton Exports. *Indian Journal of Economics and Development*, 12(4), 719-726.
- Bhagat, A. A., & Bhoge, B. S. R. (2022). Markov chain analysis on the export prospectus of Banana in India. *The Pharma innovation journal*,
- Chavan, S. D., Bansal, S., Mohapatra, S., Kaur, L., & Jadhav, A. (2023). Trade Directions of Indian Basmati Rice Export-Markov Chain Approach. *Economic Affairs*, 68(01), 541-547.
- Chetia, A., Chavan, R. V., & Bharati, S. V. (2022). Export profile and trade direction of fresh grapes from India: Markov chain approach. *The Pharma innovation journal*,
- Devi, I. B., Srikala, M., Ananda, T., & Subramanyam, V. (2016). Direction of trade and export competitiveness of chillies in India. *Agricultural Economics Research Review*, 29(2), 262-272.
- HC, Y., & Srivastava, S. K. (2020). An application of Markov chain Model to study on trade direction of export of FCV tobacco from India. *Scientific Agriculture*, 4, 73-77.

- Kusuma, D. K., & Basavaraja, H. (2014). Stability analysis of mango export markets of India: Markov Chain approach. *Karnataka Journal of agricultural sciences*, 27(1).
- Madhu, S., Kamani, D., & Mesara, H. A STUDY ON OF PRODUCTION AND EXPORT OF RICE FROM INDIA.
- Mahadevaiah, G. S., Ravi, P. C., & Chengappa, P. G. (2005). Stability analysis of raw cotton export markets of India–Markov chain approach. *Agricultural Economics Research Review*, 18(347-2016-16683), 253-259.
- Mehazabeen, A., & Srinivasan, G. (2020). Export performance of banana in India-A markov chain analysis. *Plant Archives*, 20(2), 3836-3838.
- Padmanaban, K., Mishra, P., Sahu, P. K., & Havaladar, Y. N. (2014). Export of cashew kernel from India: its direction and prediction. *Economic Affairs*, 59(4), 521.
- Pavithra, H. K., Gajanana, T. M., & Satishkumar, M. (2016). Production, changing pattern and trade directions of Indian exports in floriculture products. *Economics, Environment and Conservation journal*, 22, 47-53.
- Prabakar, C. (2020). Markov chain analysis on the export prospects of Coconut in India. *Plant Archives*, 20(2), 4202-4204.
- Singh, M. (2010). Projection of potato export from India: a markov chain approach. *Potato journal*, 37(1-2).
- Singh, O. P., Anoop, M., & Singh, P. K. (2023). Growth and direction of agricultural trade from India–An application of Markov Chain analysis. *Res. Jr. Agril Sci*, 14(1), 38-43.
- Srivastava, A. B., Singh, K. K., Supriya, S. K., Mishra, H., & Ahmad, R. (2023). Production and export dynamics of wheat in India. *Mathematics*, 8(3), 206-209.
- Zahid, M., Sharif, M. S., Ahmed, R., & Abbas, T. (2023). “Direction and Destination Pattern of Mango Export from Pakistan” A Markov Chain Approach. *Review of Education, Administration & Law*, 6(1), 75-82.