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Original Research Paper

Spatio-temporal dynamics of brinjal prices and arrivals: A case study of the terai region markets in West Bengal

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ABSTRACT

The study examined the trends and market dynamics for the prices and arrivals of brinjal (*Solanum melongena* L.) in the Terai region of West Bengal, employing robust and novel statistical methodologies to address challenges in agricultural market predictability. The research highlighted the impact of seasonality, perishability, and demand-supply imbalances on price volatility. Standardized Innovative Polygon Trend Analysis, a non-parametric approach previously unexplored in horticultural studies, provided a comprehensive analysis of the intricate cause-effect relationships between price and arrivals, capturing seasonal shifts, inter-period transitions, and non-monotonic trends overlooked by conventional methods. Increased arrivals during winter and spring caused price deflation, while summer and autumn saw reduced arrivals and corresponding price inflation. Monsoon uncertainties led to irregular arrival fluctuations and elevated prices. November and December exhibited significant price changes. In Alipurduar and Jalpaiguri, arrivals followed an increasing trend except in winter, whereas Cooch Behar and Toofanganj showed consistently declining arrivals. The study demonstrated that S-IPTA could unravel seasonal behaviors and offer practical insights for farmers and policymakers to regulate production and supply chains effectively. By bridging research gaps, this pioneering use of S-IPTA can serve as a robust tool for analyzing agricultural market trends and improving decision-making.

Keywords: Arrival, ITPA, Price, S-ITPA, Trend, Vegetable

INTRODUCTION

The price dynamics of agricultural commodities have always been a pressing issue concerning India's large agrarian economy with small and marginal farmers, that intervenes with market stability and frequent policy interventions. Vegetable prices, in particular, exert farmers' distress and inflationary pressure on consumers, as they directly impact the daily budgets of households in the country. Vegetable prices are volatile due to seasonality and perishability, limiting precise prediction (Paul et al., 2022). Under stable demand and competition, market price mainly depends on arrival volume (Sarkar et al., 2024).

Brinjal (*Solanum melongena* L.), is a major tropical vegetable in India, known as the 'King of Vegetables'. It contributes about six per cent of national vegetable production (Agricultural Statistics at a Glance, 2023) and ranks just after tomato, onion, and potato (TOP) in consumer preference. West Bengal leads brinjal output, accounting for nearly 24 per cent (3097.93 thousand metric tonnes) of India's total in 2024-25 (Department of Agriculture & Farmers Welfare, 2025). The brinjal production is reported as a fiscally profitable and employment-generating activity in the country (Mondal et al. 2019; Rayhan et al., 2021; Arun & Malaisamy, 2024). The Terai zone of the state encompasses productive soil and a favorable climate that foster farmers for its cultivation. However, major constraints faced by its farmers are price fluctuations, labor shortage, middlemen margins, industrial pollution, insufficient credit, crop insurance facilities, and transportation networks (Hiremath, 2021; Ghosh, 2021; Singh et al., 2023). The demand for fresh produce, variation in productivity during different seasons, pest and disease incidence during rainy season, hindered regular supplies due to weather vagaries, consumer willingness to spend more during festive period, means of transportation etc. influence the arrival patterns in the study area and in turn, its price volatility, making accurate price forecasting difficult. Owing to their significance in the global market, the trends and seasonality of price and arrivals of vegetables in different Indian markets were investigated over years (Paul et al., 2022; Thakur, 2022; Sarkar et al., 2024).

Hence, the economic profitability of short-duration crops like brinjal depends on price–arrival dynamics, especially during extreme shifts. Conventional parametric methods, including auto regressive integrated moving average (ARIMA) and its variants, are limited by assumptions of stationarity and linearity, while seasonal-trend decomposition using LOESS (STL) handles only single time series. For multivariate datasets like that of price-arrival across markets, a statistically robust non-parametric methodology should be deployed. This gap could be explored by improving the established non-parametric technique of innovative trend polygon analysis (ITPA) (San et al., 2021; Acar et al., 2022; Sunil et al. 2024) into its standardized version (S-ITPA) proposed by Alashan et al. (2024). However, S-ITPA remains unexplored in horticulture. This study applies S-ITPA for the first time to analyze brinjal price–arrival co-movement in West Bengal's Terai zone, providing market insights to guide farmers and consumers during crises.

MATERIALS AND METHODS

The innovative polygon trend analysis (IPTA) method is an advancement over the Innovative trend analysis (ITA) technique, which was introduced by Sen (2012). These innovative methods are specifically designed to identify seasonal trends within a complex and skewed time series data. This approach compares the sub-series derived from the parent data, facilitating a more comprehensive understanding of seasonal variations and trends within the data. Standardized IPTA (S-ITPA) enhances the ITPA by enabling a more effective visual comparison of multiple interrelated variables on a single graph, which allows a more explicit representation and better understanding of the relationships and interactive trends among the variables within the data. Moreover, seasonal transition lengths and slopes are independent of their scales and units for the desired variables.

The daily data on modal price and arrival of brinjal spanning January 2015 to December 2024 were sourced from the Directorate of Marketing and Inspection portal (https://agmarknet.gov.in/) for four selected wholesale markets of the Terai region, *viz*., Alipurduar, Cooch Behar, Jalpaiguri Sadar and Toofanganj. The selected markets are located in the areas with larger proportion of small and marginal farmers associated with vegetable production in Terai region. The markets of Alipurduar, Coochbehar and Toofanganj are also in close proximity and communication with larger markets of North-Eastern states (e.g., Guwahati, Assam) that order a higher demand for fresh vegetables. Jalpaiguri, meanwhile, is the gateway to hilly regions of Darjeeling and Sikkim, with which an impressive market channel and trade linkage exist.

The collected data were subjected to rigorous preprocessing for error correction. The dataset contained substantial missing values, particularly in 2020, owing to delayed reporting and interruptions in data collection during the COVID-19 pandemic. This gap of missing values was handled using the Kalman Filter imputation method using 'ImputeTS' package in R (Version 4.4.1). The method was based on dynamic linear modelling that accounted for the trend patterns. Once the imputation was done, the data were systematically converted into a desirable monthly timescale for both price and arrivals, market-wise, by aggregating them into monthly averages. The average price (arrival) of brinjal in a market was calculated as the arithmetic mean of daily price (arrival) values in the corresponding month.

By employing statistical standardization to the original time series, a new set of unitless datasets was obtained for the monthly averages of both price and arrivals. The ITPA methodology was implemented on the new standardized monthly data on brinjal price and arrivals.

The ten-year standardized monthly data (2015-2024) were divided into equal sub-series, with the first half (FH) ranging from 2015 to 2019 and the second, or recent half (SH) covering 2020-2024. A set of twelve parameters, based on the arithmetic mean of monthly data, was obtained respectively as the first half standardised average (FHSA) and the second half standardised average (SHSA). The trend polygons for price and arrivals were generated together on a single graph with the FHSA values of price and arrivals on the x-axis and the SHSA values of the variables on the y-axis. The reference zeroth points on the x-axis

(0, y) and y-axis (x, 0) corresponded to the FHSA and SHSA series, respectively, which provided a basis for comparing volatility within the divided dataset. The central reference point (0, 0) represented the long-term average of the variables over the entire time period. The benchmark diagonal line at 45° (a 1:1 no-trend line) in the S-IPTA plane split it into two symmetrical halves. The scatter points above this line signified an increasing trend, while those on the lower side indicated a downward trend.

Let $\hat{x}_i$ and $\hat{x}_{i+1}$ be FHSA of the price or arrival in the consecutive months and $\hat{y}_i$ and $\hat{y}_{i+1}$ be the SHSA of the variables in the consecutive months, respectively. Then the standardized seasonal trend length and slope can be calculated as:

$$S_{|AB|} = \sqrt{(\hat{x}_{i+1} - \hat{x}_i)^2 + (\hat{y}_{i+1} - \hat{y}_i)^2} \quad \text{and}$$

$$S_s = \frac{(\hat{y}_{i+1} - \hat{y}_i)}{(\hat{x}_{i+1} - \hat{x}_i)} \quad (1 \leq i \leq 12)$$

The S-IPTA approach facilitated the simultaneous evaluation of trends in interrelated price and arrivals by assessing their cause-effect relationships within different markets of the Terai region. These graphs could provide insightful perspectives on agricultural market research and seasonal dynamics. Data analysis and insightful visualizations of SITPA were performed using Microsoft Excel. A comprehensive methodology for S-ITPA has been provided (Alashan et al., 2024).

RESULTS AND DISCUSSION

The exploratory analysis of monthly arrivals and price for different markets was initially carried out to describe the conformity of the data to the parametric assumptions and their interrelationship. The maximum mean arrivals occurred from January to March, and the minimum mean arrivals coincided with monsoon season (June-September) in various markets (Table 1). The highest mean brinjal price value recorded was in October for all the markets while the lowest reported was in February for Alipurduar and Jalpaiguri and in March for Cooch Behar and Toofanganj (Table 2). The arrival records exhibited relatively higher skewness than the prices. There was an evident leap in the price data since 2020 owing to the impact of COVID pandemic. The results corroborated the high degree of pandemic impact on marketing agricultural produce in West Bengal (Impact assessment of COVID-19 on Indian agriculture and rural economy, 2020), due to disrupted weekly markets and access for farmers.

The seasonal indices (Table 3) revealed notable patterns in market activity, indicating that most markets experienced seasonality in arrivals from December to March, attributed to favorable harvest

Table 1 : Descriptive Statistics for brinjal arrivals (in Tonnes) in different markets

Market		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alipurduar	Mean	3.706	4.642	3.233	2.071	1.373	1.310	1.366	1.686	1.797	1.907	3.521	4.061
	Std. Dev.	4.849	5.906	4.441	2.937	1.502	1.803	1.688	1.880	2.359	1.967	3.773	4.717
	Skewness	1.505	1.455	2.032	2.136	2.209	2.585	2.520	1.817	1.925	1.318	0.825	1.323
	Minimum	0.280	0.264	0.322	0.411	0.364	0.323	0.294	0.343	0.274	0.318	0.232	0.292
	Maximum	13.715	16.936	14.192	9.365	5.233	6.122	5.871	6.143	7.270	5.662	9.274	13.999
Cooch Behar	Mean	1.787	1.647	1.692	1.005	0.944	0.832	0.673	0.701	0.734	0.785	1.169	1.767
	Std. Dev.	1.192	1.445	1.785	0.688	0.872	0.505	0.301	0.308	0.315	0.383	0.682	0.975
	Skewness	2.001	2.647	2.804	2.405	2.829	1.846	0.421	1.135	1.936	1.778	1.569	1.360
	Minimum	0.700	0.659	0.774	0.525	0.333	0.392	0.245	0.370	0.429	0.408	0.502	0.717
	Maximum	4.790	5.560	6.591	2.824	3.354	2.067	1.111	1.314	1.522	1.718	2.614	3.881
Jalpaiguri	Mean	2.646	2.908	3.187	3.042	2.829	2.698	2.099	2.175	1.724	1.802	2.166	2.876
	Std. Dev.	1.170	1.433	1.794	3.371	2.651	2.273	1.294	1.410	1.109	1.258	1.146	1.443
	Skewness	0.058	1.669	2.233	2.845	2.548	1.924	0.962	0.521	0.912	0.978	-0.020	-0.486
	Minimum	1.081	1.191	1.082	0.939	0.970	0.833	0.759	0.500	0.587	0.627	0.597	0.621
	Maximum	4.322	6.393	7.883	12.367	9.952	8.331	4.613	4.559	3.490	4.030	3.566	4.517
Toofanganj	Mean	5.115	4.587	3.068	1.843	1.658	1.338	1.240	1.280	1.269	1.473	1.841	3.478
	Std. Dev.	4.586	3.628	2.470	1.224	1.135	0.916	0.863	0.899	0.903	1.208	1.078	3.344
	Skewness	1.069	0.407	0.943	0.197	0.438	0.852	0.870	1.359	1.091	1.435	0.124	2.248
	Minimum	0.700	0.688	0.693	0.511	0.542	0.454	0.280	0.291	0.301	0.371	0.466	0.983
	Maximum	14.596	10.776	8.097	3.509	3.494	2.817	2.817	3.312	3.187	4.233	3.229	12.168

Table 2 : Descriptive Statistics for brinjal price (in Rs./Quintal) in different markets

Market		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alipurduar	Mean	1272.356	1131.714	1308.994	1910.052	2359.452	2451.953	2911.445	2476.902	2960.277	3609.745	2243.390	1529.627
	Std. Dev.	421.335	485.870	318.295	460.748	783.036	715.858	698.242	620.445	593.459	1005.421	627.501	534.475
	Skewness	-0.052	0.438	0.732	0.561	0.822	1.757	-0.395	-0.544	-1.198	-0.064	-0.268	0.097
	Minimum	730.348	582.525	946.347	1290.700	1367.984	1721.733	1769.000	1467.871	1632.267	2128.194	1318.600	715.113
	Maximum	1826.274	1856.036	1881.097	2769.833	3795.226	4170.700	3812.903	3162.323	3647.533	4856.645	3109.200	2431.677
Cooch Behar	Mean	1104.189	1137.517	985.308	1487.272	2012.256	2137.093	2702.902	2526.993	2810.414	3301.163	2460.575	1439.080
	Std.Dev.	478.126	533.048	315.046	540.102	757.116	623.326	803.730	800.380	635.499	926.234	951.915	552.633
	Skewness	0.759	0.431	1.461	2.890	1.719	1.405	0.399	0.881	0.390	0.815	-0.050	0.786
	Minimum	549.177	574.107	701.774	1115.068	1273.410	1493.367	1713.355	1373.032	2043.383	2271.048	1215.083	778.661
	Maximum	1991.355	1894.552	1678.661	2988.000	3838.452	3298.150	3992.839	4195.290	3796.367	5174.065	3743.000	2568.532
Jalpaiguri	Mean	1229.024	1156.211	1185.524	1366.755	1841.236	2000.165	2534.225	2196.658	2377.951	3342.618	2684.832	1465.636
	Std. Dev.	352.168	440.814	387.496	431.786	636.591	651.103	769.894	519.971	706.043	951.154	912.608	484.214
	Skewness	-0.194	1.317	0.761	1.556	1.403	1.222	0.598	0.758	0.373	-0.483	0.452	0.273
	Minimum	683.936	655.500	774.807	1009.627	1265.669	1396.267	1638.226	1735.355	1457.933	1690.532	1451.700	716.597
	Maximum	1729.290	2140.643	1904.839	2350.000	3015.968	3281.900	3897.581	3161.516	3500.267	4477.694	4370.000	2264.823
Toofanganj	Mean	1048.116	1011.844	891.081	1244.964	1923.103	2170.476	2754.181	2730.858	2921.610	3357.598	2458.590	1396.131
	Std. Dev.	441.513	438.346	290.414	494.749	1098.023	718.092	881.190	673.686	607.730	974.227	747.960	465.815
	Skewness	0.808	0.539	1.162	0.395	1.628	0.444	-0.640	-1.030	0.428	1.011	0.583	-0.743
	Minimum	558.139	475.000	500.000	543.267	981.452	1259.883	1365.436	1242.613	2118.867	2125.226	1415.200	711.710
	Maximum	1863.968	1705.232	1525.710	2031.950	4210.323	3364.060	3964.161	3697.903	3890.350	5188.726	3857.733	1885.097

and transportation conditions. In the Jalpaiguri market, arrival seasonality extended until June, probably due to the region's summer brinjal harvest causing a significant influx of produce. This highlighted how local agricultural practices and crop growing cycles shape seasonal trends in market dynamics. The price seasonality observed from June to November stemmed from reduced supply due to off-season production and challenges like monsoons impacting harvests. Moreover, demand fluctuations during these months, possibly linked to festivals, could also have contributed to price variations.

Table 3 : Seasonal indices for brinjal price and arrival

Month	Arrival				Price			
	Alipurduar	Cooch Behar	Jalpaiguri	Toofanganj	Alipurduar	Cooch Behar	Jalpaiguri	Toofanganj
January	1.33	1.48	1.11	1.77	0.58	0.56	0.65	0.52
February	1.65	1.24	1.18	1.69	0.51	0.56	0.58	0.49
March	1.32	1.18	1.28	1.2	0.59	0.49	0.6	0.45
April	0.94	0.84	1.11	0.81	0.88	0.74	0.7	0.63
May	0.67	0.71	1.09	0.77	1.11	1.02	0.95	0.95
June	0.65	0.74	1.03	0.64	1.09	1.07	1.03	1.05
Jully	0.63	0.64	0.88	0.59	1.33	1.33	1.29	1.36
August	0.8	0.67	0.85	0.6	1.17	1.25	1.15	1.39
September	0.79	0.76	0.67	0.58	1.45	1.48	1.24	1.54
October	0.79	0.8	0.67	0.66	1.64	1.67	1.7	1.7
November	1.14	1.14	0.87	0.96	1.01	1.17	1.4	1.27
December	1.29	1.8	1.25	1.74	0.64	0.65	0.73	0.68

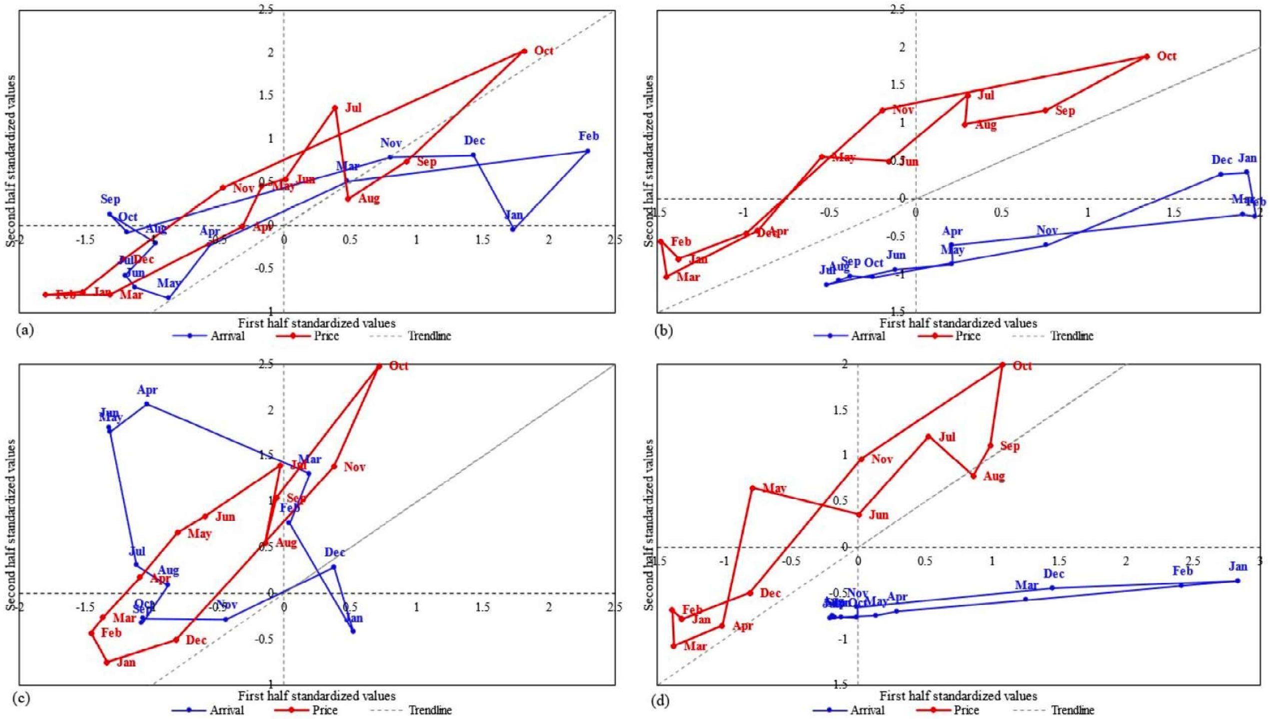

Fig. 1 : Brinjal price-arrival S-ITPA graphs for a) Alipurduar market, b) Coochbehar market, c) Jalpaiguri market, d) Toofanganj market

Tables 4 and 5, along with Fig. 1, present the results of S-ITPA for brinjal prices and arrivals in different markets, along with their corresponding characteristics. In the Alipurduar market, brinjal arrivals observed the highest significant decreasing trend during the December- January transition period. Though the brinjal quantity that arrived remained high above the average during these winter months, the negative trend continued until February. The seasonal slope values (Table 4) corroborated the same result. The shift was smooth from decreasing to having no trend in March during spring, and the trend transitioned to positive thereafter. However, no noticeable trends were established for quantity arrivals in May and November. The arrival was relatively lower during the rainy season but tended to increase over the years. The most prominent upward trend occurred in September. Meanwhile, the positive arrival trend during August was reflected in the decreasing price trend during the month. The market price transitioned significantly from the highest increasing brinjal price trend in July to the lowest negative trend in August and September, followed by the slight inflating trend in October (Table 5). The maximum price value was reported in October. The ample supply of brinjal during winter reduced its price below average during the season.

Table 4 : Seasonal transition trend characteristics for brinjal arrival

Market		Jan-Feb	Feb-Mar	Mar-Apr	Apr-May	May-Jun	Jun-Jul	Jul-Aug	Aug-Sep	Sep-Oct	Oct-Nov	Nov-Dec	Dec-Jan
Alipurduar	Slope	1.600	0.191	0.709	1.988	-0.483	-1.991	1.595	-0.960	-1.560	0.433	0.039	-2.846
	Length	1.065*	1.851*	1.277	0.686*	0.284	0.160*	0.436*	0.483*	0.244*	2.168*	0.628	0.905*
CoochBehar	Slope	-12.273	-0.374	0.243	-145.180	0.208	0.513	0.846	0.882	-0.124	0.426	0.919	0.180
	Length	0.579*	0.078*	1.738*	0.253*	0.336*	0.448*	0.088*	0.089*	0.134*	1.095*	1.375*	0.155*
Jalpaiguri	Slope	-2.458	3.546	-0.621	1.093	-4.029	-7.163	-0.918	2.110	5.232	-0.023	0.705	-4.856
	Length	1.284*	0.559*	1.442*	0.410*	0.049*	1.518*	0.321*	0.461*	0.057*	0.626*	0.995*	0.726
Toofanganj	Slope	0.128	0.130	0.135	0.270	0.069	0.138	1.386	-1.002	-0.017	149.632	0.140	0.058
	Length	0.420*	1.173*	0.975*	0.161*	0.261*	0.082*	0.035*	0.024*	0.162*	0.112*	1.477*	1.382*

* significant at 1%

Table 5: Seasonal transition trend characteristics for brinjal price

Market		Jan-Feb	Feb-Mar	Mar-Apr	Apr-May	May-Jun	Jun-Jul	Jul-Aug	Aug-Sep	Sep-Oct	Oct-Nov	Nov-Dec	Dec-Jan
Alipurduar	Slope	0.123	0.009	0.790	3.197	0.427	2.223	-10.695	0.970	1.448	0.696	1.105	1.229
	Length	0.282*	0.485*	1.276*	0.490*	0.195*	0.911*	1.061*	0.618*	1.557*	2.770*	1.123*	0.486*
CoochBehar	Slope	-2.266	-13.661	1.163	2.595	-0.148	1.920	25.139	0.398	1.211	0.461	2.067	0.866
	Length	0.259*	0.472*	0.809*	1.039*	0.393*	0.990*	0.387*	0.503*	0.925*	1.690*	1.813*	0.520*
Jalpaiguri	Slope	-2.671	1.941	1.568	1.706	0.846	0.986	7.544	5.737	1.855	3.224	1.581	0.471
	Length	0.339*	0.193*	0.521*	0.564*	0.275*	0.792*	0.854*	0.502*	1.628*	1.147*	2.235*	0.576*
Toofanganj	Slope	-1.345	-31.465	0.613	6.676	-0.365	1.633	-1.296	2.583	9.510	0.974	1.752	0.563
	Length	0.122*	0.395*	0.425*	1.522*	0.846*	0.999*	0.543*	0.351	0.885*	1.471*	1.678*	0.584*

* significant at 1%

The price and arrival trends were contrasting over time in Cooch Behar market. The prices soared gradually, and the arrivals declined in the long run. The November-December transition was crucial for brinjal prices in the market, as it marked a significant change from a higher to a lower rate. The arrival quantity was higher during the late winter and spring months of December to March, and resultantly, the price values were below the average from December to April in both halves. The pricing improved in May but remained uneven in the rainy season with highs and lows. However, it steadily increased to reach a maximum rate in October. The most significant hike in brinjal arrival was reported during the October-December transition, and it declined significantly during March-April.

The S-ITPA graph for brinjal price-arrivals in the Jalpaiguri market demarcated an apparent inflating trend for price. The seasonal pattern of increase and decrease in price was similar to the other markets where brinjal was cheap during the winter and spring seasons (December- March) and costly during the autumn (October- November). The brinjal price was lowest in January and highest in October. The price was significantly marked down to below average during November and December (Table 5), and a parallel increase was observed from February to May. The prices fluctuated during the rainy season and dropped noticeably in August. The arrivals showed an increasing trend over time, except in January, which had a declining trend. There was no trend detected during December. However, the arrival quantity of brinjal was exceptionally higher from April to June during the second half period (2020-2024), and its drop from June to July was also prominent (Table 4). The lowest arrival was recorded during September-November, which correspondingly upshot an increased price of the commodity.

The resultant price-arrival polygon patterns for Toofanganj market resembled much alike Cooch Behar market with price lying in increasing trend zone and arrivals in decreasing trend zone of the graph (Fig. 1d). No significant price trend was observed in August. The critical transition concerning brinjal happened in October- December when the price plummeted sharply and arrivals elevated. The price was lower during the winter and spring seasons (December-March), while the arrival quantity remained high during these periods. During June and November, the price maintained its second-half average value (2020-2024). The magnitude of the rate of change in arrivals did not vary significantly during the monsoon and autumn seasons, oscillating in and above the second-half arrival average. Fig. 2 displays a summarized result of the market-wise trend analysis conducted using S-ITPA and month charts.

A similar inverse relationship between price and market arrivals of brinjal during its peak period was observed in wholesale markets of Assam (Tamilselvi et al., 2021). This inference could be substantiated by the study conducted on solanaceous vegetables (Mishra & Kumar, 2012). The post-harvest prices were low due to abundant arrival, whereas, during the lean period, when the magnitude of arrival was constricted, the prices stood high. The seasonality, perishable nature, and limited role of storage amenities contributed to the price rise. Meanwhile, the increased arrival volume could also be ascribed to the improved production and newly introduced high-yielding varieties (Kundu et al., 2019). The mixed pattern of brinjal arrival series and the drop during May-October were also signified in the study.

The November-December transition was crucial for all the selected Terai markets. The onset of winter season in these regions typically coincides with October-

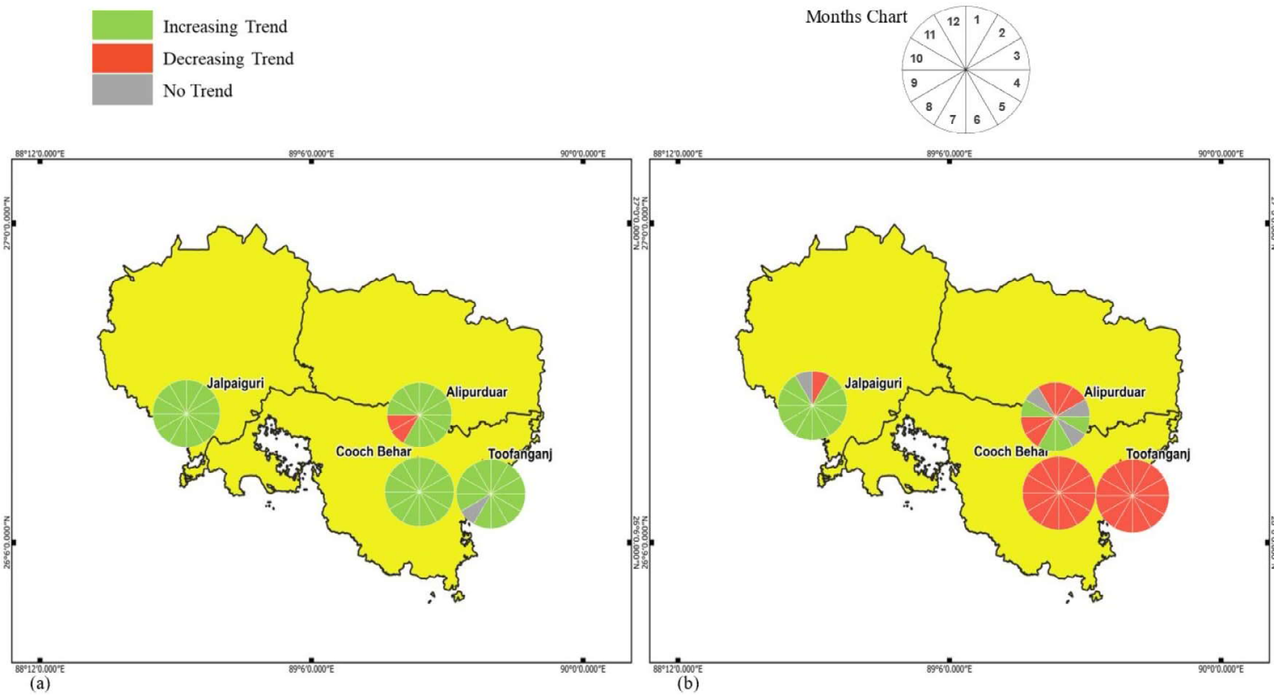

Fig. 2: Summarized results of S-ITPA and months chart of brinjal (a) price and (b) arrivals in Terai region

November, with the arrival of winter-season brinjal starting with the end of October. The supply serves as an alternative choice of fresh produce during the period, gradually replacing the demand for rainy-season brinjal. This increased supply of fresh winter brinjal reduces its price in the markets significantly during the season.

Several postharvest supply chain interventions are recommended to mitigate price volatility and optimize market arrivals of brinjal. Developing decentralized, low-cost, and scalable storage solutions such as zero-energy cool chambers and evaporative coolers can help preserve surplus produce during peak seasons and release it strategically during lean periods. Promoting time-optimized harvesting through staggered planting aligned with market demand forecasts can prevent seasonal gluts, particularly in winter and spring. Strengthening aggregation systems by establishing farmer producer organizations (FPOs) and equipping them with reliable cold chain logistics is essential to minimize spoilage during monsoon and humid conditions. Incorporating market intelligence and early warning systems based on real-time S-IPTA data can empower farmers and traders to make informed decisions and avoid distress sales. Further, promoting small-scale value addition units for drying, pickling, or pureeing can absorb excess supply during peak arrival months, reducing wastage. Lastly, targeted policy support through subsidies or minimum price mechanisms during high-arrival periods especially in markets like Alipurduar and Jalpaiguri can stabilize farmer incomes and ensure market equilibrium. Integrating these strategies with seasonal insights from S-IPTA will enhance the resilience and efficiency of the brinjal supply chain, reducing postharvest losses while ensuring fair pricing for both producers and consumers.

CONCLUSION

The S-IPTA method juxtaposed the trend patterns of price and arrivals in a single graph to comprehensively study their spatio-temporal dynamics within a market. Relevant comparisons were generated using graphs that integrated the behaviour of both variables across different months. The overall assessment over different markets implies that the increased arrival of the brinjal in winter and spring caused a deflation of its price during the same period. There was a conspicuous decrease in arrival from winter to next autumn, resulting in a parallel reverse trend for price in all markets. Irregular ups and downs were common in arrival in late summer and monsoon seasons, which impacted its price. The uncertainties in the monsoon instigated vagaries in supply, which in turn raised the price in the markets. The price of brinjal almost stood in an inflationary environment in the recent period, with very few exceptions in certain markets. In Alipurduar and Jalpaiguri markets, the brinjal arrivals in months except that of winter concentrated in increasing trend region whereas in Cooch Behar and Toofanganj, arrival entirely followed negative trend. The perusal of analysis implicated that the significant events determining price transition happened during November-December in most markets.

Evidently, the employment of the Standardized ITPA has offered a realistic understanding of the crucial time period inclined to price-arrival and the causal pattern of arrivals on the price of brinjal on a long-term basis. The seasonal behavior of both variables is also vividly elucidated in market terms. SITPA can thus be effectively used to forecast the price behaviour based on the consistent trends projected by the methodology. Such information can aid farmers, market beneficiaries, and policy developers in regulating production, supply chains, and market economics, as well as attenuating the risks and losses associated with lean and peak production periods and prioritizing interventions. Promoting region-specific cultivars and strengthening local seed systems can help align production with market needs and reduce supply-demand mismatches.

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