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RESEARCH PAPER

Export competitiveness and trade dynamics of indian maize: A Markov chain and comparative advantage analysis

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Abstract Indian maize exports have grown, particularly in Southeast Asia, necessitating an assessment of their competitiveness and trade dynamics. This study analyzes export performance using UN COMTRADE data (2012–2023). Markov chain analysis was employed to examine the trade direction and market stability of major importing countries, including Vietnam, Bangladesh, and Nepal. The findings reveal that Malaysia exhibited the highest retention probability (78 per cent), while Oman had zero retention, indicating an unstable trade pattern. Projections up to 2028 suggest that Vietnam and Bangladesh will remain the dominant markets, though their shares are expected to decline slightly. Further, export competitiveness was assessed using the Revealed Comparative Advantage (RCA), Revealed Symmetric Comparative Advantage (RSCA), and Vollrath's Revealed Competitiveness (RC) indices. The RCA values indicate that India's maize export advantage fluctuated over the years, showing strong performance until 2014 but declining thereafter. The study highlights the need for strategic policy interventions to enhance India's maize export competitiveness, ensuring sustainable trade growth in the global market.

Keywords: Maize • Direction of trade • Export competitiveness • Markov chain analysis

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Introduction

Maize or corn (*Zea mays* L.) is cultivated globally and is one of the most important cereal crops worldwide. It is known as the 'queen of cereals' because of its highest genetic yield potential among cereals. Every part of the maize plant, i.e., grain, leaves, stalk, tassel, and cob have economic value and is used in a variety of food and non-food products. It is the most versatile crop and is grown in more than 166 countries across the globe. At the global level, maize was cultivated on nearly 205 million hectares with an estimated production of 1,163 million tonnes in 2022-23. The USA continues to be the largest producer of maize with a 31.3 per cent share in global production, followed by China (22.9 per cent), Brazil (8.8 per cent), the EU (5.9 per cent), and Argentina (4.5 per cent). India ranks seventh in global maize production, contributing a modest 2.7 per cent (FAO, 2023).

In India, maize was cultivated on approximately 112.41 lakh hectares during 2023-24, marking an increase of about 5 per cent from the previous year. Over 78.8 per cent of the maize crop (85.79 lakh hectares) was grown during the kharif season, while 23.08 lakh hectares were cultivated during rabi. Compared to the previous year, the kharif maize area expanded by 3.8 per cent, while the rabi maize area grew by 2.1 per cent. The trends in area, production, and productivity of maize in India over the last decade are depicted in Figure 1.

India ranks among the top ten maize producers, with Southeast Asia being the largest market for Indian maize, mainly exported to Indonesia, Malaysia, and Vietnam (Upreti, 2020). Given the rising demand for maize in India and Southeast Asia, it is essential to focus on boosting production and enhancing exports. This requires a thorough analysis of export competitiveness and the

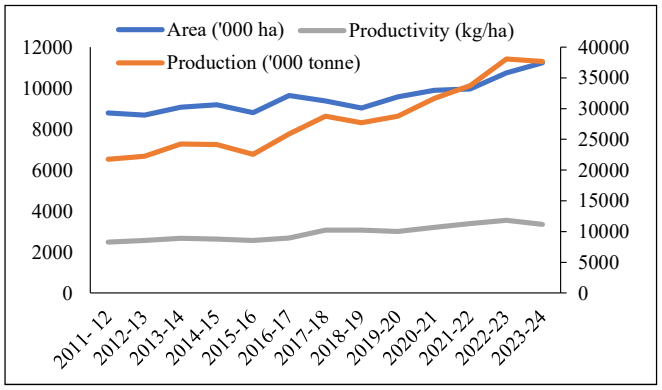

Figure 1. Trends in area, production, and productivity of maize in India (2011-12 to 2022-23)

direction of maize exports from India, along with future export projections. Understanding the performance of India's maize exports and its competitiveness in the global market is essential for devising strategic policies that enhance trade efficiency. By examining both historical data and projected trends, this research contributes to a better understanding of India's role in the international maize market and its potential for sustained export growth.

Materials and methods

Data from UN COMTRADE was utilized to analyze maize export performance (2012–2023). Markov chain analysis assessed trade direction, while export competitiveness was examined using Revealed Comparative Advantage, Revealed Symmetric Comparative Advantage and Vollrath Revealed Competitiveness.

Markov chain analysis

Markov chain analysis is primarily based on estimating the transitional probability matrix P. The element P_{ij} of this matrix indicates the probability that exports will switch from country *i* to country *j* with time. The diagonal element P_{ii} measures the probability that the export share of a country will be retained. Hence, examination of diagonal element indicates the loyalty of an importing country to a particular country's exports. In the context of the current application, the average exports to a particular country were considered to be a random variable which depended only on its past exports to that country and which can be denoted as

$$E_{jt} = \sum_{i=1}^{r} (E_{it-1})(P_{ij} + e_{jt})$$

Where, E_{jt}= Exports from India to the jth country during the year t,

E_{jt-1}= Exports to the ith country during the year t-1,

e_{jt}= The error-term which is statistically independent of E_{jt-1}, and

r = Number of importing countries.

The transitional probabilities P_{jt}, which can be arranged in a (c×r) matrix, have the following properties

$$O < P_{jt}, < 1$$

$$\sum_{i=1}^{r} P_{ij}, = 1 \; for \; all \; i$$

Thus, the expected export shares of each country during period t were obtained by multiplying the exports to these countries in the previous period (t-1) with the transition probability matrix. The transition probability matrix was estimated in the linear programming (LP) framework by the method referred to as Minimization of Mean Absolute Deviation (MAD), the LP formulation is stated as:

Min O'P* + Ie

Subject to, XP* + V = Y

GP* = 1

P* > 0

where, P* is a vector of the probabilities P_{ij}, O is a vector of zeros, I is an appropriately dimensional vector of areas, e is the vector of absolute errors (|U|), Y is the vector of exports to each country, X is a block diagonal matrix of lagged values of Y, V is the vector of errors, and G is a grouping matrix to add the row elements of P arranged in P*, to unity. Analysis was done by using LINGO software.

Revealed comparative advantage index

The Revealed Comparative Advantage (RCA) index was first introduced by Bela Balassa (1965) defined as a country's share of world exports of a commodity divided by its share of total world exports. It uses a relative share of the individual country to examine whether the country has a comparative advantage or disadvantage over the rival countries.

$$RCAij = (X_{ij}/X_{ik}) / (X_{nj}/X_{nk})$$

Where,

X_{ij} = Exports of country 'I' of commodity 'j'

X_{ik} = Exports of country 'I' of a total agricultural commodity's 'k'
X_{nj} = Exports of a world 'n' of commodity 'j', and
X_{nk} = Exports of a world 'n' of a total agricultural commodity's 'k'

The calculated value of the index lies between zero to infinity. If the value of the index is greater than one, then it shows that the country has revealed a comparative advantage in maize, and a value less than one indicates the country's comparative disadvantage.

However, RCA suffers from the problem of asymmetry as pure RCA is not comparable on both sides of unity. The index is made symmetric, following the methodology suggested by Dalum, Laursen and Villumsen (1998), Widodo (2009), and Laursen (2015) called Revealed Symmetric Comparative Advantage (RSCA). The modified formula is

$$\text{RSCA}=\frac{RCA-1}{RCA+1}$$

The value of RSCA ranges between -1 to +1 and is free from the problem of skewness. A commodity is said to have a comparative advantage in its exports if the corresponding RSCA value is positive and a disadvantage if the corresponding RSCA value is negative (Shinoj and Mathur, 2008).

Revealed competitiveness advantage (RC)

The Revealed Competitiveness (RC) index, developed by Vollrath (1991), assesses trade and supply balance using export values. It helps differentiate specific commodities from overall trade and compares competitiveness across countries. Unlike other measures, it incorporates both exports (X) and imports (M) for a comprehensive evaluation. It is expressed as:

$$\text{RC}= (X_{ij}/X_{ik})/ (X_{nj}/X_{nk}) – (M_{ij}/M_{ik})/M_{nj}/M_{nk}$$

Where,
M_{ij} = imports of country 'I' of commodity 'j'
M_{ik} = imports of country 'I' of a total agricultural commodity's 'k'
M_{nj} = imports of a world 'n' of commodity 'j', and
M_{nk} = imports of a world "n' of a total agricultural commodity's 'k'

The values of index must be either positive or negative. If the values depict positive, the commodity of the country is competitive and if the index value is negative means it will not competitive internationally in that commodity trade. Therefore, value of RC is a perfect measure to show the balances in supply and demand as well as competitiveness and edges in comparative advantages (Singh, 2020).

Results and discussion

The top 10 maize-importing countries from India in 2023 in terms of both value and quantity exported is given in Table 1. Vietnam is the largest importer, accounting for 48.25 per cent of the total export value and 50.54 per cent of the quantity. Bangladesh and Nepal follow, with 24.36 per cent and 14.47 per cent of the value share, respectively. Malaysia and Thailand contribute smaller shares, while Oman, Myanmar, Sri Lanka, and the UAE have minimal trade volumes. The "Rest of the World" (ROW) category represents 4.06 per cent of the value and 3.24 per cent of the quantity. Total maize exports from India amount to USD 703,050 thousand and 2.31 million MT.

Trade direction of maize export from India-Markov chain analysis

The trade direction of Indian maize exports was analyzed using a Markov chain model as shown in Table 2, estimating the transitional probability matrix (TPM) for six major importers: Vietnam, Bangladesh, Nepal, Malaysia, Thailand, and Oman, with all other destinations grouped under "Others." The TPM provides insights into market stability, where diagonal elements indicate trade retention, row elements reflect the market loss to competitors, and column elements represent market gain from competing countries.

The analysis revealed that Malaysia was the most stable importer, retaining 78 per cent of its maize imports from India. Conversely, Oman exhibited zero retention, indicating an unstable trade pattern. Malaysia lost 4 per cent of its share to Oman and 17.2 per cent to others, while gaining marginally from Vietnam (0.1 per cent) and others (1.7 per cent). Nepal lost 38.8 per cent of its share to Bangladesh but gained 100 per cent from Oman and 16.2 per cent from others. Vietnam lost significant shares to Bangladesh (34.9 per cent), Thailand (2.9 per cent), and others (8.5 per cent) but gained 52.6 per cent from Bangladesh and 67 per cent from Thailand.

Table 1. Top ten countries importing maize from India (2023)

Importer	Value ('000 USD$)	% share in value	Quantity (MT)	% share in quantity
Vietnam	3,39,197	48.25	11,68,359	50.54
Bangladesh	1,71,272	24.36	5,40,537	23.38
Nepal	1,01,760	14.47	3,69,058	15.97
Malaysia	30,749	4.37	1,03,247	4.47
Thailand	9,983	1.42	5,809	0.25
Oman	5,693	0.81	17,383	0.75
Myanmar	5,273	0.75	3,130	0.14
Sri Lanka	4,513	0.64	15,060	0.65
UAE	3,975	0.57	12,973	0.56
Ecuador	2,111	0.30	1,234	0.05
ROW	28,524	4.06	74,850	3.24
World	7,03,050	100	23,11,640	100

Source: www.intracen.org; ROW- rest of the world

Table 2. Transitional probability matrix of Indian maize export, from 2012 to 2023

Country	Vietnam	Bangladesh	Nepal	Malaysia	Thailand	Oman	Others
Vietnam	**0.535**	0.349	0.000	0.001	0.029	0.000	0.085
Bangladesh	0.526	**0.349**	0.116	0.000	0.000	0.008	0.000
Nepal	0.000	0.388	**0.608**	0.000	0.003	0.000	0.000
Malaysia	0.000	0.000	0.000	**0.788**	0.000	0.040	0.172
Thailand	0.670	0.000	0.000	0.000	**0.330**	0.000	0.000
Oman	0.000	0.000	1.000	0.000	0.000	**0.000**	0.000
Others	0.000	0.000	0.162	0.017	0.000	0.018	**0.802**

Bangladesh, in turn, lost 52 per cent of its share to Vietnam, 11.6 per cent to Nepal, and 0.8 per cent to Oman, while gaining 34.9 per cent from Vietnam and 38.8 per cent from Nepal. Thailand lost 67 per cent of its share to Vietnam, gaining only 2.9 per cent from Vietnam and 0.3 per cent from Nepal. The findings suggest that Malaysia, Nepal, Vietnam, Bangladesh, Thailand, and the "Others" category will likely remain stable importers, whereas Oman is expected to remain an unstable market for Indian maize exports.

Projection of Indian maize exports to major importing countries

With the help of the transitional probability matrix, market share proportions of Indian maize exports to major importing countries were estimated up to the year 2024 to 2028 in Table 3. It was projected that during 2024, the major market for Indian maize would be Vietnam with 38.76 per cent. The projected exports to Vietnam exhibited a decreasing trend in both absolute value and percentage to total export. Bangladesh followed the same scenario, that is, the projected exports showed a decreased trend from 29.86 to 28.65 per cent respectively during 2024 to 2024. With regard to Malaysia, projected export values showed a decreasing trend from 3.07 to 2.03 per cent percent during the estimated period. Similarly projected export share of Indian maize to Thailand also decreased from 1.86 to 1.69 per cent. The projected export share of Nepal increased from 13.89 to 15.79 per cent from 2024 to 2028.

Actual and estimated shares of Indian maize export to importing countries

The actual and estimated shares of maize exported from India to different countries (in percentage term) were shown in Table 4. A comparison of this proportion during the study period revealed that the observed proportions of export shares were inconsistent with the estimated

Table 3. Projected exports of Indian maize to major importing countries: 2024 to 2028 ('000 USD)

Year	Vietnam	Bangladesh	Nepal	Malaysia	Thailand	Oman	Others
2024	272364.67 (38.76)	209803.31 (29.86)	97574.44 (13.89)	21604.42 (3.07)	13082.08 (1.86)	4109.93 (0.58)	84085.15 (11.97)
2025	264746.21 (37.68)	206238.62 (29.35)	101494.86 (14.45)	18832.19 (2.68)	12726.02 (1.81)	4149.10 (0.59)	94437.00 (13.44)
2026	258559.54 (36.80)	203856.27 (29.01)	105182.06 (14.97)	16818.45 (2.39)	12397.04 (1.76)	4194.85 (0.60)	101615.79 (14.46)
2027	253778.48 (36.12)	202295.97 (28.79)	108357.02 (15.42)	15348.90 (2.18)	12118.62 (1.72)	4223.70 (0.60)	106501.30 (15.16)
2028	250215.21 (35.61)	201314.54 (28.65)	110927.33 (15.79)	14270.01 (2.03)	11896.67 (1.69)	4239.89 (0.60)	109760.34 (15.62)

Figures in parentheses indicate percentage to total export from India

shares of export, which were derived from the Markov chain process. This could be due to limitation of the model that the present estimates depend only on the previous year observations and the exports also depend on sudden policy changes, leading to abrupt increase or decrease in exports to a country.

The actual share of Vietnam, Bangladesh, and Malaysia, maize exports showed fluctuations over the study period (2012 to 2023). A similar picture was in the prediction of export share too, where the increase was from 26.79 to 48.28 per cent in terms of actual share and from 17.03 to 39.59 per cent in terms of predicted share. With regard to Bangladesh, the actual and estimated export share showed fluctuations from 4.93 to 24.38 and 11.77 to 30.98 per cent, respectively. The actual proportion of Malaysia share of imports from India showed decreasing trend from 20.97 to 4.38 per cent. The estimated export share also decreased from 17.33 to 3.62 percent. With respect to others, the actual proportion of exports also showed a decreasing trend from 44.56 to 6.30 per cent. The actual and estimated exports to Bangladesh, Vietnam, Nepal and Thailand, increased both in absolute as well as in relative percentage to the total exports from India during the same period.

Export competitiveness

Revealed comparative advantage index (RCA)

The RCA is derived from the export of maize from India during the period 2012 to 2023. A perusal of Table 5 reveals that India has a comparative advantage in maize export for the year 2012 to 2014. Similar result for RCA values for maize exports also found by Geetha and Srivastava during 2007 to 2014. India was not much efficient in maize exports during the year from 2015 to 2023 as RCA indices were not of higher value and were is less than 1. The results of RCA index were supported by the values of the RSCA measure. The RSCA index value had values approaching negative except for the year 2012 to 2014.

Revealed competitiveness advantage

The Revealed Competitiveness Advantage (RC) ratio was calculated for both imports and exports of Indian maize in terms of value. The RSCA and RC indices were used to validate the RCA results and assess whether India holds a comparative advantage in the international maize market (Manasi, 2021). Table 6 shows that India had a competitive advantage in maize production and trade, as indicated by RC values greater than unity during the period from 2012 to 2014. RC indices were found to be ranging from 0.06 to 1.21 during the study period. This positive RC value indicates that India's share of maize exports in the agricultural export basket, relative to the world's maize exports in the global agricultural export basket, is larger than India's share of maize imports in the global maize import trade within the total agricultural imports.

Conclusion

The study highlights the dynamic nature of India's maize exports, with major markets concentrated in Southeast Asia and South Asia. Vietnam, Bangladesh, and Nepal emerge as the most significant importers, while Malaysia, Thailand, and Oman display fluctuating retention rates. Markov chain analysis reveals that Malaysia is the most

Table 4. Actual and Estimated Shares of Indian Maize Export to Importing Countries ('000 USD $)

	Vietnam		Bangladesh		Nepal		Malaysia		Thailand		Oman		Others	
Year	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted
2012	303434	192825	55863	133319	20135	109717	237523	196237	1824	9611	9132	19034	504648	471814
	(26.79)	(17.03)	(4.93)	(11.77)	(1.78)	(9.69)	(20.97)	(17.33)	(0.16)	(0.85)	(0.81)	(1.68)	(44.56)	(41.66)
2013	273962	216224	128247	160822	52450	141723	266218	219141	3426	9405	9869	21145	524356	490064
	(21.77)	(17.18)	(10.19)	(12.78)	(4.17)	(11.26)	(21.15)	(17.41)	(0.27)	(0.75)	(0.78)	(1.68)	(41.66)	(38.94)
2014	144332	135779	107435	107916	51533	118553	146340	121932	3132	5487	14155	13470	373423	337210
	(17.18)	(16.16)	(12.78)	(12.84)	(6.13)	(14.11)	(17.41)	(14.51)	(0.37)	(0.65)	(1.68)	(1.60)	(44.44)	(40.13)
2015	14797	38467	57953	43752	47291	50467	17722	15173	100	648	3793	2437	68894	59603
	(7.03)	(18.27)	(27.52)	(20.78)	(22.46)	(23.97)	(8.42)	(7.21)	(0.05)	(0.31)	(1.80)	(1.16)	(32.72)	(28.31)
2016	741	10308	18360	37380	79083	56610	2854	2764	378	426	1566	803	29702	24390
	(0.56)	(7.77)	(13.84)	(28.17)	(59.60)	(42.67)	(2.15)	(2.08)	(0.28)	(0.32)	(1.18)	(0.61)	(22.39)	(18.38)
2017	899	7384	12787	39087	88342	64806	2882	3157	264	424	1316	1142	51062	41548
	(0.57)	(4.69)	(8.12)	(24.81)	(56.07)	(41.13)	(1.83)	(2.00)	(0.17)	(0.27)	(0.84)	(0.73)	(32.41)	(26.37)
2018	21120	45002	63186	66257	94844	77541	6347	6186	700	1198	1679	1990	66812	56510
	(8.29)	(17.67)	(24.81)	(26.02)	(37.24)	(30.45)	(2.49)	(2.43)	(0.27)	(0.47)	(0.66)	(0.78)	(26.23)	(22.19)
2019	1258	9738	14776	40813	90675	63418	83	659	1929	993	1027	742	34110	27493
	(0.87)	(6.77)	(10.27)	(28.37)	(63.03)	(44.08)	(0.06)	(0.46)	(1.34)	(0.69)	(0.71)	(0.52)	(23.71)	(19.11)
2020	8454	131607	238159	130422	114304	102148	1806	1826	2671	1591	1257	2492	22629	19191
	(2.17)	(33.81)	(61.18)	(33.50)	(29.36)	(26.24)	(0.46)	(0.47)	(0.69)	(0.41)	(0.32)	(0.64)	(5.81)	(4.93)
2021	316296	358481	355051	287330	136397	138219	68922	55550	3873	11150	6004	6633	49065	78244
	(33.81)	(38.32)	(37.95)	(30.71)	(14.58)	(14.77)	(7.37)	(5.94)	(0.41)	(1.19)	(0.64)	(0.71)	(5.24)	(8.36)
2022	234579	445322	575785	332268	127373	161446	66402	54094	25366	15872	3090	9057	85717	100250
	(20.98)	(39.82)	(51.49)	(29.71)	(11.39)	(14.44)	(5.94)	(4.84)	(2.27)	(1.42)	(0.28)	(0.81)	(7.66)	(8.96)
2023	339219	278138	171272	217666	101462	94497	30749	25430	9983	13672	5693	3470	44246	69748
	(48.28)	(39.59)	(24.38)	(30.98)	(14.44)	(13.45)	(4.38)	(3.62)	(1.42)	(1.95)	(0.81)	(0.49)	(6.30)	(9.93)

Note: Figures within the parentheses indicate percentage to total export of maize

Table 5. RCA and RSCA of maize export from India, 2012 to 2023

Year	RCA	RSCA
2012	1.12	0.05
2013	1.22	0.10
2014	1.00	0.004
2015	0.32	-0.50
2016	0.22	-0.63
2017	0.23	-0.61
2018	0.35	-0.47
2019	0.19	-0.67
2020	0.48	-0.34
2021	0.75	-0.13
2022	0.73	-0.14
2023	0.57	-0.26

Figures are rounded off to their nearest integer

Table 6. Revealed competitiveness Advantage (RC) of maize from 2012 to 2023

Year	Vollrath Index
2012	1.12
2013	1.21
2014	1.00
2015	0.30
2016	0.15
2017	0.20
2018	0.32
2019	0.06
2020	0.37
2021	0.74
2022	0.73
2023	0.57

stable importer, whereas Oman is an unstable market for Indian maize. The projected export trends indicate a decline in India's maize export share to Vietnam, Bangladesh, and Malaysia, while Nepal's share is expected to increase. Despite its importance in global maize trade, India's revealed comparative advantage (RCA) in maize exports has been inconsistent, indicating a need for enhanced competitiveness.

To strengthen India's position in the global maize market, policy measures should focus on improving productivity, ensuring price stability, and enhancing export infrastructure. Strengthening trade relations with stable importers like Vietnam, Bangladesh, and Nepal through long-term agreements can ensure sustained demand. Additionally, investment in quality control measures, logistics, and value addition (such as maize-based processed products) can enhance India's competitiveness. Policy interventions should also aim at diversifying export destinations beyond Southeast Asia to mitigate risks associated with market fluctuations. Furthermore, facilitating farmer access to improved maize varieties, efficient storage, and supply chain management will be crucial in enhancing production efficiency and meeting international standards. By implementing these strategies, India can position itself as a reliable maize exporter, ensuring long-term sustainability in global trade.

References

Balassa, B. (1965). Trade liberalization and revealed comparative advantage. *The Manchester School*, **33**: 99-123.

Dalum, B., Laursen, K. & Villumsen, G. (1998). Structural change in OECD export specialisation patterns: Despecialisation and stickiness. *International Review of Applied Economics*, **12**: 423-443.

Felicia, W. & Hasan, G. (2013). Global maize trade and food security: Implications from a social network model. *NIH Public Access,* **33**: 1-18.

Geetha, R. S. & Srivastava, S. K. (2019). Performance and determinants of maize production in India. *International Journal of Current Research in Biosciences and Plant Biology*, **6**: 17-25.

Laursen, K. (2015). Revealed Comparative Advantage and the Alternatives as Measures of International Specialisation. *Eurasian Economic Review*, **5**: 99-115.

Manasi, P. (2021). Export performance, competitiveness, and stability analysis of Indian wheat (Doctoral Dissertation, Jau, Junagadh).

Shinoj, P. & Mathur, V. C. (2008). Comparative Advantage of India in Agricultural Exports vis-á-vis Asia: A Postreforms Analysis. *Agricultural Economic Research Review*, **21**: 60-66.

Singh, O. P., Anoop, M. & Singh, P. K. (2020). Revealed comparative advantage, competitiveness and growth performance: Evidences from India's foreign trade of agricultural commodities. *Indian Journal of Agricultural Economics*, **75**: 560-577.

Vollrath, T. L. (1991). A theoretical evaluation of alternative trade intensity measures of revealed comparative advantage. *Weltwirtschaftliches Archive*, **127**: 265-280.

Widodo, T. (2009). Comparative Advantage: Theory, Empirical Measures and Case Studies. *Review Economic Studies*, **4**: 57-82.

Upreti, J., Acharya, P., Upadhyaya, J. & Shrestha, J. (2020). Heterosis in maize hybrids at farmer's field in Dang district of Nepal. *Fundamental and Applied Agriculture*, **5**: 188-193.

www.fao.org.

www.intracen.org.