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Enhancing India's Agricultural Exports: Prospects and Challenges



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Preface

India's agricultural sector continues to play a central role in ensuring food and nutritional security, supporting rural livelihoods, and contributing to overall economic growth. In recent decades, the growing integration of domestic agriculture with global markets has added a new dimension to this role. Agricultural exports have emerged as an important pathway for value addition, market diversification, and income enhancement, while also presenting new challenges related to competitiveness, sustainability, and resilience.

India's experience with agricultural exports over the past two decades reflects both progress and complexity. Expansion in export volumes and destinations has been accompanied by increased exposure to international price volatility, non-tariff measures, and evolving global standards related to quality, safety, and environmental performance. At the same time, concerns regarding natural resource use, particularly water, and the uneven regional distribution of export benefits underline the need for a balanced and well-informed export strategy.

The policy paper entitled "*Enhancing India's Agricultural Exports: Prospects and Challenges*" provides a systematic assessment of trends in India's agricultural trade, examines the sources of export growth, and highlights emerging policy issues related to diversification, market access, and resource use. By drawing attention to both opportunities and constraints, the paper offers evidence-based perspectives relevant to policymakers, researchers, and development practitioners.

I hope that the insights presented in this policy paper will support the formulation of economically sound and environmentally responsible agricultural trade policies that are consistent with India's long-term development objectives. NAAS remains committed to strengthening the interface between scientific knowledge and public policy in support of sustainable and inclusive agricultural development. I take this opportunity to place on record my appreciation to the Convener (Dr. Anjani Kumar) and Co-Convener (Dr. K. Elumalai) for their leadership in steering this policy paper. I also acknowledge the valuable contributions of the Reviewer (Dr. Naveen P. Singh) and Editors (Dr. R.K. Jain & Dr. R.K. Pal), whose critical insights and dedicated efforts have significantly enriched this document.

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(M.L. Jat)
President, NAAS

Enhancing India's Agricultural Exports: Prospects and Challenges

1. BACKGROUND

Global agricultural markets have undergone rapid integration over the past three decades, driven by trade liberalization, technological change in logistics, expansion of transnational agri-food firms, and restructuring of food retail systems. As a result, the scale and complexity of international agricultural trade have expanded significantly since the mid 1990s (United Nations, 2021, 2024). A substantial body of empirical literature suggests that agricultural trade can enhance efficiency, stimulate productivity growth, and improve consumer welfare, provided domestic markets and institutions are adequately integrated with global value chains. Trade exposure can support structural transformation by enabling a shift from low productivity agriculture towards higher value activities within and beyond the farm sector (Teignier, 2018). However, such transformation critically depends on complementary investments in infrastructure, logistics, product and factor markets that link agriculture with the broader economy (Timmer, 1988).

Against this backdrop, India's engagement with global agricultural markets has deepened since the late 1990s, alongside broader economic reforms. Notably, India has transitioned from being a net foodgrain importer to a significant exporter of selected commodities such as rice, fish and fish products, spices, and cotton. Over time, agricultural trade policy has increasingly emphasized export expansion as a pathway for enhancing farm incomes and foreign exchange earnings. At the same time, domestic policy priorities have continued to emphasize foodgrain self-sufficiency and price stability (Hoda and Gulati, 2013). Accordingly, restrictive trade policies such as higher import tariffs, export bans, quantitative restrictions, and phytosanitary measures, were put in place at different times (Pursell and Gulati, 1993; Ahmed, 1996; Athukorala, 2005; Acharya *et al.*, 2012; Saini and Gulati, 2016).

Some of these restrictions, however, were brought down with introduction of economic reforms and the World Trade Organization (WTO) Agreement on Agriculture in the mid-1990s (Jha and Srinivasan, 2004; Mullen *et al.*, 2004). As a result, India's agricultural export has increased by eight times, from US\$ 6.4 billion to US\$ 51.0 billion, between 1996 and 2023 (United Nations, 2024). Concomitantly, imports of agricultural products have increased by 10 times, from US\$ 3.4 billion to US\$ 34.1 billion. Despite these observed trends, the agricultural trade surplus has remained positive for India. This shows that agriculture acts as an important contributor to foreign exchange earnings despite structural transformation of the India's economy in recent times.

However, there is limited empirical evidence on changes in different aspects of India's agricultural trade in recent decades and their implications for export promotion and challenges thereof. More specifically, there is a need to generate knowledge on

changing pattern of India’s agricultural trade at the disaggregate product level and changes in trade specialization patterns. Given a consistent rise in agricultural exports, it is important to examine the sources of export growth along with intensive and extensive margins for suitable policy interventions for diversification of export basket and/or export destinations. Further, concerns are often raised among the academicians, policy makers and development practitioners regarding increased export of agricultural products leading to export of scarce water in virtual form resulting in over exploitation and depletion of water resources in the country.

2. DYNAMICS OF INDIA’S AGRICULTURAL TRADE

India’s agricultural products have attained prominence in the world trade basket over time. Its export share in the world has increased considerably from 1.35 percent in 2001 to 2.47 percent in 2023. India’s share of world imports has also increased from 0.69 percent to 1.63 percent (United Nations, 2024). During the same period, value of agricultural exports increased from US\$ 6.8 billion in 2001/2003 to a massive US\$ 51.7 billion in 2021/2023 (Table 1). The average annual growth rates show an impressive 15.7 percent increase in agricultural exports during the period 2001 to 2010, and then a deceleration to 7.8 percent per year between 2011 and 2023. Agricultural imports have also decelerated in the recent period as compared to their high growth in the previous period of analysis. Interestingly, India’s agricultural trade surplus has remained positive overtime indicating that agriculture acts an important contributor to foreign exchange earnings.

Various reforms undertaken by the Government of India in the areas of decontrol of fertilizer prices, removal of control on inter-state grain movement, doing away with the quantitative restrictions on exports and imports, decanalisation of agricultural trade and reduction of import tariff during the 1990s resulting in the opening of the agricultural sector to global competition. The extent of openness of agriculture captures the level

Table 1. India’s agricultural exports and imports

| Period | Agricultural exports and imports (US\$ billion) | | | |
|--------------|---|--------|-------|---------------|
| | Export | Import | Total | Trade surplus |
| 2001 to 2003 | 6.8 | 4.0 | 10.8 | 2.8 |
| 2008 to 2010 | 20.0 | 11.0 | 31.0 | 9.0 |
| 2013 to 2015 | 41.3 | 20.4 | 61.7 | 20.8 |
| 2021 to 2023 | 51.7 | 34.0 | 61.9 | 14.7 |
| | Average annual growth rate (percent) | | | |
| 2001 to 2010 | 15.71 | 16.96 | 15.61 | 20.41 |
| 2011 to 2023 | 7.79 | 8.43 | 7.83 | 9.39 |

Source: United Nations (2024)

of trade penetration into agricultural output and the relative importance of agricultural trade in the national economy. Agricultural outward orientation can also be computed as the share of agricultural exports in gross value added (GVA) and the share of agricultural exports in the national gross domestic product (GDP).

Between 2002/03 and 2023/24, the trade openness indices showed an upward trend (Figure 1). Arising trade openness over time shows consistent performance of agricultural trade despite some degree of uncertainty observed in trade policy at times for meeting certain objectives such as price stabilisation and adequate food availability. It is noteworthy to point out that the agricultural exports share in agricultural value added reached at 9.0 percent in 2023 and that of agricultural trade at 15.0 percent. Another measure of trade openness captured in terms of the share of agricultural exports in national GDP exhibited an upward trend implying an improvement in the outward orientation of agricultural sector. The sector's outward orientation, however, has remained stagnant till 2012-13 and then improved to reach 1.5 percent of national GDP in 2023/24.

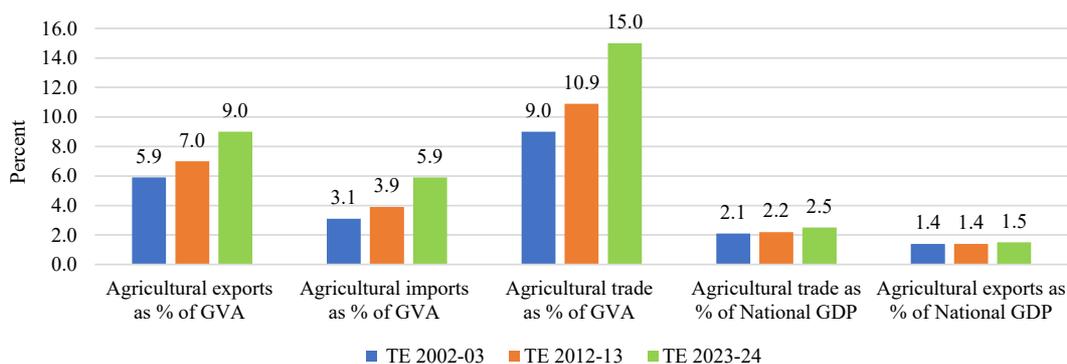


Figure 1. Agricultural trade openness (Source: United Nations, 2024)

The export composition of agricultural products is provided in Table 2. There is little change in the relative position of commodities between 2001/2003 and 2021/2023. In 2021/2023, five products accounted for over 60 percent of total agricultural exports. These are cereals; fish and fish products; sugar and sugar related products; coffee, tea, mate, and spices, and meat and edible meat offal. The relative importance of meat products in the export basket has increased over time, which now accounts for 6.7 percent of the value of agricultural exports.

The export share of cereals has improved from 19.0 percent to 24.0 percent between 2001/2003 and 2021/2023. But there has been a slight decline in the relative importance of fish and fish products, and of coffee, tea, mate, and spices. The export of cereals accounted for the largest value of US\$ 12,333 million. Dairy products, birds eggs, natural honey, edible prod nes, edible vegetables and certain roots and tubers have retained their relative position in the export basket, while there has been a fall in the initial importance

Table 2. Agricultural export composition of India

| Product code | Product description | Value (US\$ million) | | Share in total exports (%) | |
|--------------|--|----------------------|----------------|----------------------------|------------|
| | | 2001/03 | 2021/23 | 2001/03 | 2021/23 |
| 01 | Live animals | 2.4 | 8.0 | 0.04 | 0.02 |
| 02 | Meat and edible meat offal | 290.2 | 3466.7 | 4.26 | 6.71 |
| 03 | Fish and crustaceans, molluscs, and other aquatic invertebrates | 1287.2 | 6466.7 | 18.90 | 12.51 |
| 04 | Dairy products, birds' eggs, natural honey, edible prod nes | 75.4 | 590.4 | 1.11 | 1.14 |
| 05 | Products of animal origin, not elsewhere specified or included | 39.9 | 250.5 | 0.59 | 0.48 |
| 06 | Live trees and other plants, bulbs, roots, cut flowers, and ornamental foliage | 36.2 | 92.8 | 0.53 | 0.18 |
| 07 | Edible vegetables and certain roots and tubers | 261.4 | 1733.3 | 3.84 | 3.35 |
| 08 | Edible fruits and nuts, peel of citrus fruit or melons | 551.3 | 1466.7 | 8.10 | 2.84 |
| 09 | Coffee, tea, mate, and spices | 727.5 | 4166.7 | 10.68 | 8.06 |
| 10 | Cereals | 1284.9 | 12333.3 | 18.87 | 23.87 |
| 11 | Products of the milling industry, malt, starches, inulin, wheat gluten | 69.6 | 691.1 | 1.02 | 1.34 |
| 12 | Oil seeds, oleaginous fruits, miscellaneous grains, seeds, fruit, etc. | 293.3 | 1933.3 | 4.31 | 3.74 |
| 13 | Lac, gums, resins and other vegetable saps and extracts | 234.2 | 974.6 | 3.44 | 1.89 |
| 14 | Vegetable planting materials, vegetable products not elsewhere specified or included | 16.9 | 47.0 | 0.25 | 0.09 |
| 15 | Animal/vegetable fats and oils, and their cleavage products, etc. | 174.3 | 1800.0 | 2.56 | 3.48 |
| 16 | Preparations of meat, fish, crustaceans, molluscs, or other aquatic invertebrates | 30.8 | 899.5 | 0.45 | 1.74 |
| 17 | Sugars and sugar confectionery | 361.2 | 4966.7 | 5.30 | 9.61 |
| 18 | Cocoa and cocoa preparations | 3.2 | 161.5 | 0.05 | 0.31 |
| 19 | Preparations of cereal, flour, starch/milk, pastrycooks' products | 53.9 | 713.8 | 0.79 | 1.38 |
| 20 | Preparations of vegetables, fruit, nuts, or other parts of plants | 68.6 | 908.6 | 1.01 | 1.76 |
| 21 | Miscellaneous edible preparations | 131.1 | 1233.3 | 1.93 | 2.39 |
| 22 | Beverages, spirits, and vinegar | 27.7 | 379.3 | 0.41 | 0.73 |
| 23 | Residues and waste from the food industry, preparations of animal fodder | 436.3 | 2300.0 | 6.41 | 4.45 |
| 24 | Tobacco and manufactured tobacco substitutes | 202.7 | 1137.3 | 2.98 | 2.20 |
| 3301 | Essentials oils (terpeneless or not), resinoids, extracted oleoresins | 68.9 | 956.9 | 1.01 | 1.85 |
| 5201 | Cotton (not carded or combed) | 18.0 | 1551.9 | 0.26 | 3.00 |
| | Others | 62.0 | 447.6 | 0.91 | 0.87 |
| | Total | 6809.0 | 51677.6 | 100 | 100 |

Source: United Nations (2024)

of edible fruits and nuts, peel of citrus fruit or melons, oil seeds, oleaginous fruits, miscellaneous grains, seeds, fruit, etc. and lac, gums, resins and other vegetable saps and extracts. In the meantime, value of export of cotton (not carded or combed) rose from a mere US\$ 18 million in 2001/2003 to a whopping US\$ 1552 million in 2021/2023, with a corresponding share of 0.26 percent and 3.0 percent in total agricultural exports.

There has been little dynamism over time in the composition of India's imports of agricultural products (Table 3). Three commodities account for 74 percent of import value. They are animal/vegetable fats and oils and their cleavage products; edible vegetables, certain roots and tubers, and edible fruit and nuts; and peel of citrus fruit or melons. These three commodities have retained their position in the import basket over the years. There is a slight increase in the import share of oil seeds, oleaginous fruits, miscellaneous grains, seeds, fruits, etc., sugars and sugar confectionery, and of beverages, spirits and vinegar between 2001/2003 and 2021/2023. Import share of each of these commodities accounted for about 3.0 percent. Similarly, the import of essential oils has risen from 0.4 percent in 2001/2003 to over 1.0 percent in 2021/2023. The import of raw silk (not thrown) and wool (not carded or combed) has fallen considerably due to increase in their import duties for protecting the interests of domestic industries. Likewise, imports of cotton (not carded or combed) dropped from 8.5 percent in 2001/2003 to 2.6 percent in 2021/2023.

Having analyzed the composition of major agricultural exports from India, it is important to examine their destination markets. The East Asia and the Pacific region accounted for the largest export destination for India's agricultural exports with a worth of US\$ 11 billion. Exports to this region constituted about 29.0 percent of total exports during recent years (Figure 2). The Middle East and North Africa (MENA) region has emerged as India's second-largest export market. Agricultural exports to this region have increased substantially in recent years. During 2001/2003, agricultural exports to this region accounted for 17.2 percent, which further increased to 23.5 percent in 2017/2019.

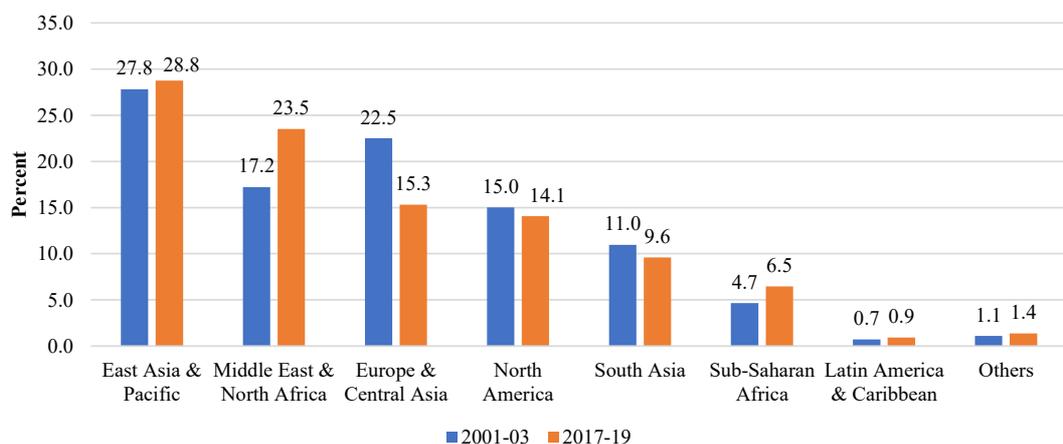


Figure 2. Major export destination (Source: United Nations, 2024)

Table 3. Agricultural import composition of India

| Product code | Product description | Value (US\$ million) | | Share in total imports (%) | |
|--------------|--|----------------------|-----------------|----------------------------|---------------|
| | | 2001-03 | 2021-23 | 2001-03 | 2021-23 |
| 01 | Live animals | 0.54 | 12.10 | 0.01 | 0.04 |
| 02 | Meat and edible meat offal | 0.09 | 5.24 | 0.00 | 0.02 |
| 03 | Fish, crustaceans, molluscs, and other aquatic invertebrates | 8.91 | 151.03 | 0.22 | 0.44 |
| 04 | Dairy products, birds' eggs, natural honey, edible products of animals not elsewhere specified or included | 17.47 | 43.18 | 0.44 | 0.13 |
| 05 | Products of animal origin not elsewhere specified or included | 12.49 | 43.96 | 0.31 | 0.13 |
| 06 | Live trees and other plants, bulbs and roots, cut flowers and ornamental foliage | 1.71 | 34.67 | 0.04 | 0.10 |
| 07 | Edible vegetables and certain roots and tubers | 617.30 | 2400.00 | 15.45 | 7.06 |
| 08 | Edible fruit and nuts; peel of citrus fruit or melons | 353.71 | 4033.33 | 8.85 | 11.87 |
| 09 | Coffee, tea, mate, and spices | 102.23 | 1000.20 | 2.56 | 2.94 |
| 10 | Cereals | 1.01 | 101.06 | 0.03 | 0.30 |
| 11 | Products of the milling industry, malt, starches, inulin, wheat gluten | 5.55 | 82.51 | 0.14 | 0.24 |
| 12 | Oil seeds, oleaginous fruits, miscellaneous grains, seeds, fruits, etc. | 34.81 | 954.74 | 0.87 | 2.81 |
| 13 | Lac, gums, resins and other vegetable saps and extracts | 29.81 | 351.65 | 0.75 | 1.04 |
| 14 | Vegetable planting materials, vegetable products not elsewhere specified | 1.44 | 103.89 | 0.04 | 0.31 |
| 15 | Animal/vegetable fats and oils, and their cleavage products | 1900.00 | 18666.67 | 47.54 | 54.95 |
| 16 | Preparations of meat, fish, crustaceans, molluscs, etc. | 0.49 | 22.03 | 0.01 | 0.06 |
| 17 | Sugars and sugar confectionery | 19.52 | 732.98 | 0.49 | 2.16 |
| 18 | Cocoa and cocoa preparations | 12.23 | 410.23 | 0.31 | 1.21 |
| 19 | Preparations of cereal, flour, starch/milk, pastrycooks' products | 18.35 | 155.26 | 0.46 | 0.46 |
| 20 | Preparations of vegetables, fruits, nuts or other parts of plants | 13.39 | 139.42 | 0.33 | 0.41 |
| 21 | Miscellaneous edible preparations | 39.28 | 220.30 | 0.98 | 0.65 |
| 22 | Beverages, spirits, and vinegar | 20.27 | 1136.02 | 0.51 | 3.34 |
| 23 | Residues and waste from the food industry, preparations of animal fodder | 54.09 | 905.95 | 1.35 | 2.67 |
| 24 | Tobacco and manufactured tobacco substitutes | 6.54 | 69.84 | 0.16 | 0.21 |
| 3301 | Essentials oils (terpeneless or not) resinoids, extracted oleoresins | 17.48 | 353.24 | 0.44 | 1.04 |
| 5002 | Raw silk (not thrown) | 132.46 | 159.57 | 3.31 | 0.47 |
| 5101 | Wool (not carded or combed) | 152.74 | 222.09 | 3.82 | 0.65 |
| 5201 | Cotton (not carded or combed) | 339.55 | 871.00 | 8.50 | 2.56 |
| | Others | 83.13 | 589.14 | 2.08 | 1.73 |
| | Total | 3996.57 | 33971.31 | 100.00 | 100.00 |

Source: United Nations (2024)

The importance of Europe and Central Asia as destination markets declined. Although agricultural exports to this region have increased in absolute terms, the rate of increase of export flow was relatively low compared to other regions. The export share to North America was by and large stable barring the period of global financial crisis. India is a major economic power in the South Asian region and even though it has strong cultural similarity with them, it could not tap the market potential much in this region. Agricultural export share to this region has marginally come down and has constituted only 9.6 percent during the recent year. An increase in agricultural exports to Sub-Saharan Africa indicates it to be an emerging market for India's products.

3. SOURCES OF EXPORT GROWTH

This section examines the composition of India's agricultural export growth by separating changes attributable to deepening existing trade relationships from those arising through diversification, drawing on established approaches in the trade literature (Brenton and Newfarmer, 2007; Amurgo-Pacheco and Pierola, 2008). Specifically, the framework differentiates between growth driven by higher sales of existing products in established markets and growth generated through entry into new products or destinations. This decomposition enables a clearer understanding of whether export expansion is primarily rooted in diversification across products, across markets, or both.

Figure 3 shows contribution of intensive and extensive margin to changes in India's agricultural exports at the aggregate level. It can be seen that intensive margin contributed to 71 percent of total changes in exports, while extensive margin contributed to 29 percent. Higher export growth at the intensive margin indicates a higher survival rate of existing trading relationship and ability to retain long term trade relations with the same partner countries. This is further reflected in lower rate of partner extinction

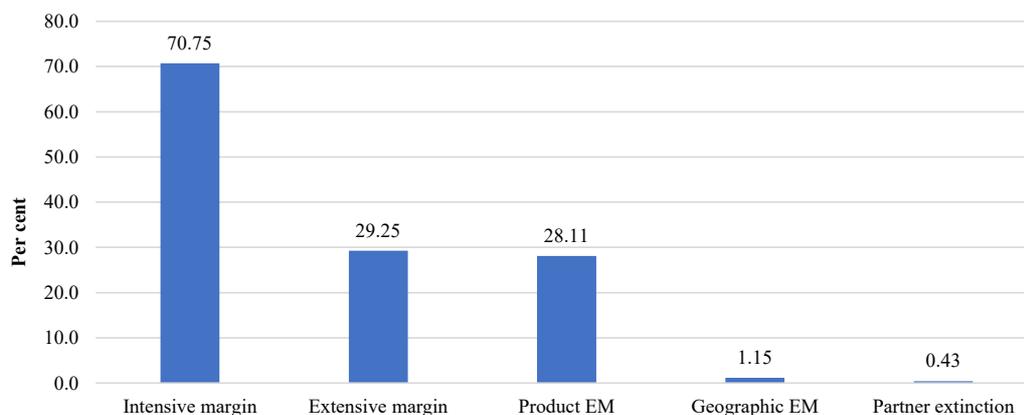


Figure 3. Intensive and extensive margins of agricultural exports: 2001 to 2020

Source: United Nations (2021)

Note: Product EM- product extensive margin; Geographic EM- geographical extensive margin

at 0.43 percent. This clearly points out that intensification of exports of exiting products to the old destinations dominates the changes in exports. The contribution of export diversification to agricultural exports growth remains subdued in the last two decades, but it appears to be more a promising source of expansion of exports.

Within extensive margin, product diversification contributed more than geographic diversification to export growth. That is, export of new products to existing markets dominates export of existing products to new markets. The product extensive margin contributed to 28.1 percent export growth, while geographic extensive margin accounted for a meagre 1.2 percent only. This shows that on the export diversification front, India exports different variety of products from the same industry to the existing markets as against exporting them to the new markets. Export expansion with new export products to new geographies appears to be limited.

India lost a few partner countries for export of its existing products between the period 2001 and 2020. Partner extinction was computed by summing the value of exports lost across the products. India's export of existing products declined sharply for Germany at 22.6 percent, which was the far highest among the partner countries. Other countries where India lost its existing exports significantly included Austria, Trinidad & Tobago, Malta, Japan, Guyana and United Kingdom. The loss of exports of certain agricultural products can be attributed to product diversification to a large extent and geographical diversification to a lesser extent.

Intensive and extensive margin by type of products is given in Table 4. We have grouped the products using the six-digit Harmonized System (HS) of classification into different categories based on the nature of products and production processes. In terms of type of products, India's export growth was largely driven by intensifying the export of existing products. Intensive margin ranged from 60.2 percent on agricultural raw materials to 89.0 percent on processed agricultural products during 2001 and 2020. Exports of horticultural products have grown mostly at intensive margin with a contribution of 88.2 percent. The share of extensive margin was as high as 41.4 percent on the export of cereals, oilseeds and vegetable oils. Within this extensive margin, product diversification accounted for a substantial growth in export of cereals, oilseeds and vegetable oils (39.7 percent). For agricultural raw materials and animal products, product extensive margin was found to

Table 4. Intensive and extensive margins by products

| Product type | Intensive margin (%) | Extensive margin (%) | Geographic EM (%) | Product EM (%) |
|---------------------------------------|----------------------|----------------------|-------------------|----------------|
| Animal products | 70.88 | 29.12 | 1.01 | 28.11 |
| Horticultural products | 88.23 | 11.77 | 3.54 | 8.23 |
| Cereals, oilseeds, and vegetable oils | 58.61 | 41.39 | 1.73 | 39.66 |
| Processed agricultural products | 89.04 | 10.96 | 2.23 | 8.74 |
| Agricultural raw materials | 60.17 | 39.83 | 0.04 | 39.79 |

Source: United Nations (2021)

be the major driver of their export growth. On the whole, both intensive and extensive margin contributed to exports at the product category level though intensive margin accounted for a larger share than extensive margin.

4. VIRTUAL WATER TRADE IN CROP PRODUCTS

The idea of virtual water was articulated in the 1990s to draw attention to the way international trade redistributes water embedded in agricultural commodities across regions with differing water endowments. The idea of virtual water was articulated in the 1990s to draw attention to the way international trade redistributes water embedded in agricultural commodities across regions with differing water endowments. In this context, virtual (or embedded) water denotes the total water consumed during production, including water depleted through evapotranspiration. Accordingly, trade in agricultural goods entails an indirect transfer of water resources from exporting to importing economies and the amount of commodity exports determine the value of virtual water exported. From an importer perspective, value of virtual water is the value that the country would have consumed if it had to produce the imported commodity itself (Hoekstra and Hung, 2002). It basically shows the amount of water saved by importing that commodity rather than producing it at home.

It is a common argument in the literature that virtual water trade eases pressure on water resources in the water scarce countries by importing water intensive goods. This enables substitution of domestic water used for agricultural production with imported virtual water. In this way, water scarce countries can save their limited water and reallocate it for other domestic requirements (Haddadin, 2003; Yang and Zehnder, 2007; Fracasso, 2014; Oki, Yano and Hanasaki, 2017). However, studies have questioned the empirical validity of the relationship between water endowment and virtual water flows among the countries (Hoekstra and Hung, 2003; Kumar and Singh, 2005; Fracasso, Sartori, Schiavo, 2016). The studies that have examined virtual water flows between India and its partner countries, and among Indian states (Kumar and Jain, 2007; Katyaini and Barua, 2017; Kayatz *et al.*, 2019; Harris *et al.*, 2020), are limited in scope in terms of the commodity coverage, geographical coverage and method of estimation.

The virtual water content of crops and crop products, referred to as “water footprint¹”, has been computed and made available at a detailed product level by Mekonnen and Hoekstra (2010). The present research uses the country level and crop specific total water footprint¹ for calculating India’s virtual water trade flows. The export and import data at the six-digit HS classification was used, covering 206 crops and crop products that were traded across 218 partner countries during 2001 to 2020.

¹ “Water footprint” has three components: blue, green, and grey. Blue water footprint refers to the volume of surface and groundwater consumed in the production process of a product; green water footprint refers to the consumed volume of rainwater that is stored in the soil as soil moisture, which is the source water for rainfed agriculture; grey water footprint refers to the volume of freshwater required to assimilate the pollutants based on the existing ambient water quality standards (Mekonnen and Hoekstra, 2010). The study uses sum of these three components at all India level for select crops.

India's trade in virtual water flows provides an interesting picture with a significant rise in imports over exports. The export of virtual water embedded in crops products has increased considerably from 48.1 billion m³ during 2001/03 to 125.3 billion m³ in 2018/10 (Table 5). But annual growth in export of virtual water has slumped during 2011/20 as compared to a very high growth registered during 2001/10. On the contrary, growth in import of virtual water has increased considerably from 5.4 percent to 11.0 percent between the periods 2001/10 and 2011/20. The import of virtual water associated with crop trade has increased substantially from 39.2 billion m³ in 2001/03 to 147.7 billion m³ during 2018/20. The increase in volume of exports and import of virtual water flows corresponds with a rise in quantity of exports and imports of crops and crop products; but the volume of imports is greater than the exports during the recent years. As a result, the virtual water trade balance has remained negative. These results show that India became a net importer of virtual water during the recent period. This negative virtual water trade balance indicates the net volume of virtual water saved by India through international trade in crop products.

Table 5. Trend in India's virtual water trade

| Period | Export quantity (billion tonnes) | Import quantity (billion tonnes) | Virtual water export (billion m ³) | Virtual water import (billion m ³) | Virtual water trade balance (billion m ³) |
|---------|-------------------------------------|-------------------------------------|--|--|---|
| 2001-03 | 12.8 | 4.3 | 48.1 | 39.2 | 8.9 |
| 2008-10 | 19.1 | 7.5 | 96.3 | 54.7 | 41.6 |
| 2018-20 | 29.0 | 14.8 | 125.3 | 147.7 | -22.3 |

Source: Authors' estimates

Among the products, rice accounted for the largest volume of virtual water exports. The volume of virtual water exports embedded in rice exports increased about three times between 2001/2003 and 2018/2020, from 10.2 billion m³ to 32.1 billion m³. This constituted for about 28.0 percent of the total virtual water exported by India (Kannan and Kumar, 2023). Rice is cultivated under puddled soil conditions in most of the rice growing regions of India. This method of cultivation requires about 2,986 m³ of water for the production of one ton of rice (Mekonnen and Hoekstra, 2010). Since it is a water-intensive crop, higher rice export lead to higher exports of virtual water.

Exports of cotton (not carded or combed) and castor oil and its fractions (whether or not refined) constituted the next largest sources of virtual water exported after rice. In fact, cotton constituted 15.1 percent of total virtual water exports and castor oil with 11.1 percent during 2018/2020. Although primary products of certain crops are not directly utilized for consumption, their processing into secondary products such as oilcake involves water. Thus, a rise in the export of different types of oilseed cake results in increased virtual water exports.

In case of import of virtual water, edible oils accounted for about 56.9 percent of total volume of virtual water imported, while the import of pulses, cashew nuts, and sugarcane

accounted for the rest of the total virtual water imported (Kannan and Kumar, 2023). During 2018/2020, among imported crop products “sunflower seed or safflower oil, crude” constituted the largest volume of virtual water imports (50.1 billion m³). Its share has increased considerably from 3.4 percent in 2001/2003 to 33.9 percent of total virtual water imports in 2018/2020. Soyabean oil crude, whether or not degummed accounted for the second largest volume of virtual water imports (8.9 percent). Among pulses, lentils dried, shelled, whether or not skinned or split and pulses, nes (not elsewhere specified) constituted 4.3 percent and 3.3 percent of total virtual water imports during 2018/20, respectively.

4.1. Export and Import Destinations for the Virtual Water Trade

A substantial volume of virtual water has been exported from India to China and Bangladesh (Table 6). China remains the largest export destination for India’s virtual water, even after

Table 6. India’s major partner countries for virtual water exports

| Country | Virtual water exports (billion m ³) | | | Total virtual water exports (%) | | |
|----------------------|---|-----------|-----------|---------------------------------|-----------|-----------|
| | 2001-2003 | 2008-2010 | 2018-2020 | 2001-2003 | 2008-2010 | 2018-2020 |
| China | 0.72 | 19.72 | 13.35 | 1.49 | 20.49 | 10.63 |
| Bangladesh | 6.90 | 8.48 | 12.57 | 14.32 | 8.82 | 10.01 |
| United States | 2.45 | 2.45 | 6.99 | 5.07 | 2.55 | 5.57 |
| Iran, Islamic Rep. | 0.16 | 1.46 | 6.73 | 0.33 | 1.51 | 5.35 |
| Nepal | 0.40 | 0.83 | 5.73 | 0.83 | 0.86 | 4.56 |
| Vietnam | 1.45 | 7.27 | 4.92 | 3.01 | 7.55 | 3.91 |
| Saudi Arabia | 1.95 | 3.11 | 4.35 | 4.05 | 3.23 | 3.46 |
| United Arab Emirates | 1.96 | 4.76 | 3.85 | 4.07 | 4.95 | 3.07 |
| Indonesia | 3.90 | 4.27 | 3.56 | 8.09 | 4.43 | 2.83 |
| Netherlands | 1.26 | 2.08 | 3.12 | 2.62 | 2.16 | 2.48 |
| Pakistan | 0.51 | 6.99 | 2.61 | 1.07 | 7.26 | 2.08 |
| Malaysia | 2.01 | 3.88 | 2.53 | 4.17 | 4.03 | 2.01 |
| Somalia | 0.18 | 0.33 | 2.32 | 0.38 | 0.35 | 1.84 |
| Sri Lanka | 1.80 | 1.55 | 2.13 | 3.73 | 1.61 | 1.69 |
| France | 1.03 | 1.66 | 2.12 | 2.13 | 1.72 | 1.68 |
| Iraq | 0.39 | 0.17 | 1.95 | 0.82 | 0.18 | 1.55 |
| Korea | 1.53 | 2.46 | 1.93 | 3.18 | 2.56 | 1.54 |
| Thailand | 1.01 | 2.46 | 1.90 | 2.09 | 2.55 | 1.51 |
| Canada | 0.23 | 0.31 | 1.71 | 0.47 | 0.32 | 1.36 |
| United Kingdom | 0.80 | 0.92 | 1.53 | 1.66 | 0.96 | 1.22 |

Source: Authors’ estimates

volume of virtual water exports to it fell down from 19.7 billion m³ in 2008/10 to 13.4 billion m³ in 2018/20. In total exports of virtual water, China and Bangladesh respectively constituted 10.6 percent and 10.0 percent during 2018/20. The virtual water exports to the United States have remained by and large, stable between 2001/03 and 2018/20. It can be observed that Islamic Republic of Iran, Nepal and Vietnam have emerged as the important partner countries for virtual water exports from India during the recent years. India's export of virtual water embedded in export of crop products to Saudi Arabia and United Arab Emirates has remained stable overtime. These countries accounted for over 3.0 percent of total virtual water export during 2018/20. The other important virtual water export destination markets include Indonesia, Netherlands and Malaysia.

Analysis shows that India's virtual water flows to both "water abundant" and "less water abundant countries". There is no consistent pattern in the virtual water exports to the partner countries based on their level of water resources availability during the study period. India exported virtual water through export of crop products to "water abundant" countries such as United States, Nepal, Indonesia, Malaysia and Canada². India also exported virtual water to destinations where renewable internal freshwater resources per capita was much higher than that of India. These countries include China, Vietnam, Sri Lanka, France, Thailand and United Kingdom, among others. Hence, it is clear that the state of water abundance or water scarcity of destination countries does not affect the bilateral virtual water exports.

India's import of virtual water from major partners by volume of virtual water import is given in Table 7. Ukraine was the largest source of import of virtual water accounting for 30.12 percent of total virtual water import during 2018/20. The major products that India imports from Ukraine included oilseeds, pulses and wheat. The volume of import of virtual water embedded in the import of these commodities had increased considerably from 0.24 billion m³ in 2001/03 to 6.5 billion m³ in 2008/10 and then to 44.5 billion m³ in 2018/20. Argentina was the second largest source of virtual water imports after Ukraine. Although in percentage terms, import of virtual water from Argentina declined from 22.5 percent to 16.3 percent between 2001/03 and 2018/20, in absolute terms, its contribution to imports increased from 8.8 billion m³ to 24.1 billion m³ between the same period.

The volume of import of virtual water from the imports of Brazil, Canada, Russian Federation, Benin, Tanzania, Mozambique and Ghana has steadily increased overtime. From these countries, India imports mainly the commodities such as pulses, oilseeds, cotton waste and cashew nuts. The share of import of virtual water from the imports of Brazil, Canada and Russian Federation accounted for 6.2 percent, 4.3 percent and 4.0 percent, respectively. Myanmar is another important source of import of pulses by India. The volume of import of virtual water associated with such imports from Myanmar was 6.4 billion m³ in 2001/03, which declined to 3.5 billion m³ during 2018/20. In percentage terms, the fall in import of virtual water from Myanmar was quite sharp from 16.4 percent to 2.3 percent between the same period, perhaps due to rise in imports

² Average renewable internal freshwater resources per capita during 2018/20 is: United States (8624.1 m³), Nepal (6953.1 m³), Indonesia (7559.7 m³), Malaysia (17907.0 m³) and Canada (76890.9 m³)

Table 7. India's major partner countries for virtual water imports

| Country | Virtual water imports (billion m ³) | | | % of total virtual water imports | | |
|-----------------------------|---|-----------|-----------|----------------------------------|-----------|-----------|
| | 2001-2003 | 2008-2010 | 2018-2020 | 2001-2003 | 2008-2010 | 2018-2020 |
| Ukraine | 0.24 | 6.48 | 44.53 | 0.60 | 11.85 | 30.12 |
| Argentina | 8.84 | 6.97 | 24.07 | 22.53 | 12.75 | 16.28 |
| Brazil | 2.74 | 3.90 | 9.12 | 6.98 | 7.13 | 6.17 |
| Canada | 2.84 | 6.88 | 6.37 | 7.23 | 12.58 | 4.31 |
| Russian Federation | 0.11 | 0.88 | 5.58 | 0.27 | 1.61 | 3.77 |
| Benin | 0.81 | 1.45 | 5.08 | 2.06 | 2.65 | 3.43 |
| United States | 2.97 | 3.21 | 4.79 | 7.57 | 5.88 | 3.24 |
| Myanmar | 6.42 | 5.84 | 3.45 | 16.37 | 10.67 | 2.33 |
| Tanzania | 1.56 | 2.17 | 3.21 | 3.98 | 3.98 | 2.17 |
| Mozambique | 0.38 | 0.66 | 2.94 | 0.96 | 1.21 | 1.99 |
| Ghana | 0.23 | 1.88 | 2.81 | 0.60 | 3.43 | 1.90 |
| Côte d'Ivoire | 1.20 | 3.13 | 2.68 | 3.07 | 5.72 | 1.81 |
| Indonesia | 0.84 | 1.33 | 2.07 | 2.14 | 2.43 | 1.40 |
| United Arab Emirates | 0.05 | 0.18 | 2.01 | 0.13 | 0.33 | 1.36 |
| Switzerland | 0.02 | 0.01 | 1.98 | 0.06 | 0.02 | 1.34 |
| Ethiopia (excludes Eritrea) | 0.11 | 0.10 | 1.92 | 0.28 | 0.18 | 1.30 |
| Australia | 1.45 | 1.19 | 1.75 | 3.70 | 2.18 | 1.18 |
| Singapore | 0.09 | 0.07 | 1.57 | 0.23 | 0.12 | 1.06 |
| Nigeria | 0.33 | 0.23 | 1.23 | 0.85 | 0.42 | 0.83 |
| Guinea-Bissau | 0.73 | 1.13 | 1.23 | 1.85 | 2.07 | 0.83 |

Source: Authors' estimates

from Ukraine and Argentina. However, the on-going Russia-Ukraine conflict may alter the source of import of some of the crop products from other markets.

5. RECOMMENDATIONS

India's agricultural exports recorded significant growth during the period, 2001 to 2023. Agricultural exports were greater than agricultural imports resulting into a positive trade surplus. This indicates that agriculture continues to be an important source of foreign exchange earnings. The trade openness, both the intra- and inter-sectoral level has improved overtime. Cereals, particularly rice, accounted for the largest share of export value followed by fish and fish products. India's agricultural exports across all product types expanded along the intensive margin (that is, intensifying the export of

existing products). Although intensive margin accounted for a larger share, the growth along the extensive margins was an important driver of expansion of exports at the product level. At the extensive margin, contribution of product diversification to export growth was more important than geographical diversification. Product diversification constituted a substantial share of the export growth of cereals, oilseeds, and vegetable oils. Product extensive margin was also the major contributor of growth of export of agricultural products such as raw materials and animal products.

As regards virtual water trade in crop products, India imports more virtual water than it exports through international trade in agricultural products. This implies that India has favorable terms of trade in virtual water with respect to its trading partners. The negative virtual water trade balance indicates net savings of virtual water through international trade. Among the products, rice accounted for the largest volume of virtual water exported from India. Cotton not carded or combed and castor oil and its fractions, whether or not refined account for the next largest volume of virtual water exports after rice. With respect to imports, edible oils and pulses are the major sources of India's virtual water imports. The import of edible oils alone constituted 56.9 percent of overall virtual water imports. Based on the findings of the study, the following recommendations are made:

1. Agricultural trade policies should aim at the diversification of agricultural exports through a product-specific focus that is based on export demand and the exploration of new destination markets for agricultural products.
2. There is a need for exploring new markets such as countries in Africa and east Asia for India's agricultural commodities in the event of changing geo-political and economic scenario. Diversified markets ensure constant demand for India's products and cope with any risks arising due to escalation in tariff and non-tariff measures from the traditional partner countries.
3. Export diversification should be an important strategy for expansion of agricultural exports. There is a huge scope for achieving higher growth in agricultural exports through development of new product/varieties and identification of new markets; these opportunities along with enabling policy environment will act as incentives for exporting firms to invest in product innovation and technological upgradation.
4. There is a need to formulate product specific export strategy for boosting exports. There is a scope for improving export of fruits, nuts, vegetables, dairy products, and fish & fish products.
5. Agricultural trade policy should aim at integrating value chain with trade at all levels with a view to strengthen domestic, regional and international trading relations.
6. There is a need to disseminate and encourage adoption of good management practices among farmers for ensuring quality agricultural exports and reducing border rejections.
7. Develop long term policy for boosting export of processed agricultural products through product innovation and investment in processing industry and infrastructure facilities.

REFERENCES

- Acharya, S. S., R. Chand, P. S. BIRTHAL, S. Kumar, and D. S. Negi. 2012. *Market Integration and Price Transmission in India: A Case of Rice and Wheat with Special Reference to the World Food Crisis of 2007/08*. Rome: Food and Agriculture Organization.
- Ahmed, R. 1996. "Agricultural Market Reforms in South Asia." *American Journal of Agricultural Economics* 78 (3): 815–819.
- Amurgo-Pacheco, A., and M. D. Pierola. 2008. *Patterns of Export Diversification in Developing Countries: Intensive and Extensive Margins*. Policy Research Working Paper 4473. Washington, DC: World Bank.
- Athukorala, P.-C. 2005. "Agricultural Trade Policy Reforms in India." *South Asia Economic Journal* 6 (1): 23–36.
- Brenton, P., and R. Newfarmer. 2007. *Watching More Than the Discovery Channel: Export Cycles and Diversification in Development*. Policy Research Working Paper 4302. Washington, DC: World Bank.
- Fracasso, A. 2014. "A Gravity Model of Virtual Water Trade." *Ecological Economics* 108: 215–228.
- Fracasso, A., M. Sartori, and S. Schiavo. 2016. "Determinants of Virtual Water Flows in the Mediterranean." *Science of the Total Environment* 543: 1054–1062.
- Haddadin, M. J. 2003. *Exogenous Water: A Conduit to Political Stability in the Middle East*. *Water Resources Development* 19(1): 41–56.
- Harris, F., C. Dalin, S. Cuevas, N. R. Lakshmikantha, T. Adhya, E. J. M. Joy, P. F. D. Scheelbeek, B. Kayatz, O. Nicholas, B. Shankar, A. D. Dangour, and R. Green. 2020. "Trading Water: Virtual Water Flows through Interstate Cereal Trade in India." *Environmental Research Letters* 15: 1–13.
- Hoda, A., and A. Gulati. 2013. *India's Agricultural Trade Policy and Sustainable Development*. Issue Paper No. 49. Geneva: International Centre for Trade and Sustainable Development.
- Hoekstra, A. Y., and P. Q. Hung. 2002. *Virtual Water Trade: A Quantification of Virtual Water Flows Between Nations in Relation to International Crop Trade*. Value of Water Research Report Series No. 11. The Netherlands: UNESCO-IHE.
- Hoekstra, A. Y., and P.Q. Hung. 2003. "Virtual Water Trade: A Quantification of Virtual Water Flows between Nations to International Crop Trade." In *Virtual Water Trade Proceedings of the International Expert Meeting on Virtual Water Trade*. Value of Water Research Report Series No. 12, edited by A. Y. Hoekstra, 25–47. The Netherlands: IHE DELFT.
- Jha, S., and P. V. Srinivasan. 2004. *Achieving Food Security in a Cost Effective Way: Implications of Domestic Deregulation and Reform Under Liberalized Trade*. MTID Discussion Paper No. 67. Washington DC: International Food Policy Research Institute.

- Kannan, E., and Kumar, A. 2023. *Trends and determinants of India's virtual water trade in crop products*. IFPRI Discussion Paper 2213. Washington, DC: International Food Policy Research Institute (IFPRI). <https://doi.org/10.2499/p15738coll2.137023>.
- Katyaini, S., and A. Barua. 2017. "Assessment of Interstate Virtual Water Flows Embedded in Agriculture to Mitigate Water Scarcity in India (1996–2014)." *Water Resources Research* 53: 7382–7400.
- Kayatz, B., F. Harris, J. Hillier, T. Adhya, C. Dalin, D. Nayak, R. F. Green, P. Smith, and A. D. Dangour. 2019. "More Crop per Drop: Exploring India's Cereal Water Use Since 2005." *Science of the Total Environment* 673: 207–217.
- Kumar, M. D., and O. P. Singh. 2005. "Virtual Water in Global Food and Water Policy Making: Is There a Need for Rethinking?" *Water Resources Management* 19: 759–789.
- Kumar, V., and S. K. Jain. 2007. "Status of Virtual Water Trade from India." *Current Science* 93 (8): 1093–1099.
- Mekonnen, M. M., and A. Y. Hoekstra. 2010. "The Green, Blue and Grey Water Footprint of Crops and Derived Crop Products." *Volume 2: Appendices, Value of Water Research Report Series No. 47*. The Netherlands: University of Twente.
- Mullen, K., D. Sun., D. Orden, and A. Gulati. 2004. *Producer Support Estimates (PSEs) for Agriculture in Developing Countries: Measurement Issues and Illustrations from India and China*. MTID Discussion Paper No. 74. Washington DC: International Food Policy Research Institute.
- Oki, T., Yano, S. and Hanasaki, N., 2017. Economic aspects of virtual water trade. *Environmental research letters*, 12(4), p.044002.
- Pursell, G. and Gulati, A., 1993. *Liberalising Indian agriculture: an agenda for reform* (Vol. 1172). World Bank Publications.
- Saini, S., and A. Gulati. 2016. "India's Food Security Policies in the Wake of Global Food Price Volatility." In *Food Price Volatility and its Implications for Food Security*, edited by M. Kalkuhi, J. von Braun, and M. Torero, 331-54. New York: Springer.
- Teignier, M. 2018. The role of trade in structural transformation. *Journal of Development Economics* 130: 45-65.
- Timmer, C.P., 1988. The agricultural transformation. *Handbook of development economics*, 1, pp.275-331.
- United Nations. 2021. *International Merchandise Trade Statistics Database (UN Comtrade)*. United Nations Statistics Division, New York.
- United Nations. 2024. *UN Comtrade Database*. United Nations Statistics Division, New York.
- Yang, H., and A. Zehnder. 2007. "Virtual Water: An Unfolding Concept in Integrated Water Resources Management". *Water Resources Research* 43: W12301.

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