Transforming Indian Agriculture: Agenda for Reforms

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Abstract

A transformed and reformed agriculture sector, focusing on transformative reforms should support India's objective of achieving a $5 trillion economy. The paper deliberates on a reforms agenda to transform the agriculture sector for doubling farmers' income, while managing the VUCA (volatility, uncertainty, complexity, ambiguity) world of farmers. It discusses growth trends of agriculture in the country. It goes on to examine critical issues and challenges in the agriculture sector, viz. small size of average holdings and low income of farmers, low agricultural productivity, stagnant capital formation in agriculture, climate change and agriculture, and market constraints. An agenda for reforms to transform Indian agriculture is presented, and includes strategies for doubling farmers' income, enhancing irrigation potential through increase in investment, promoting water-use efficiency by focusing on micro-irrigation and use of precision irrigation technologies, System of Rice Intensification (SRI), direct seeded rice, zero tillage, etc. Promotion of tech-driven agriculture by agri-tech start-ups through Artificial Intelligence (AI), machine learning (MI) and robotics could transform Indian agriculture, benefitting small and marginal farm holders. The paper deliberates on the three agriculture marketing reform Acts, which are expected to create an ecosystem which promises to enable farmers to come out of the VUCA world, and also suggests certain amendments. Investments in rural infrastructure and efficient agri-value chains to enable the acceleration of agricultural growth, creation of new economic opportunities, and generation of employment, are discussed. India is among the top ten exporters of agriculture products in the world, but its share is only 2.1 percent, and therefore, the country needs to catch up with Brazil and China. The agri-export strategy should include integration of value-added agri-produce with global value chains (GVC), by adopting the best agricultural practices involving productivity gains and cost competitiveness. Climate Smart Agriculture (CSA) and Water-Energy-Food (WEF) nexus approach to support water-use efficiency, use of renewable energy and mitigation of GHG emissions, food security and sustainable agriculture, have been highlighted. The paper argues in favour of methods like System of Rice Intensification (SRI), drip irrigation, soil amendments, organic matter management, different tillage, rotation, and cultivar selection, can facilitate mitigation of methane emission from paddy cultivation. A thrust on credit by banks to animal husbandry, dairy, and fisheries along with horticulture, farm mechanisation, warehouses and cold chains, to farmers, FPOs and agripreneurs, is imperative to increase the share of agriculture term loans in total agriculture credit disbursed, from the current 40 percent to 60 percent, to accelerate capital formation in agriculture. Addressing the problems in implementation of PM Krishi Bima Yojana by state governments and insurance companies need to be prioritised. The combination of futures and options can give market participants the benefit of price discovery of futures and simpler risk management of options. FPOs need to be encouraged to participate in futures and options trading of NCDEX. The paper concludes by stating that effective implementation of these transformative strategies, could lead to sustainability of Indian agriculture, and facilitate the achievement of doubling farmers' income by 2024-25, while mitigating agrarian distress.

Key words: Reforms Agenda; Doubling farmers' income; Agri-marketing reforms; Rural infrastructure; Agri-exports; Agri-tech; Climate Change

JEL Classification Codes: Q13; Q14; Q15; Q16; Q17; Q18

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1. Introduction

India's target of achieving a $5 trillion economy needs to be supported by a transformed and reformed agriculture sector. It is, therefore, imperative that the agriculture sector should support the objective by focusing on transformational reforms, while targeting an annual agri-GVA growth of 5 percent.

The criticality of agriculture for sustainable and inclusive growth of the Indian economy can be gauged from the fact that, the sector provides employment to about 42.4 per cent of the total workforce in India, but contributes only about 14.6 per cent (2019-20) to the country's real Gross Value Added (GVA)[†]. About 86 per cent of operational holdings in the country are in the small and marginal categories, and the average size of an operational holding is only 1.08 hectare (ha). Due to fragmentation and disorganisation, farmers face constraints in procuring inputs like seeds and fertilizers at reasonable prices, lack bargaining power in the market for realising better value for their produce, and have inadequate access to technology, extension services, market, credit and crop insurance. As a result, majority of the small and marginal farm holders are unable to realise optimal value from their farming operations, resulting in agrarian distress.

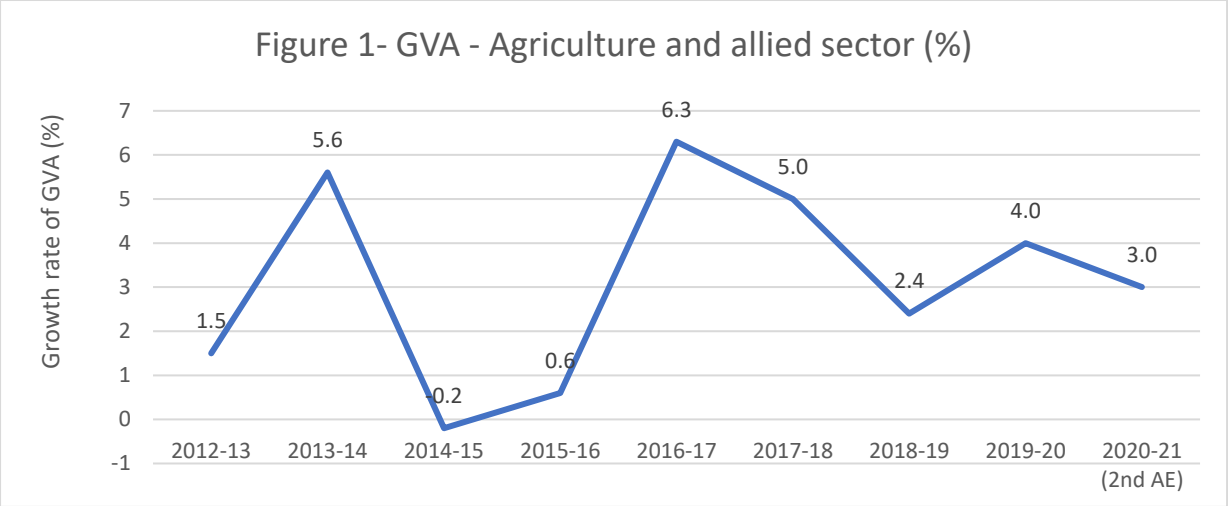
This paper deliberates on a reforms agenda for transforming the sector for doubling farmers' income (DFI) and empowering small and marginal farm holders to move from subsistence farming to farm enterprises integrated to agri-value chains, while managing the VUCA (volatility, uncertainty, complexity, ambiguity) world to mitigate agrarian distress.

The rest of the paper is organised as follows: Section 2 presents growth trends in Indian agriculture during the period 2010-11 to 2019-20. Critical issues and challenges in the agriculture sector in India are discussed in section 3. Section 4 presents the agenda for reforms to transform Indian agriculture. Section 5 concludes the paper.

2. Indian Agriculture Sector: Growth Trends

[†] Based on data accessed from Press Note - First Advance Estimates of National Income, 2020-21, National Statistical Office Ministry of Statistics & Programme Implementation, Government of India

The average annual growth of agri-GVA during the period 2012-13 to 2020-21‡ stood at 3.1 percent. The period witnessed sharp dips in the growth in 2012-13 (1.5 percent), 2014-15 (-0.2 percent) and 2015-16 (0.6 percent) (Figure – 1), due to less than normal monsoon rainfall in these years. On the other hand, good monsoon rains resulted in high growth rates in agri-GVA during the years 2013-14 (5.6 percent), 2017-17 (6.3 percent), 5.0 percent (2017-18), 4.0 percent (2019-20) and 3.0 percent (2020-21) (Figure-1). However, in spite of India making great strides in terms of food security and being the leading producer of rice, wheat, pulses, sugarcane and cotton, agriculture in the country continues to be heavily dependent on monsoon rains.



Source: Data accessed from: (1) Press Note on First Revised Estimates of National Income, Consumption, Savings and Capital Formation 2018-19, MoSPI, Government of India; and (2) Press Note on Second Advanced Estimates of National Income 2020-21, 26 February 2021, MoSPI, Government of India.

The country recorded its highest foodgrain production of 296.7 million tonnes (MT) in 2019-20 (Table–1). However, the CAGR of foodgrain production during the period 2011-12 to 2019-20 was only 1.8 percent, due to low CAGR of rice (1.6 percent), wheat (1.7 percent), and nutri/ coarse cereals (1.5 percent). Pulses recorded the highest CAGR of 4.5 percent, due to sharp increase in production in 2016-17, as the farmers were encouraged to grow pulses, on account of significant increase in minimum support prices (MSPs).

Among commercial crops, groundnuts experienced the highest CAGR of 4.2 percent, during the period under review (Table-2). The CAGRs of other crops were very low, e.g., Soybean (-0.9), sugarcane (0.7 percent), tea (2.7 percent), coffee coffee (-0.3 percent), cotton (-1.3 percent), and jute and mesta (-2.0 percent).

‡ 2020-21 data is as per Second Advance Estimate of GDP, 26 February 2021, MoSPI, GoI.

Table – 1: Foodgrain Production in India (2011-12 – 2019-20) (Million Tonnes)

Crops	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (4th AE)	CAGR(%) 2011-12 - 2019-20
Rice	105.3	105.2	106.7	105.5	104.4	109.7	112.8	116.5	118.4	1.6
Wheat	94.9	93.5	95.9	86.5	92.3	98.5	99.9	103.6	107.6	1.7
Nutri/ Coarse cereals	42.0	40.0	43.3	42.9	38.5	43.8	47.0	43.1	47.5	1.5
Pulses	17.1	18.3	19.3	17.2	16.3	23.1	25.4	22.1	23.2	4.5
Total Foodgrains	**259.3**	**257.1**	**265.1**	**252.0**	**251.5**	**275.1**	**285.0**	**285.2**	**296.7**	1.8

Source: First Advance Estimates of Production of Foodgrains for 2020-21. Ministry of Agriculture and Farmers' Welfare, GoI. Calculations of CAGR by the author

Table – 2: Production of Commercial Crops in India (2011-12 – 2019 – 20)

(Lakh Tonnes)

Crops	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (4th AE)	CAGR(%) 2011-12 - 2019-20
Groundnut	69.6	46.95	97.14	74.0	67.3	74.6	92.5	67.3	101.0	4.2
Soybean	122.1	146.66	118.61	103.7	85.7	131.6	109.3	132.7	112.2	-0.9
Other oilseeds	106.2	115.8	111.74	97.4	99.5	106.6	112.7	115.3	121.1	1.0
Total nine oilseeds	**298.0**	**309.41**	**327.49**	**275.1**	**252.5**	**312.8**	**314.6**	**315.2**	**334.2**	0.9
Sugarcane	3610.4	3412.0	3521.42	3623.3	3484.5	3060.7	3799.1	4054.2	3557.0	0.7
Tea$	10954.6	11350.7	12087.8	11971.8	12331.4	12504.9	13250.5	13500.4	13608.1	2.7
Coffee$	3140.0	3182.0	3045.0	3270.0	3480.0	3120.0	3160.0	3195.0	2993.0	-0.3
Cotton#	352.0	342.2	359.02	348.1	300.1	325.8	328.1	280.4	354.9	-1.3
Jute & Mesta##	114.0	109.3	116.9	111.3	105.2	109.6	100.3	98.2	99.1	-2.0

$ Lakh Kg; # Lakh bales of 170kg each; ## Lakh bales of 180kg each

Source: (1) First Advance Estimates of Commercial Crops for 2020-21, Ministry of Agriculture and Farmers' Welfare, GoI. (2) Handbook of Statistics on the Indian Economy 2019-20, Reserve Bank of India (For Tea and Coffee). Calculations of CAGR by the author

3. Indian Agriculture: Critical Issues and Challenges

India is self-sufficient in the production of foodgrains, horticulture crops and milk. However, Indian agriculture has long been suffering from structural problems, which need to be addressed urgently. Farmers in India, truly live in a VUCA world of volatile prices, uncertain rainfall and income, complex institutional mechanisms, restrictive laws, and policy ambiguities. Some of the critical issues and challenges confronting Indian agriculture are presented in the following sub-sections.

3.1 Small Size of Holdings and Low Income

The predominance of small and marginal holdings in India has resulted in inefficiency in cultivation and low average income of farmers. The findings of NABARD All India Rural Financial Inclusion Survey 2016-17 (NAFIS) (NABARD, 2018), reveal that for agricultural households in the size class of less than 0.1 ha of land, wage labour was the most prominent source of income, with the average monthly contribution of ₹3,508 (43.1 percent) to the total income of ₹8,136, while cultivation contributed 7 percent (₹566). On the other hand, the share of average monthly income from cultivation in respect of agricultural households with landholdings of greater than 2 ha was 51.6 percent (₹7,572) (Table -3). The findings of NAFIS indicate a positive correlation between the average monthly income and size class of land possessed. Further, states like Punjab (₹23,133), Haryana (₹18,496) and Kerala (₹16,927) have witnessed much higher average income of agricultural households, compared to Uttar Pradesh (₹6,668), Andhra Pradesh (₹6,920), and Jharkhand (₹6,991). Therefore, reducing regional disparities in agricultural income need to be prioritised.

Strategies for promoting sustainable agricultural growth and enhancing farmers' income, should include a group approach through farmer producer organisations (FPOs)/ farmer producer companies (FPCs). A group approach can improve market access to land, and help spread the risk of farming among a larger number and increase production opportunities by experimenting with higher value, and more risk prone crops with larger payoffs (Agarwal, 2016). Further, a group would be better placed to enter into non-exploitative contract farming arrangements (ibid.).

Table - 3

Average Monthly Income of Agricultural Household from Different Sources by Size Class of Land Possessed (Rs. per month per household)

Size classes	<0.01 ha		0 .01 to 0.40 ha		0.41 to 1.00 ha		1.01 to 2.00		>2.00 ha	
Source of income	Amount	Share (%)	Amount	Share (%)	Amount	Share (%)	Amount	Share (%)	Amount	Share (%)
Cultivation	566	7.0	1488	22.4	2501	30.6	4485	44.9	7572	51.6
Livestock rearing	1345	16.5	517	7.8	624	7.6	763	7.6	978	6.7
Other enterprises	251	3.1	384	5.8	455	5.6	416	4.2	1030	7.0
Wage labour	3508	43.1	2932	44.1	3044	37.3	2777	27.8	3340	22.7
Govt./ Pvt. Service	2192	26.9	1281	19.3	1398	17.1	1419	14.2	1612	11.0
Other sources	274	3.4	48	0.7	148	1.8	130	1.3	150	1.0
Total income	**8136**	**100**	**6650**	**100**	**8171**	**100**	**9990**	**100**	**14682**	**100**

Source: NABARD All India Rural Financial Inclusion Survey 2016-17 (NAFIS), NABARD

3.2 Low Agricultural Productivity

India is the largest producer of pulses and groundnut in the world, and the second largest producer of paddy, wheat and sugarcane. However, stagnation in yield of major crops has been observed during the past two decades. The average yield of rice increased from 1,901 kg/ha in 2000-01 to 2,705 kg/ha in 2019-20 (Table-4), at a CAGR of 1.8 percent (Table-5). The second decade (2010-11 to 2019-20) witnessed a marginally higher CAGR of yield of rice at 1.7 percent against 1.6 percent in the previous decade (2000-01 to 2009-10). Wheat experienced an increase in average yield from 2,708 kg/ha in 2000-01 to 3,421 kg/ha in 2019-20, at a CAGR of 1.4 percent. The CAGR of productivity of wheat increased from 0.7 percent during the decade 2000-01 to 2009-10 to 1.5 percent during the following decade (2010-11 to 2019-20). Pulses experienced a CAGR of yield of 1.5 percent in both the decades under review.

Among commercial crops, a sharp increase in yield of cotton was witnessed during 2013-14 (532 bales/ ha compared to 190 bales/ ha in 2000-01), due to the introduction of Bt cotton in 2009-10. The CAGR of yield of cotton during the past two decades (2010-11 to 2019-20) stood at 11.3 percent (Table – 6 and Table – 7). However, the CAGR declined sharply from 4.3 percent during the decade 2000-01 to 2009-10 to -2.1 percent during 2010-11 to 2019-20, reflecting a stagnation in yield of cotton, after benefitting from the introduction of Bt cotton.

Groundnut has witnessed an increase in CAGR of yield from 3.3 per cent during the first decade to 4 percent during the following decade (2010-11 to 2019-20), mainly due to the introduction of improved varieties of seed.

Yield of major crops in India also compare poorly with that of other countries in the world. India ranks second in the production of paddy and wheat, but the yields are much below those of other leading producers. India's average yield of paddy in 2016 at 3,790 Kg/ha was much lower compared to China (6,866 Kg/ha), Indonesia (5,236 Kg/ha), Bangladesh (4,586 Kg/ha), Vietnam (5,574 Kg/ ha) and the World average (4,577 Kg/ha) (Figure 2). In case of wheat, India's average yield at 3,034 Kg/ ha, was lower than that of China (5,396 Kg/ha), the US (3,541 Kg/ha), Canada (3,470 Kg/ ha) and the World average (3,401 Kg/ha) (Figure 3).

Table – 4

Yield of Foodgrains in India

(Kg/ha)

Crops	2000-01	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (4th AE)
Rice	1901	2239	2393	2461	2424	2390	2400	2494	2576	2638	2705
Wheat	2708	2988	3177	3117	3075	2872	3034	3200	3368	3533	3421
Nutri/ Coarse cereals	1027	1531	1590	1617	1677	1729	1579	1750	1934	1944	1976
Pulses	544	691	699	789	764	744	656	786	853	757	817
Total Foodgrains	**1626**	**1930**	**2078**	**2129**	**2101**	**2070**	**2056**	**2129**	**2235**	**2286**	**2325**

Source: Handbook of Statistics on the Indian Economy 2019-20, RBI

Table – 5

CAGR of Foodgrains Yield in India

Crops	**CAGR (%) 2000-01-2009-10**	**CAGR (%) 2010-11 - 2019-20**	**CAGR (%) 2000-01 - 2019-20**
Rice	1.6	1.7	1.8
Wheat	0.7	1.5	1.4
Nutri/ Coarse cereals	3.2	2.8	3.6
Pulses	1.5	1.5	2.1
Total Foodgrains	1.6	1.6	2.0

Source: Author's calculations based on data accessed from Handbook of Statistics on the Indian Economy 2019-20, RBI

Table – 6

Yield of Commercial Crops in India

(Kg/ha)

Crops	2000-01	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20 (4th AE)
Groundnut	977	1411	1323	996	1750	1400	1465	1398	1893	1422	2065
Soybean	822	1327	1208	1354	983	950	738	1177	1058	1192	928.0
Total oilseeds	810	1193	1133	1169	1153	1037	968	1195	1284	1271	1236.0
Sugarcane	68577	70091	71668	68254	69839	69859	70720	69001	80198	80105	77893
Tea	1682	1726	1956	2027	2121	2113	2176	2165	2285	2109	2126
Coffee	959	838	852	846	799	847	876	761	765	767	718
Cotton	190	499	491	486	532	461	415	512	443	378	451
Jute & Mesta	1867	2192	2283	2281	2449	2550	2421	2585	2435	2508	2641

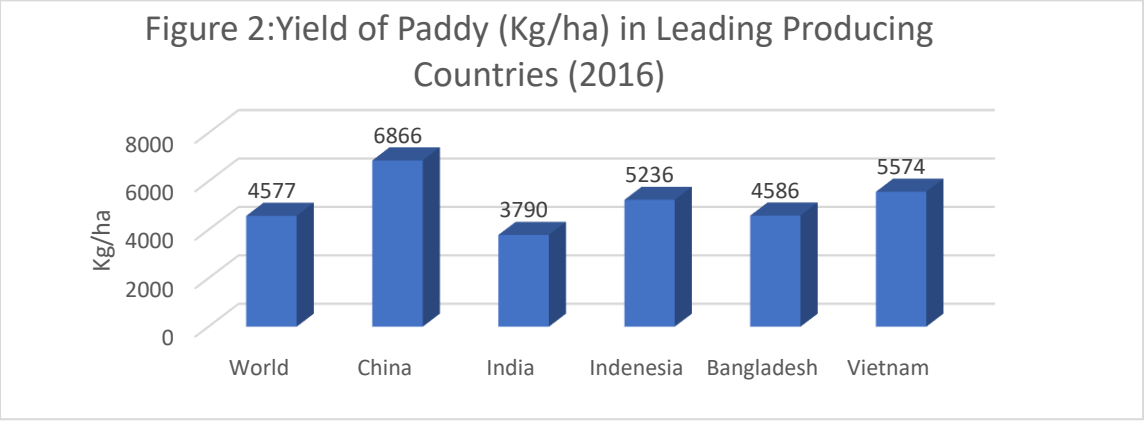
Source: Handbook of Statistics on the Indian Economy 2019-20, RBI

Table – 7

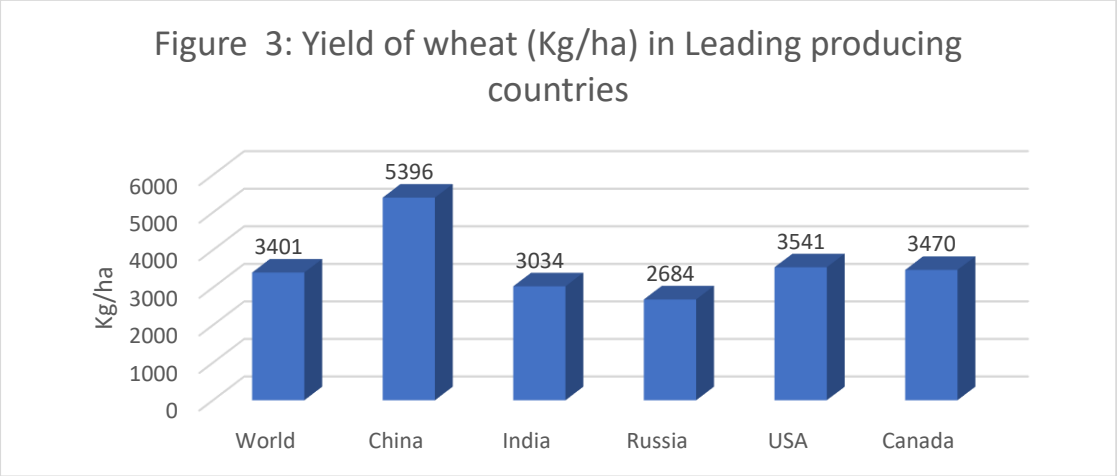
CAGR of Yield of Commercial Crops in India

Crops	CAGR (%) 2000-01- 2009-10	CAGR (%) 2010-11 - 2019-20	CAGR (%) 2001-01 - 2019-20
Groundnut	1.8	4.0	3.3
Soybean	3.0	-2.5	0.6
Total oilseeds	2.6	1.0	2.1
Sugarcane	0.5	1.5	0.9
Tea	0.3	1.9	1.8
Coffee	-2.1	-1.6	-0.7
Cotton#	11.3	-2.1	4.3
Jute & Mesta##	1.8	1.7	1.7

Source: Author's calculations based on data accessed from Handbook of Statistics on the Indian Economy 2019-20, RBI



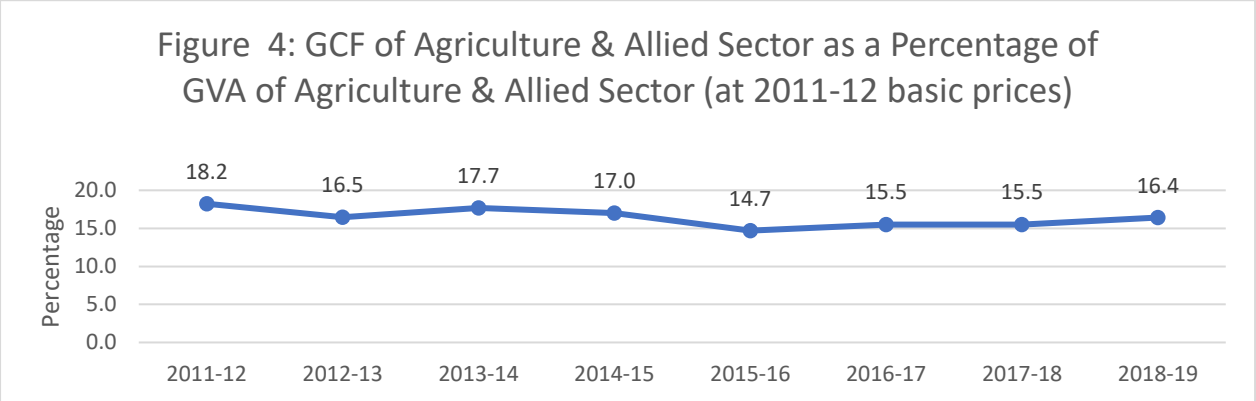
Source: Data accessed from Agricultural Statistics at a Glance 2018, Ministry of Agriculture and Farmers' Welfare, GoI



Source: Data accessed from Agricultural Statistics at a Glance 2018, Ministry of Agriculture and Farmers' Welfare, GoI

3.3 Stagnant Capital Formation in Agriculture

Capital formation in agriculture is of critical importance for the sustainability of agricultural growth. The percentage share of Gross Capital Formation (GCF) in agriculture and allied sector in the Gross Value Added (GVA) of the sector, declined steadily from 18.2 percent in 2011-12 to 14.7 percent in 2015-16, before rising slowly to 16.4 percent in 2018-19 (Figure-4), which is too meagre to address the issue of sustainability of Indian agriculture. Therefore, capital formation through rural infrastructure development assumes significance. Public sector investment in rural infrastructure would result in high growth of the agricultural sector, and could also crowd-in private sector investment.



Source: Based on data accessed from Economic Survey 2020-21, Ministry of Finance, GoI and National Income Statistics 2020, MoSPI, GoI

3.4 Climate Change and Agriculture

Climate change poses a major and growing threat to food security (FAO, 2016). It would be a daunting challenge to produce enough food for the increasing population in the face of decreasing resources and changing climate. The extent of the estimated adverse impact of

climate change on crop yields in India and selected regions of the world is presented in Table-8. The estimated loss in yields in respect of major crops like rice (-30 per cent), wheat (-23 per cent) and maize (-31 per cent) during 2050-69 in India, due to climate change is quite alarming. Further, the net emissions from agriculture in carbon dioxide equivalent in 2014 in the world was as much as 5,241,761 thousand tonnes. China (707,640 thousand tonnes), India (626,864 thousand tonnes) and Brazil (441,905 thousand tonnes) account for the major quantum of net emissions from agriculture.

Table – 8

Projected Changes (%) in Crop Yield Due to Climate Change

Geographical location	Period	Crops (Estimated yield change)
China	2050-69	Soybean (-45.9)
India	2050-69	Maize (-31), Soybean (-32.9)
Central India, South India, Sri Lanka	2050-69	Rice (-30), Wheat (-23)
South Asia	2050-69	Major crops (-18.9)
World	2050-69	Major crops (-8.2)

Source: Table A.1, State of Food and Agriculture 2016, FAO

3.5 Market Constraints

A critical problem faced by India's agriculture sector is the fragmented and distortions-ridden state of agricultural markets. One of the major reasons for low income of farmers is lack of competitive market structure, which is bereft of transparent price discovery system. Small and marginal farm holders lack the bargaining power to sell their produce at remunerative prices due to the exploitation by traders (*arhatiyas*) in the Agriculture Produce Marketing Committee (APMC) markets. Lack of aggregation of produce makes it uneconomical for farmers to transport their produce to the APMC markets for their sale.

GoI announces Minimum Support Price (MSP) in respect of 23 commodities. However, only few states like Punjab, Haryana and M.P., have strong procurement systems and FCI procures major quantities of wheat from these states (84.8 percent during Rabi Marketing Year 2020-21). Farmers in these states are able to sell wheat and paddy at MSPs, which over the years have incentivised farmers to shift to water-guzzling paddy farming from traditional maize cultivation, leading to over-exploitation of groundwater. Paddy procurement during 2020-21 is dominated by Punjab, U.P. and Haryana, accounting for almost 50 percent of total.

It is argued that the demand for legal status for MSP is untenable as the Centre does not have the wherewithal to buy all the 23 commodities, and fearing legal action, private players would avoid buying. Interestingly, the Commission for Agricultural Costs and Prices (CACP) in its Kharif Policy 2018-19 had suggested a legislation conferring on farmers 'the Right to Sell at MSP.' This idea is worth considering.

4. Transforming Indian Agriculture: Agenda for Reforms

An agenda for reforms to transform Indian agriculture is presented in the following sub-sections.

4.1 Doubling Farmers' Income

GoI has envisioned the achievement of doubling farmers' income (DFI) by the year 2024-25. The following seven-point strategy for DFI is mostly under implementation: (i) irrigation with focus on water-use efficiency, viz. "per drop more crop" (PDMC) through Pradhan Mantri Krishi Sinchayee Yojana (PMKSY); (ii) quality seed and soil health, (iii) investments in warehouses and cold chains; (iv) value addition through food processing; (v) electronic National Agriculture Market (e-NAM); (vi) increase in the coverage and effective implementation of Pradhan Mantri Fasal Bima Yojana (PMFBY); and (vii) promotion of ancillary activities like dairy, poultry, bee-keeping and fisheries. The strategy for DFI, involving increase in private investment by 6.62 per cent per annum from the base year 2015-16 at the national level, should also include among others: (a) promoting higher agricultural growth in less developed regions, including rainfed areas, with a focus on marginal and small holders; (b) strengthening livestock related activities and crop diversification to high value produce like horticulture, in line with market signals; (c) shifting priority focus to post-production management and the agricultural marketing system; (d) sizeable increase in institutional credit to farmers; (e) allocation of more resources by state governments towards minor irrigation; and (f) incentivising private corporate sector to participate in investments in agriculture (GoI, 2017). In order to achieve DFI, GoI can use income policy to protect the poor, free up prices for farmers, and allow private trade to stock and operate freely and have unhindered exports (Gulati and Hussain, 2017). What is also needed is the continuance of PM-KISAN, with possibly a higher allocation, along with top-up by states, on the lines of YSR-Rythu Bharosa-PM-KISAN of Andhra Pradesh.

4.2 Irrigation and Water-use Efficiency

India is a water-stressed country, and the declining per capita availability of water in the country poses a major challenge to the growth of agriculture. Out of the country's 4 percent share of global freshwater availability, the agriculture sector consumes about 78 percent share of water (Sharma, et al., 2018). However, while only 48.7 per cent of the net sown area in the country is irrigated, the depletion of groundwater, which accounts for about 60 per cent of the country's irrigated area, has adverse impact on irrigation cost and crop productivity. Therefore, implementation of PMKSY and PDMC should create higher irrigation potential and ensure water-use efficiency.

Water-guzzling crops like paddy and sugarcane together occupy about 25 percent of the gross cropped area and consume over 60 per cent of the total irrigation water supplied to agriculture, leaving most of the other crops water-starved (Sharma, et al., 2018). The overall irrigation efficiency in India is observed to be low compared to global standards due to the use of conventional flood irrigation technique, practised in large parts of the country.

In order to improve water-use efficiency of crop cultivation, the use of precision irrigation technologies needs to gain momentum. Water stress can be reduced and availability of water can be increased through cost-based water pricing. There is also a need to make a paradigm shift from use of input intensive technology to significantly enhancing input productivity, e.g., the use of water-saving technology like micro-irrigation, System of Rice Intensification (SRI), direct seeded rice, zero tillage, etc.

4.3 Tech-driven agriculture

According to NITI Aayog (2018), Artificial Intelligence (AI) will have significant global impact on agricultural productivity at all levels of the value chain. AI and embedded systems in agriculture sector via smart irrigation system can result in the efficient use of water resources. Drip irrigation system can be fully automated using IoT, resulting in significantly higher crop yield due to much better water-use efficiency than traditional drip irrigation system. NITI Aayog and IBM have partnered to develop a crop yield prediction model using AI to provide real time advisory to farmers. Also, Microsoft in collaboration with ICRISAT, has developed an AI Sowing App. The app sends sowing advisories to participating farmers on the optimal date to sow.

According to NASSCOM and Zinnov (2020), agri-tech start-ups are using technology drivers such as AI, machine learning (ML), robotics and satellite communication to serve farmers' needs. The interface of agriculture with technology steered entrepreneurship is increasing competitiveness, leveraging digitisation and relying on innovation to solve varied challenges in the sector (Kant, 2021). There are 735 agri-tech start-ups in India which are enabling Indian agriculture to become future ready, by facilitating small and marginal farm holders to adopt precision agriculture, while significantly raising crop productivity and improving resource-use efficiency. There is a need to scale up the agri-tech start-up ecosystem for the benefit of majority of farmers.

4.4 Agriculture Marketing Reforms

GoI's vision of DFI signified a paradigm shift in agriculture policy from ensuring food security to income security of farmers, by maximising their gains through post-production activities. The enactment of Farmers' Produce Trade and Commerce (Promotion and Facilitation) Act, 2020 (FPTC Act, 2020), Farmers (Empowerment and Protection) Agreement on Price Assurance and Farm Services Act, 2020 (FAPAFS Act, 2020) and Essential Commodities (Amendment) Act, 2020 (ECA, 2020), signifies the ushering in of the long-awaited comprehensive agri-marketing reforms.

The FPTC Act, 2020 enables the creation of an ecosystem where farmers and traders would enjoy the freedom of choice relating to sale and purchase of farmers' produce which facilitates remunerative prices through competitive alternative trading channels, involving barrier-free inter-state and intra-state trade. Further, in order to develop an efficient nation-wide agri-marketing system, e-NAMs need to be scaled up and made more efficient, and all private markets and accredited warehouses should be linked to e-NAMs.

The FAPAFS Act, 2020 provides for a national framework on farming agreements that protects and empowers farmers to engage with agri-business firms, processors, wholesalers, exporters or large retailers for farm services and sale of future farming produce at a mutually agreed remunerative price framework in a fair and transparent manner. The fear of exploitation of farmers by corporate entities can be addressed if FPOs become party to the contract farming

agreements[4]. Further, Section 14(1) of the Act could be considered for amendment to allow farmers/ FPOs to have the option to approach District Courts for settlement of disputes. The new Acts are expected to create an ecosystem which promises to enable farmers to come out of the VUCA world.

An important announcement in the Union Budget 2021-22 has been the availability of Agriculture Infrastructure Fund (AIF) to APMCs for augmenting their infrastructure facilities. Also, 1,000 more APMC *mandis*, will be integrated with e-NAMs (from the present 1,000 e-NAMs). These announcements should assure farmers that APMCs are here to stay, and would indeed grow stronger, to face competition from private markets, leading to transparent price discovery, while benefitting the farmers, especially the small and marginal holders.

4.5 Rural Infrastructure and Efficient Agri-Value Chains

Investment in rural infrastructure is a pre-condition to enable the acceleration of agricultural growth, creation of new economic opportunities, and generation of employment. It is, therefore, worth appreciating that the Union Budget 2021-22 has enhanced the allocation under Rural Infrastructure Development Fund (RIDF), administered by NABARD, by a whopping 33.3 percent to ₹40,000 crore over the allocation in the previous year's Budget. During its 26-year journey, RIDF has evolved into a dependable and timely source of funding for rural infrastructure projects for state governments.

Setting up of mega food parks, integrated cold chains, food processing units, agro-processing clusters, and implementation of Operations Greens Scheme, under GoI's comprehensive package of PM Kisan SAMPADA Yojana (PMKSY) , will not only provide a big boost to the growth of food processing sector in the country but also ensure higher income to farmers, while creating huge employment opportunities especially in the rural areas, reducing wastage of agricultural produce, and enhancing the export of processed foods. The Production Linked Incentive (PLI) Scheme for the food processing sector is a step in the right direction.

India is the largest producer of milk in the world, having increased from 146.3 million tonnes in 2014-15 to 198.4 million tonnes in 2019-20 (GoI, 2021). The country is also the second largest fish producing country in the world, and fisheries is the fastest-growing (12 percent real

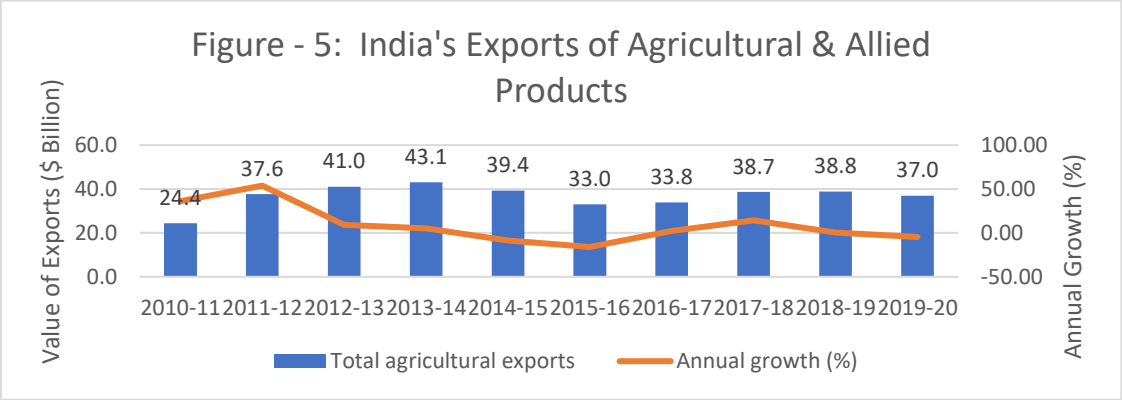
[4] As per Section 10 of FAPAFS Act, 2020 .

GVA growth in 2018-19) sub-sector of agriculture and allied sector. A focus on development of efficient dairy and fisheries value chains could significantly increase employment and improve the income of smallholder farmers.

4.6 Agriculture Export Reforms

India ranks among the top ten exporters of agricultural products in the world. According to WTO's *World Trade Statistical Review 2020*, the country's share in global agricultural exports increased from 1.1 percent in the year 2000 to 2.2 percent in 2017, valued at $39 billion, but fell to 2.1 percent in 2019, valued at $37 billion. In order to catch-up with Brazil ($89 billion) and China ($82 billion), India needs to bring about structural reforms in the agriculture sector, including a stable trade policy regime (Roy, 2021).

India's agricultural exports experienced huge fluctuations during the ten-year period 2010-11 to 2019-20 (Figure – 5). The ten-year CAGR was 1.7 percent. During the first five-year period 2010-11 to 2014-15, agri-exports increased at a CAGR of 11.5 percent. The second five-year period (2015-16 to 2019-20) witnessed a slump in the CAGR to 3.7 percent, from the previous period.



CAGR: 2010-11 to 2019-20 = 1.7%; 2010-11 to 2014-15 = 11.5%; 2015-16 to 2019-20 = 3.7%

Source: Author's calculations based on data accessed from Economic Survey, Government of India (various issues) and World Trade Statistical Review 2020, WTO

The Agriculture Export Policy (AEP), 2018 of GoI, aims at achieving an export target of $60 billion by 2022 and $100 billion within a few years, thereafter. This is indeed a humongous task, and achieving the target would involve a paradigm shift from a "business-as-usual" approach to a well-calibrated, comprehensive, strategic and result-oriented agri-export policy and action plan.

The agri-export strategy should include integration of value-added agri-produce with global value chains (GVC), by adopting the best agricultural practices involving productivity gains and cost competitiveness. Also, in order to boost exports of dairy products and make the dairy sector globally competitive, GoI needs to consider the development of Dairy Export Zones (DEZs) in collaboration with state governments (Roy, 2021). The AEP has recommended the establishment of Agriculture Export Zones (AEZs), to facilitate value addition of agri-commodities for increasing exports in a WTO compatible manner. In order to ensure higher income to farmers, FPOs need to be linked to AEZs to supply SPS-compliant agri-products.

4.7 Climate Mitigation and Adaptation for Sustainable Agriculture Development

Climate Smart Agriculture (CSA) works to reconcile the objectives of sustainably increasing agricultural productivity and incomes, building resilience and adapting agriculture to climate change, and reducing and removing greenhouse gas emissions from agriculture (FAO, 2019). Drip irrigation is a CSA technology, which saves water and energy, while reducing GHG emissions. Expansion in the use of solar-powered AI-based drip irrigation systems across all states in India and for major crops, viz. rice, wheat, horticultural crops and sugarcane can be an integral part of a Water-Energy-Food (WEF) nexus approach to support water-use efficiency, use of renewable energy and mitigation of GHG emissions, food security and sustainable agriculture. The WEF nexus approach helps us to better understand the complex and dynamic interrelationships between water, energy and food, so that we can use and manage our limited resources sustainably (FAO, 2014).

A viable model of "solar trees" in farms where FPOs can own solar panels as source of irrigation and also income for farmers by selling power to the grid, needs to be promoted. This model along with GoI's Ministry of Non-Renewable Energy's scheme KUSUM, Gujarat Government's Suryashakti Kisan Yojana, Tata-IWMI Dhundi cooperative project *Solar Power as Remunerative Crop* in Gujarat, and other state-run solar-powered irrigation systems, would enable the achievement of Government of India's target of 175 GW installed capacity of renewable energy by 2022, while increasing the scope for India to raise its Nationally Determined Contribution (NDC) ambition of reducing GHG emission.

Methane (CH_4) emissions contribute to a third of the current anthropogenic GHG warming. Paddy cultivation contributes about 15-20 percent of the total anthropogenic CH_4 emissions.

Methods like System of Rice Intensification (SRI), drip irrigation, soil amendments, organic matter management, different tillage, rotation, and cultivar selection, can facilitate mitigation of methane emission (Roy, 2020).

4.8 Research and Development and Extension Services:

The needs of farmers in terms of information and technology support have become more complex, due to the rapid pace of developments in the agriculture sector. India needs a vibrant, responsive, market oriented and globally competitive agricultural research ecosystem (NITI Aayog, 2017). However, budgetary allocation for research and development in agriculture has remained meagre, viz. ₹8,514 crore in Union Budget 2021-22, which is much below the agri-R&D spent by global private companies like Bayer (Gulati, 2021). Therefore, budgetary resources for R&D on seeds (HYV and GM), and agri-technology, need to be enhanced significantly. The private sector, too, needs to enhance investment in R&D.

Further, there is a need to revitalise agriculture extension services by making them more relevant and useful in order to improve agricultural productivity. Also, efforts need to be made to enhance post-harvest processing and value-added activities at the farm. FPOs/ FPCs could be developed into alternative agencies for providing extension services to farmers.

4.9 Agriculture Credit

Adequate and timely availability of bank credit, at affordable rates of interest is essential to improve agricultural productivity and sustainability. Therefore, the enhancement in the target for agricultural credit to ₹16.5 lakh crore in the Union Budget 2021-22 from ₹15 lakh crore in FY21, is welcome. It is also important to note that the focus will be on ensuring increased credit flows to high-growth and high-value activities, viz. animal husbandry, dairy, and fisheries. A thrust on credit by banks to these sub-sectors along with horticulture, farm mechanisation, warehouses and cold chains, to farmers, FPOs and agripreneurs, is imperative to increase the share of agriculture term loans in total agriculture credit disbursed, from the current 40 percent to 60 percent, to accelerate capital formation in agriculture.

4.10 Risk Management

The PMFBY is a path-breaking scheme which aims to provide insurance coverage and financial support to the farmers in the event of failure of any of the notified crops as a result of natural

calamities, pests and diseases. It also aims at stabilising the income of farmers to ensure their continuance in farming. Further, it encourages farmers to adopt innovative and modern agricultural practices, to ensure flow of credit to the agricultural sector. However, the problem of delay in settling of claims needs to be addressed urgently by state governments and insurance companies. Further, FPOs need to educate and sensitise small and marginal farm holders about the importance of PMFBY in risk mitigation.

Futures markets provide a market mechanism to balance the imbalance of the supply-demand pattern of agricultural commodities. Trading in futures not only provides price signals to the market of today, but also of months ahead, and provides guidance to sellers (farmers/ growers/ processors) and buyers (consumers) of agricultural commodities in planning ahead and, in financing and marketing commodities. Further, the combination of futures and options can give market participants the benefit of price discovery of futures and simpler risk management of options. FPOs need to be encouraged to participate in futures and options trading of NCDEX.

5. Conclusion

An enabling environment for agricultural sustainability needs to be created through massive investment in irrigation, with a focus on water-use efficiency, enhancement in total factor productivity of crops, tech-driven agriculture, climate-smart agriculture, creation of rural infrastructure, development of efficient agri-value chains, agri-marketing reforms, promotion of agri-exports, enhancing spending on R&D, credit innovations, and agri-risk management. Also, tenancy reforms need to be carried out by states. Effective implementation of these transformative strategies, could lead to sustainability of Indian agriculture, and facilitate the achievement of doubling farmers' income by 2024-25, while mitigating agrarian distress.

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