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Analysis of Trends in Smart Agricultural Transformation in India

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Abstract

India is the largest country in the world in terms of area under cultivation. There has been a shift in policy paradigm from production orientation to marketing with the implementation of Doubling Farmers' Income Committee Report in 2017. For doubling farmers' income, agriculture has to be transformed to Smart Agriculture or what is known in common parlance as Smart Agriculture Transformation (SAT). The objective of the study is to assess the readiness for SAT in India. Components of SAT are: Digitalisation of trading process, promotion of online trading; Uberisation of agricultural commodities; Construction of specialised e-markets with infrastructural facilities and formation of agricultural production centres in the country. The readiness for SAT is assessed on the basis of such conditions. Analysis of different indicators for assessing readiness towards SAT in India has revealed that more than 50% of essential components of Readiness indicators for SAT are much below the desired level and 25% of essential indicators of Readiness are non-existent. Moreover, major stakeholders of agricultural transformation, particularly small holders and agricultural labourers, petty traders and marketing agents need to be revamped. The decline in public investment in agriculture coupled with neo-liberal economic policies have slowed down the transformation process in the country. The study concludes that transformation of agriculture into Smart Agriculture in India demands active intervention of the Central and State Governments in agriculture and allied sectors with substantial hikes in public investment as 80% of farmers are incapable undertaking investment for infrastructure development. The case studies reveal that the specialised markets for coriander, cumin and other important food products do not adhere to basic minimum hygienic conditions required for the promotion of export to international markets.

Introduction

The concept of Smart Agricultural Transformation (SAT) is different for different countries and its modalities and application do vary across nations. SAT includes three components, *viz.*,(i) Smart; (ii) Agriculture; and (iii) Transformation. The word 'Smart' refers to application of modern technology in every sphere of agriculture to achieve the objective of augmenting income per unit of investment. In this context, transformation refers to changes in the structure, functions and role of institutions and functionaries enabled by a collective political (enabling) environment to address the objective of augmenting farmers' income per unit of time, capital and land. There were a set of enabling factors for SAT to come into existence and such enabling factors do vary across states. Broadly, such enabling factors include core elements of planning and delivery (Boettiger *et al.*, 2017). Those enabling factors are clubbed together and form Readiness Indicators

and a country's status of SAT is measured in terms of level of such indicators. There were several attempts to assess the Readiness of Agricultural Transformation in the Indian context and the attempts have broadly concluded that there exist serious shortfall to support transformation. Shortfalls include enabling political leadership, lack of accessibility to good analytics and misalignment of key stakeholders in the transformation process (*ibid*). However, the level of readiness of these indicators is rather hard to measure while other indicators such as government's allocation in the budget for agriculture, technological advancement and risk aversion and mitigation mechanism can be measured.

India was the fifth largest economy in the world with a size of US $ 2.9 trillion in 2019 (GoI, 2020). The world output growth registered a deceleration in growth rate from 2.9% since the financial meltdown in 2009 and it has left, reckless and unprecedented down turn in the domestic economy of India. Uncertainties have driven major economic powers like USA and China to resort to protectionist regime of 20th century and it has further added to the slowdown in the Indian economy. Amidst the weakened performance of the global trade and manufacturing, annual average growth rate of GDP was 4.8% in 2019-20,a normal year before the Covid-19 pandemic. The deceleration in real GDP growth in India is attributable equally to supply and demand side constraints. In the demand side, decline in the rate of growth of real fixed investment, induced by sluggish growth in real consumption and contraction of exports. Consequent upon the sluggish growth rate, number of casual farm labourers declined by 3.2 million or from 10.9 to 7.7 million during the period between 2011-12 and 2017-18(GoI, 2020).

Although agriculture is one of the relatively explored area of research in the Indian context, yet research is confined to erstwhile policy paradigm of augmenting production and productivity along with state's assurance of remunerative price (Mohanakumar, 2014; Patnaik, 2015). While emphasising the importance of the price factor, post-production process and trade assume special significance. The study on Indian Agriculture and allied sectors by Doubling Farmers' Income (DFI) committee, made an attempt to place Indian agriculture in the global scenario with emphasis on income augmentation through trade. The DFI Committee stressed the need for transforming Indian agriculture through technological change (GoI, 2017). In a study of ten major e-markets in the state of Karnataka, Aggarwal, *et al* (2016) argued that the agricultural commodity markets in India called for reforms with a focus on rules and regulations, building up institutions and incentivising agents in the market by digitalising the trading activity in Electronic National Agricultural Market (e-NAM) (Aggarwal*et al.*, 2016). In a study on making Smart Agriculture Transformation, Beriya and Saroja (2019) observed that smart technology helped reducing input costs and brought the supply price down by augmenting productivity. The study suggested that digitalisation of agriculture, particularly marketing, had helped farmers to have a data driven and customised decision support system. Readiness for agricultural transformation demands that transformation process in agriculture calls for a common set of institutional, organisational and political factors. The study has adopted 25 indicators to measure the level of readiness for agricultural transformation. The study on Climate Smart Agriculture (CSA) in India underlined the importance of adapting technical change and use of advanced science in agricultural practices

for augmentation of production and productivity without compromising on the neutral impact on climate (Shelat,2014). Against the backdrop, objectives of the paper are two-fold: i) Identify important bottlenecks and constraints in the transformation process to SAT and CSA; (ii) Assess the readiness for transformation into SAT in India. Given the objectives, discussion in the paper is organised as follows. Following the introduction, section 1 critically reviews the performance of agriculture and allied sectors in India during the post-liberalisation period with a focus on major bottlenecks which constrain the transformation of Indian agriculture into Smart Agriculture. In section 2, major policy initiatives for SAT are reviewed and section 3 assess the readiness for SAT in India. Major gaps in SAT are discussed in section 4 and the study is concluded in section 5.

SECTION 1

1.1 Performance of Agriculture and Allied Sectors in India- Analysis of Post-Reform Period

The growth strategy has shifted from an inward oriented import substituting regime to export oriented growth paradigm by 1980s.The export-led growth has been incorporated into the main thrust of the development paradigm by early 1990s with the introduction of economic reforms in June 1991 and subsequent implementation of regulations under WTO. Ever since, policy outlook has been fine-tuned to carve out a larger share in the external market. Agriculture and allied sectors have been incorporated into the export orientation framework as one of major drivers of its growth. Although India occupies a leading position in the global trade of agricultural commodities, yet value of agricultural export from India accounted for only 2.15% of the world trade in agricultural commodities (Govt. of India, 2019). It is notwithstanding the fact that the total arable land in India is the largest as compared to USA, China and Canada. Export of agricultural commodities from India valued at Rs 2746700 million while its import valued at Rs 1370000 million in 2018-19 (GoI, 2020). It may also be noted that trade surplus in agriculture and allied sectors helped the country to keep its trade balance to its present position. On diversification of external markets for agricultural commodities from India, USA, Saudi Arabia, Iran, Nepal and Bangladesh continue to be major markets and, to an extent, it is attributable to likeliness in agricultural production and consumption pattern. The underlying thrust of the policy shift is the swing away from improvement in production and productivity to income enhancement of farmers. The Prime Minister of India announced the shift in agricultural policy on 28th February 2016, at Rai Bareilly in Uttar Pradesh. It has been incorporated into the main frame of agricultural policy as Doubling Farmers' Income (DFI) by 2022 ever since the announcement. Agriculture and allied activities, particularly crop husbandry, has been transforming into an economic enterprise. Agriculture is comprised of two segments, *viz.*, production and post-production. The post-production is the source of value addition and income enhancement. In other words, the change in policy paradigm focusses more on post-production and marketing of the produce under the new economic paradigm for agricultural sector in India.

There has been a renewed policy thrust to revive agricultural growth since the mid-2000s. The government has initiated programmes such as interest subvention on crop loans, National Food

Security Mission, Rashtriya Krishi Vikas Yojana (RKVY), Pulses Development Programme, Soil Health Card Scheme, Pradhan Mantri Krishi Sinchai Yojana, National Agricultural Market for Electronic Trading, National Livestock Mission, and Pradhan Mantri Fasal Bima Yojana. These schemes are multi-pronged and are aimed at augmenting farmers' income as part of DFI.

The departure from the focus on production to income approach has evolved from the perspective that post-production activities are crucial. In other words, the shift in approach needs promotion from "fork- to-farm" demand and price signals, rather than a "farm-to-fork" push. As the Indian farming system is mostly rain-fed and dependent on weather changes, which are beyond the regulatory capacity of farmers, farmers are not assured of a positive return from crop production. The income approach takes into account output, input and product prices. In order to increase net income of farmers, efficient monetization of production is inevitable. There is also a need for creating an enabling environment for post-production activities, and, therefore post-production policy regime needs to be addressed in the perspective of what market demand. In order to achieve the objective of promoting post-harvesting process, constraints of small holders along with diversified crop production in small quantities need to be addressed. Moreover, there has not yet been a breakthrough in production and post-harvesting technology since 1960s, rural infrastructure for primary processing of harvested crops, lack of warehousing, inefficient system of marketing of agricultural produce and huge post-harvest losses. Wide gap exists in invention of technology by institutions and its innovation at the farm level or what is called the long gestation period between technology invention and its innovation. Major structural rigidities on transforming agriculture into a profit-making and sustainable enterprise is the drought-resistant crop varieties and absence of sustainable management of surface and ground water resources. An income support scheme to major agricultural produce would not resolve the crisis in Indian agriculture in as much as terms of trade has turned against agriculture since the late 1980s. It neutralises total factor productivity and inflationary pressures (GoI,2017). While acknowledging the hike in administered prices through Minimum Support Price (MSP), a more effective intervention needs to be put in place by way of reinforcing and reforming existing institutions for post-production processing and value realization through creating better marketing facilities. It would help to link farmers with domestic and external markets. The newly or reformed institutions should address myriad forms of agricultural production, for which agricultural policies be product and content specific.

The recent debate on economic slowdown in India is centred around the fall in consumption expenditure in rural India and it may be viewed from the perspective of stagnation in the farm production sector since early 2010s. Enhancement of income of agriculture sector would drive down poverty and ensure better living standard and inclusive growth. In 2004, National Commission for Farmers was set up and the Commission submitted its final recommendation in October 2006. Among its major recommendations, assurance of a minimum support price, making agriculture a sustainable source of livelihood to people in rural India, and ensuring a remunerative income through adequate intervention in post-harvest issues were important. It is worth pointing out that land reforms, application of science and technology, especially soil testing to disseminate use of fertilizers, optimum use of water resources', augmenting productivity and providing credit were important recommendation of the Commission. In conformity with

the neo-liberal policy framework of the government, the Commission recommended integration of domestic market by removing trade barriers across states in India and Indian market with the world market. The recommendation appears to be the source of price stability and crisis in the farm sector.

The DFI Committee observed that 22.56% of farmers are still below the official poverty line primarily because the average monthly consumption expenditure of an agricultural household in India was Rs 6223 against an income of Rs 6426. Further, agriculture situation in India is fraught with a handful of deficiencies due to sheer negligence of scientific cultural practices in agriculture and allied sectors. The 70th Round of NSSO survey sub-divided the total income of agricultural households by major economic activity under the broad industrial classification of agricultural and allied activities. It was estimated that out of the total annual income of Rs. 77,976 of an agricultural household, 47% was contributed by cultivation(crop production) and agricultural wages and salaries constituted 32% followed by livestock (13%) and non-farm business 8%. Comparable data of income of agricultural households are available for 2002-03 and 2012-13. During this period, agricultural households' income registered an annual growth rate of 11.8% at current prices and 3.6% at constant prices and the rate of growth was much less than the GDP growth rate in real terms. It may also be noted that there was negative growth rate in agricultural households' income in seven states. Using the growth rates for current and constant prices, agricultural households' income was estimated by DFI Committee and found it to be Rs. 96,703 at current prices and Rs. 74,108 in 2015-16 at 2011-12prices. The DFI Committee also estimated the annual income for agricultural households for different size class of land holdings and found that the income of small and marginal farmers in 2015-16 was Rs. 79,779 at current prices. The corresponding figure for large farmers was Rs. 6,05,393. It provides a pointer to the level of inequality exists among farming community at large.

The average annual income of agricultural households from all components of income, *viz.*, cultivation, livestock, non-farm business, and wages and salaries were Rs. 77,976 in 2012–13. (NSSO, 2014). The average annual income is estimated at Rs. 97,799(As per the estimation of Human Development Study by NCAER, the data is related to the year 2011-12). Although the income from cultivation is nearly the same as revealed by different data sources, yet there is a difference of Rs. 3,000 in the case of non-farm business and Rs. 4,000 in the case of livestock (higher in the case of NSSO). There is a significant difference in the case of annual wage earnings and salaries per agricultural household, which is Rs. 24,801 as per the NSSO's estimate and Rs. 45,783 in IHDS data. These differences could be attributed to the sampling errors adopted by two data sources or it could also be due to non-sampling errors. It has also been found that share of income from cultivation increases with the size of landholdings. At the lower end of the spectrum of land size, wages and salaries constitute the principal source of income. It may be noted that the share of income from wages and salaries, non-farm business and livestock decline as land size increase. From a policy perspective, there is a wide variation in the average agricultural household income across regions in India. Moreover, significant differences exist in agricultural income between two agricultural crop seasons. The agricultural income during *Kharif* season is higher than the *Rabi* season. The all-India average of annual household income during July-December seasons was US$ 302 and US$ 217 for the January-June season and the principal

reason for the difference in agricultural household income between *Kharif* and *Rabi* season were attributed to water scarcity and lack of irrigation. The average income per household from livestock do also vary across states and it shows that there is considerable scope for policy intervention to augment income from livestock for households. The observed differences in the annual income of agricultural households across different sub-occupation within agriculture and allied sectors and across different states in India assume special significance and any policy approach to Indian agriculture needs to take those factors into account.

The share of agriculture and allied sectors in Gross Value Added remain more or less constant around 15% to 18% during the last one decade (GoI, 2022). However, the government has taken measures to increase the Minimum Support Price and provided an assured income support of Rs 6000 per annum to farmers with less than 2 hectares of land. The observed trend in agricultural practices underline that such freebies would not resolve the crisis in the farm sector. However, for farmers, something is better than nothing.

India has a gross cropped area of 198.36 million hectare in which 48.62% (96.46 million hectare) of the area is irrigated. It is worth mentioning in this context that there have been severe agro-climatic constraints in augmenting productivity of major crops. For the optimum use of scarce water, a scheme called 'more crop per drop' has been introduced. The problem of excessive dependence on rainwater remain a puzzle for more than half of the area under cultivation in India. Another major constraint of Indian agriculture for mechanisation is the excessive dependence of the work force on agriculture. In the total workforce dependent on agriculture, 45% are cultivators (farmers) and 55% are agricultural workers. In the rural population, more than 75% of the workforce eke out their living directly or indirectly from agriculture and allied activities. However, agriculture has seized to be a source of livelihood to about 50% of the workforce engaged in agriculture as reported in early 2000s.They would prefer to abandon agriculture, provided an alternative employment avenue is opened to them (NSSO, 2003).

The distress in agriculture was manifested in a spate of suicides of about 0.3 million farmers in two decades from different parts of the country. Against this backdrop that the Government observed "Over the years, several new challenges have emerged before the sector with fragmentation of agriculture holdings and depletion of water resources, ICT based climate-smart agriculture can enhance agricultural productivity and sustainability. Smallholder farming can be a lucrative livelihood opportunity with the application of appropriate technologies and adoption of natural, organic and Zero Budget Natural Farming" (Govt. of India, July 2019: 172). The statement underlines the importance of transforming agriculture with a focus on active and user-friendly technological intervention. The exhortation may be viewed against the hard facts and inadequate public investment in agriculture on the one hand and sharp shooting up of input prices including fertilisers, oil and pesticides.

Another notable characteristic of agriculture situation in India is its preponderance of small holdings (<2 hectare of land)in total operational holdings of agricultural land in India. Small land holders account for 85% of total number of holdings in India. The semi-medium size of holdings (2-4 hectare of land) and medium size of holdings (4 – 10 hectare of land) accounted for 9.45% and 3.76% of total land holdings respectively. Large holdings (>10 hectare of land) accounted

for only 0.57% of the land holdings in India. Conversely, there has been a marginal increase in average size of holdings barring the marginal category of farmers. Table 1 shows the trend in average size, relative share and area under different types of holding.

The credit to farm sector in India shows that there exist significant differences across states in the agricultural credit disbursement. To provide comprehensive coverage of risks from pre-sowing to post harvest against natural non-preventable risks, Pradhan Mantri Fasal Yojana (PMFBY) has been introduced since 2015-16. The PMFBY covers 23% of the gross cropped area in the country under insurance and it is expected to increase the insurance by 50%. The Government has created a national insurance portal for agricultural insurance. It is a web-based integrated IT platform that provides interface among all stakeholders to access data related to insured farmers under PMFBY and Restructured Weather Based Crop Insurance Scheme (RWBCIS). In 2018-19, 564.50 lakh farmer application covering an area of 517.70 lakh have been insured for a sum of Rs 2.35 lakh crore. In 2019, under PMFBY, Rs 17756 crore was claimed and Rs 16763 crore was disbursed. In the country, 23 out of 28 states implemented the scheme. The discussion with the farmers in a district in Jhalawar in Rajasthan revealed that insurance companies cheat farmers by refusing the insured sum in case of death of animal or crop loss. Often, the insurance companies implement the strategy of pocketing farmers' insured amount by stating that the cause of death of animal or crop loss due to natural calamity is not under the scheme (DSJ, 2022). For effective implementation of SAT, a more transparent crop insurance scheme which gain the confidence of farmers need be placed.

Table 1. Relative Share of Land Holdings and Average Size of Holdings 2010-11 and 2015-16

Category of Holdings	Land Holdings (%)		Area (%)		Average Size of holdings (Hectare)	
	2010-11	2015-16	2010-11	2015-16	2010-11	2015-16
Marginal	67.1	68.52	22.50	24.16	0.39	0.38
Small	17.9	17.69	22.1	23.19	1.42	1.41
Semi-Medium	10	9.45	23.60	23.65	2.71	2.70
Medium	4.20	3.76	21.2	19.96	5.76	5.72
Large	0.7	0.57	10.6	9.04	17.38	17.1

Note: 1. Land use statistics is collected in India on a quinquennial basis by the Ministry of Agriculture, Cooperation and Farmers Welfare, Government of India. The latest data is available for the year 2015-16.

Source: Agriculture Census 2015-16, Phase 1, Ministry of Agriculture, Cooperation and Farmers Welfare, Government of India

1.2 Animal Husbandry Sector

India is the largest producer of milk in the world with a production of 209.96 million tonnes in 2020-21 and it has registered an annual growth rate of 8.15% for more than a decade. The per capita availability of milk in India was 427 grams per day in 2020-21. Livestock is the second largest sector in agriculture and allied sectors contributing 4.35% of the Gross Value Added while the crop production sector contributed 10.70% to GVA in India in 2020-21. Livestock sector

has registered a growth rate of 8.5% during the last five years. The Government has launched National Animal Disease Control Programme (NADCP) with a financial outlay of Rs. 133430 million for the period 2019-23. The purpose of the programme is to increase milk production and productivity with a long-term objective of enhancing export earnings from the sector. The productivity of milch animal in India as percentage of other countries is much lower and it has significant bearing on the competitiveness of Indian dairy sector in the international market (Table 2). Another important issue with milk production sector in India is the significant differences in average yield per animal across different states in India (Table 3).

Table 2. Milk Yield Per Animal in India and Other Major Milk Producing Countries

Country	Milk Yield of India as % of Other Countries
European Union	19
Australia	21
Mexico	28
Argenina	24
New Zealand	33
Russian Federation	29
Ukraine	37
Brazil	100
Pakistan	93
China	39

Source: Dairyman

Table 3. Average Milk Yield per Animal per Day (milk in kg)- 2018

States	Buffalo	Cow-Exotic	Cow- Indigenous
Andhra	4.73	7.42	2.08
Bihar	3.95	6.11	2.94
Gujarat	4.87	8.94	4.07
Haryana	7.54	8.37	5.22
Karnataka	2.7	6.11	2.35
Kerala	3.28	3	0.59
M.P.	3.98	7.38	2.52
Maharashtra	4.35	7.08	1.76
Punjab	8.72	11.04	6.59
Rajasthan	5.76	7.75	3.68
Tamil Nadu	4.42	6.87	2.71
UP	4.45	7.09	2.59
West Bengal	5.42	3.58	2.65
India	4.91	6.78	2.50

Source: Economic Survey, 2018.

1.3 Indian Agriculture in the World Economy

India ranks first or second in the production of several agricultural commodities in the word (Table 4). However, the issue of concern is the low productivity. Table 4 compares characteristic features of Agriculture in India with major producers in the world.

Table 4. India's Position in the World Agriculture (2016)

Item	India	World	India's share in the world & Rank
Arable land (Area million hectare)	156.46	1423.79	10.99 (1)
Total Cereal Production (Million tonnes)	297.85	2909.20	10.24 (3) After China and USA
Pulses (Million tonnes)	18.15	83.46	21.75 (1)
Oilseeds Production (million tonnes)			
Groundnut (in shell)	7.46	44.91	16.62 (2)
Rapeseed	6.80	68.09	9.98 (3)
Commercial crops Production (million tonnes)			
Sugarcane	348.45	1861.18	18.72 (2)
Tea	1.25	5.91	21.14 (2)
Coffee (Green)	0.35	9.32	3.73 (7)
Jute	1.90	3.31	57.31(1)
Cotton (lint) 2013	6.05	24.77	24.43 (2)
Tobacco (unmanufactured)	0.78	6.40	12.23 (2)
Fruits and Vegetables (million tonnes)			
Vegetable primary & lemon	123.63	1229.51	10.06 (2)
Fruits	88.47	710.50	12.45 (2)
Potatoes	43.42	374.25	11.60(2)
Onion (dry)	20.93	94.94	22.05(2)
Livestock (in Million no)			
Cow	186.04	1488.96	12.49(2)
Buffalo	112.57	199.39	56.46 (1)
Milk (Million Tonne)	165.33	809.80	20.42 (1)

Source: Agriculture Statistics at a Glance 2018, P.221-222 (FAOSTAT, 2019)

Table 5. Productivity (Kg/ha) of Principal Crops in India and World (2016)

Item	India	World	India's share in the world production
Paddy	3790	4577	21.65
Wheat	3034	3401	12.32
Maize	2616	5632	2.35
Pulses	588	958	21.75
Sugarcane	70394	70134	18.72
Groundnut (in shell)	1287	1606	16.62
Tobacco	1698	1795	2.67

Source: Agriculture Statistics at a Glance 2018,P.221-222 (FAOSTAT, 2019)

1.4 Composition of Gross Value Added from Agriculture and Allied Sectors

A brief history of Indian agricultural growth since the onset of Five-Year Plans in 1951 underlines that economic growth is driven by the performance of agriculture and allied sectors. Annual average growth rate of agriculture and allied sector in India has remained constant at 2.88% during 2014-15 to 2018-19 and it is much below the targeted growth rate for the sector to achieve the avowed objective of doubling farmers' income by 2022. Notwithstanding the fact that the crop production sector performed relatively better during 2020-21 and 2021-22, average performance of the crop production sector is below the potential. However, fluctuations in agricultural output growth have substantially reduced as measured in terms of coefficient of variation (0.8%) during 2005 to 2018.Unlike in Indonesia and Malaysia, relative share of agriculture and allied sectors in GVA of India has been declining over the years and contributed 18.8% in 2021-22.Broadly, there are four divisions within agriculture, *viz.*, crop production, livestock, forestry and logging, fishing and aquaculture. It is clear from Table 6 that the relative share of crops in GVA has declined much faster from 11.8% to 8.7% during the period 2012-13 to 2017-18,but started increasing marginally by 2018-19 in the GVA of the country. It underlines that the smart technology intervention is more important for the crop production sector. It is important to note that 58% of the value of output from agriculture and allied sector is contributed by the crop production followed by livestock sector. In other words, performance of crop production and animal husbandry dominate agriculture and allied sectors in India.

Table 6. Contribution of Agriculture and Allied Sectors in GVA at Constant Price (2011-12)

(Percentage)

Sector/sub sector	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Agriculture, forestry & fishing	18.2	18.6	18.2	17.7	18	18.3	17.6	18.4	20.2	18.6
Crops	11.8	11.4	10.3	9.2	9	8.7	9.7	10.7	11.1	–
Livestock	4	4.3	4.4	4.6	4.8	5.1	5.3	5.2	6.2	–
Forestry & logging	1.5	1.5	1.4	1.3	1.2	1.2	1.3	1.4	1.5	–
Fishing & aquaculture	0.9	0.9	0.9	1.0	0.9	1.1	1.1	1.2	1.3	–

Note: NA-Not Available

Source: Economic Survey, Govt. of India, 2019

1.5 Government Expenditure, Capital Formation and Agriculture Sector in India

Given the structure of holdings in India with 85% of landholdings under marginal and small (< 2 hectare of land), farmers are incapable of undertaking large investments and therefore public sector investment in agriculture is a pre-condition. It may be noted that Gross Capital Formation in agriculture and allied activities (Table 7) is around 16% of the Gross Value Added from Agriculture. Moreover, in Gross Capital Formation(GCF) in agriculture, contribution of the government sector is less than 3% and the private sector contributes more than 13.7%.

Table 7. Gross Capital Formation in Agriculture & Allied Sectors

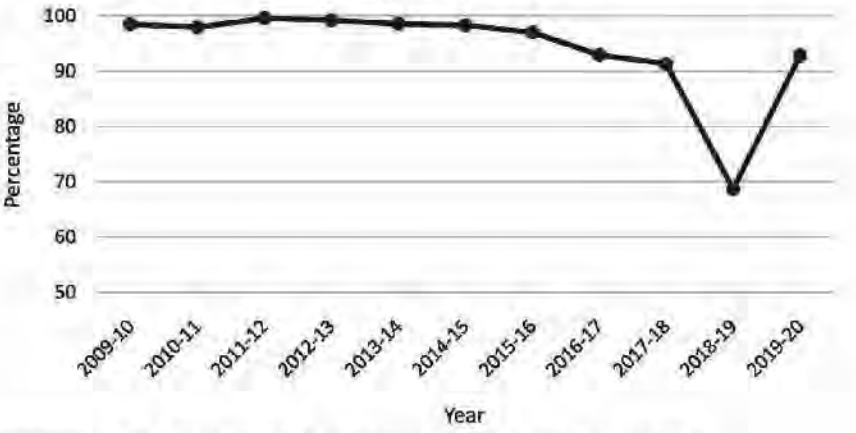
	Gross Capital formation (GCF) in Agriculture and Allied sector) at 2011-12 prices (Rs Million)			GCF in Agriculture & Allied Sector as % of its GVA		
Year	Public	Private	Total	Public	Private	Total
2012-13	360190	2150750	2510940	2.4	14.1	16.5
2013-14	339250	2504990	2844240	2.1	15.6	17.7
2014-15	371720	2354910	2726630	2.3	14.7	17.0
2015-16	425220	1951270	2376480	2.6	12.1	14.7
2016-17	477670	2193860	2671530	2.8	12.7	15.5
2017-18	460320	2262900	2723210	2.5	12.3	14.8
2018-19	534930	2431380	2966310	2.8	12.9	15.8
2019-20	470400	2546320	3016710	2.4	12.8	15.2
2020-21	467280	2798050	3265330	2.3	13.7	15.9

Note: NA – Not Available

Source: Economic Survey, 2022

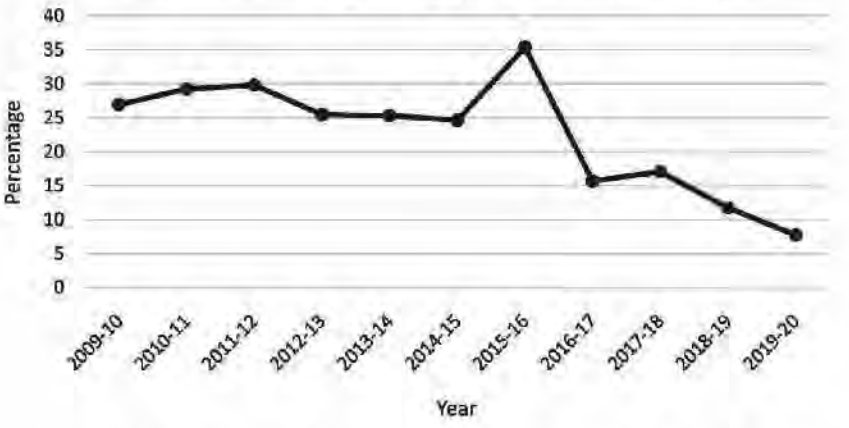
In public sector investment, outlay on research and education for farm sector assumes special significance. Small holders are incapable to undertake investment in research and innovation. It is found that expenditure for research and education in agriculture remains less than 0.5% of the GVA. Another important factor influencing performance of agricultural sector is the relative share of actual expenditure budgeted and expended for agricultural sector. There are two aspects in budget outlays for agriculture and allied activities. Share of agriculture in the total budget outlay has declined from 5% in the late 1990s to 4% in the last decade. The actual expenditure in agriculture and allied sectors in the budget outlay has been on the decline and reached 70% in 2018-19 (Figure 1). More worrisome is the fact that more than 30% of the budget allotted for agriculture remains unspent every year. In the case of the actual expenditure for research and education in agriculture, its share in total expenditure has been declining rather sharply (Figure 2).

Fig 1. Actual Expenditure in Agriculture and Allied Activities to Budget Allocation



Source: Department of Agriculture, Cooperation and Farmers Welfare

Fig 2. Share of Actual Expenditure to Budget Allocation for Research and Education in the Budget on Agriculture and Allied Activities



Source: Department of Agriculture, Cooperation and Farmers Welfare (Data as on 30.11.2020)

1.6 Trends in Foreign Trade of Agricultural Commodities in India

There has been a consistent increase in the foreign trade of agricultural commodities from India since the introduction of economic reforms in 1991. The trade in agricultural commodities received a stimulus with the announcement of Doubling Farmers' Income (DFI) by 2022.The external trade of agricultural commodities from India constituted only 2.15% of the world agricultural trade (2018). Moreover, there is little diversification of trade in agricultural commodities in India in terms of both product and destinations. The USA, Saudi Arabia, Iran, Nepal and Bangladesh continue to be the major destinations of exports of agricultural commodities from India. In 2018-19, India exported Rs 2.7 lakh crore worth of agricultural commodities against an import of Rs 1.37 lakh crore. Important items of exports of agricultural commodities from India include rice, spices, cotton, oil meals, sugar, castor oil, tea, coffee and fresh vegetables in which rice and spices still constitute more than 25% of the total value of agricultural exports.

SECTION 2

2.1 Policy Initiatives for SAT-Current Status

It has been argued that farmers do not adopt modern technology as they lack adequate finance and other infrastructure requirements for adoption. There exist bottlenecks from both supply and demand sides for the adoption of discriminatory fertiliser applications. Absence of extension services, non-availability of technology and modern agricultural practices from the government are important supply side factors while lack of awareness of farmers on the advantages of extension services is an important factor from the demand side. Further, agriculture has seized to be a sufficiently remunerative economic engagement, which also dissuade farmers from being keen on adoption of advanced technology in agriculture. Table 8 shows the adoption rate of extension services by farmers from different sources. Adoption rate of technology by farmers. It shows the willingness of farmers to adopt advanced technology in agriculture, if it is supplied. However, there has been a substantial cut in extension services as part of the neo-liberal economic policies since 1990s. A Coriander farmer from Bara district in Rajasthan reported (2019) "Pesticides vendors of unknown companies come to our village and sell pesticides. On application in the field, we fall sick. We do not know the brand, quality and quantity of usage. There is no government department or field offices in nearby areas of the village to seek advice. Agricultural office remains closed and field officers of the government do not pay visit to the village".

Table 8. Farmer Households Adopted Technical Advice from Different Sources

Sources	Households who adopted advice during the season Jan-June, 2013 (per cent)	Adopting households who reported the advice as useful during the season Jan-June, 2013 (per cent)
Extension Agent	86	94
Krishi Vigyan Kendra	79	98
Agricultural university/college	81	93
Private commercial agents (including drilling contractor)	87	96
Progressive farmer	92	97
Radio/t.v./newspaper/internet	64	95
Veterinary department	92	98
NGO	85	99
Any agent	85	NA

Source: Economic Survey, 2019

Table 9 explains the current status of schemes and programmes for SAT in India. Most of such programmes were introduced in 2017. These programmes are ongoing programmes and in a few cases, the programmes were introduced in the last two years.

Table 9. Smart Agricultural Transformation (2019 December)

Programme / Scheme	Year & Outlay (Rs million)	Objectives (Physical and Financial Achievements)	Constraint / Challenges
E-NAM (National Agricultural Marketing)	2016, Outlay – Rs 1960 (2019-20)	• To promote marketing facilities for farmers by integratingquality assurance. • 585 agricultural markets in 18states have been developed into electronic marketing system; E-Trade provided for 150 commodities with tradable parameters. 1.27 lakh traders joined the scheme from different states and specialised markets. • Inter-state trade in 12 states started;165 million farmers registered under the scheme; 0.127 million traders registered with E-NAM.	Inadequate number of quality assaying labs. Lack of internet connectivity and other necessary infrastructure for e-NAM.

Programme / Scheme	Year & Outlay (Rs million)	Objectives (Physical and Financial Achievements)	Constraint / Challenges
Gramin Agricultural Markets (GrAMs)	2018-19 Rs. 20000 (2019-20)	• To Develop/upgrade agricultural markets in villages by providing basic and supporting infrastructure and marketing infrastructure. • 707 rural markets were developed with basic infrastructure and MGNREGA. • Rs 20000 million Agricultural Market Infrastructure Fund has been created.	Lack of information on rural agricultural Markets. Lack of coordination between state governments and local governments.
Integrated Scheme for Agricultural Marketing (ISAM)	2019-20 Rs. 4080 (2019-20)	• To Develop Agricultural Market Infrastructure. • Provide innovative technologies for post-harvest process. • Encourage collective farm level processing through FPOs. • Provide Quality Certification; integrated value chain. **Project components** • AMI- Integrated Scheme for Agricultural Marketing. • MRIN –Integrated Scheme for Information Network. • SAGF – Strengthening of AGMARK Grading Facility. • VCA –Venture Capital Assistance. • NIAM – National Institute of Agricultural Marketing.	Certain states do not respond positively to the programme.

Programme / Scheme	Year	Objectives (Physical and Financial Achievements)	Constraint / Challenges
Farmers' Producers Organization (FPO)	2011-12 Depends on state governments to suggest FPO formation under Annual Action Plan for RKVY	• Mobilising farmers into 15-20 groups at the village level. • Enhance productivity through capacity building. • Encourage usage of quality inputs and services and form cluster competitiveness. • Ensure remunerative price through market aggregators.	Lack of professional support and inadequate infrastructure for FPOs. Banks are reluctant to extend credit to FPOs. There is no cold-chain management programmes for FPOs.
Contract Farming Act of 2017	Circulated to state governments by May 2018	To line/integrate farmers with agro-processing units; Ensure better price realization for farm produce; Reduce Post-harvest losses.	Many states are rather unwilling to enact Contract Farming Act of 2017.

Source: Discussion with officials in the Ministry of Agriculture, Marketing Division, Government of India, 2019

Table 10. Major Schemes for Enhancing *Production and Productivity of* Crops in India

Scheme	Objectives
Sub-Mission on Agricultural Extension (SMAE) is implemented under National Mission on Agricultural Extension and Technology (NMAET). Introduced in 2014-15. Now SMAE has been subsumed as a sub-scheme underthe Green Revolution Krishonnati Yojana from 2017-18.	SMAE includes following components:- • Support to Extension Programme for Extension Reforms. • Mass Media Support to Agricultural Extension; Agri Clinics & Agri Business Centres (ACABC); • Extension Support to Central Institutes; • Strengthening/Promoting Agricultural Information System including Kisan Call Centers (KCC).
AGMARKNET (Agricultural Marketing Information Network)	Launched in March 2000 • To provide electronic connectivity to wholesale markets. • To collect, analyse and disseminate market information to farmers, traders, policy makers and other stakeholders. • More than 3200 markets are covered under the scheme and more than 2700 markets are reporting data at Agmark net portal. • More than 350 commodities and 2000 varieties are covered under the scheme.
Mission for Integrated Development of Horticulture (MIDH)	• Scheme for the holistic growth of the horticulture sector; • While Government of India (GOI) contributes 85% of the total outlay for developmental programmes, 15% is contributed by State Governments.
Computerized Registration of Pesticides (CROP)	• Online Application for Registration of Pesticides under 9(3) and 9(3b); • On line status checking. Frequent email notification to the applicant at certain milestone of the registration process till Deficiency Reporting and Approval. • Online application for the grievances.
Plant Quarantine Clearance	• Plant Quarantine Information System facilitates importers to apply online for import permit, • Import Release Order and Exporters to apply online for Phyto-sanitary Certificate.

Scheme	Objectives
DBT in Agriculture	• Direct Benefit Transfer (DBT) portal for agriculture and store all the Beneficiaries with Scheme information at a national level.
Pradhanmantri Krishi Sinchayee Yojna (PMKSY)	• To access the means of protective irrigation to all agricultural farms in the country, • To ensure efficiency in water use,'Per drop More crop' scheme has been introduced.
Kisan Call Center	• The scheme was launched in January 2004. Main aim of the scheme is to answer farmers' queries on a telephone call in own language. These call centers are working in 21 different locations in the country covering all States and UTs.
m-Kisan	• It is a SMS Portal for farmers to receive information/ services/ advisories through SMS in their language, about the preference of agricultural practices and location.
Jaivik Kheti	• Jaivikkheti portal is a unique initiative of the Ministry of Agriculture (MoA), Department of Agriculture (DAC) along with MSTC to promote organic farming globally. It is a one stop solution for facilitating organic farmers to sell their organic produce and promoting organic farming and its benefits.
e-NAM	• National Agriculture Market (e-NAM) is a pan-India electronic trading portal which networks the existing APMC mandis to create a unified national market for agricultural commodities.
Soil Health Card	• Soil Health Card Scheme is a scheme launched by the Government of India on 19th February, 2015. A Soil Health Card is used to assess the current status of soil health.
Pradhan Mantri Fasal Bima Yojana (PMFBY)	• Launched on 18 February 2016. i) Security coverage and financial support to farmers in the event of crop failure due to natural calamities, pests and diseases; ii) To stabilise the income of farmers to ensure their continued engagement in farming; iii) To adopt innovative and modern agricultural practices and to ensure adequate flow of credit to agricultural sector.

It has been estimated that more than 900 schemes exist for the crop production in India. Multiplicity and duplication of schemes and programmes dilute the import of such schemes.

It needs to be noted that there has not yet been an assessment of objectives, targets and realisation of objectives of these programs and policies. Unless such crucial analysis is undertaken, readiness assessment cannot be assessed. It is one of the major lacuna of agricultural promotion schemes in India.

2.2. Essentials for SAT

There exist several pre-requirements for effective implementation of SAT in India. Identification of key stake holders for digitalisation of agriculture is the first and foremost factor. Important stake holders are small holders in agriculture as they constitute more than 85% of total holdings in India. The second stakeholder is agricultural labourers. Agricultural labour force in India remains relatively unskilled and lack computer literacy and awareness of SMART technology. Agricultural labours are the major driving force who take the technology to the field. Input Vendors and manufacturers are the third stake holders for SAT. As farmers depend on the private sector for fertilisers, pesticides, artificial insemination for cattle and buffalo, its trading agents in villages disseminate knowledge about cultural practices and application of inputs, pesticides and agricultural implements. They have to be trained along with farmers and a process of certification of private vendors of inputs and agricultural implements needs to be a part of the programme for digitalisation. Availability of cheap credit to farmers on time is another pre-requisite for transforming agriculture with digitalisation. Recent policy framework to launch Farmer Producers' Organisations (FPOs) can be effective in helping Farmers to avail credit. Digitalisation of trading practices, online traders in agricultural commodities, Committees for National Agricultural Marketing Committees or what is called Specialised Markets, Self Help Group of farmers and other information and formal groupings of farmers are a few other essential requirements for SAT. It needs to be admitted that many of such pre-requirements are either non-existent or do not function effectively.

Traders, commission agents, exporters of agricultural commodities, local self-government institutions in villages, village traders, trading agents in villages of agricultural commodities are other vital actors in SAT. However, it needs to be underlined that government is the primary stakeholder in the digitalisation process. Agriculture in India still remains a state governments' subject of governance and, therefore, the role of central government in introducing schemes and programmes are pivotal while effective implementation of the scheme rest with state governments.

SECTION 3

3.1 Readiness Assessment

In this section, a case study to explain the status of adoption of technology for two major export-oriented crops, viz., coriander and cumin are included along with an assessment of readiness for SAT. There exists a set of enabling factors for SAT to come into existence and such enabling factors do vary across countries and regions. Broadly, the enabling factors should include core

elements of planning and delivery (Boettiger et al. 2017). These enabling factors are put together and form Readiness Indicators. A country's status of SAT is measured in terms of its level of indicators. There were several attempts to assess the readiness for agricultural transformation in the Indian Context and the attempts have broadly concluded that there is a lack of support for transformation from political leadership, lack ok accessibility to good analytics and misalignment of key stakeholders in the transformation process (ibid). The key stakeholders include, political leadership, civil society and farmers, traders and input vendors.

It is important to assess the readiness for agricultural transformation in the Indian context. Readiness can be assessed based on data on different indicators of agricultural transformation. Table 11 shows readiness assessment of India. In certain cases, requisite data is hard to come by. However, a broad assessment of readiness of the country in pursuing Smart Agricultural Transformation is under way. The adaption rate in certain cases is below the level of expectation because agriculture in India is predominantly of a small holder type and engagement in farming and dairying are governed by subsistence requirement.

Table 11 shows the readiness indicators and the relevant ratings for two time points. Important findings from Table 11 are:

(i) Requisite data are not available for several important indicators to assess the Readiness for SAT;

(ii) Variables for which data is available, latest statistics are not available for policy purpose.

(iii) Most of the indicators in 2010 are either low and inadequate to arrive at a meaningful assessment.

(iv) After the introduction of DFI policy in India, data on e-NAM and digitalisation are available in the ministry, but such data may take a few more years to be made available in public domain.

Table 12 shows the Readiness Indicators, Hypothesis and Ratings based on the data presented in Table 11. Table 13 summarises the Readiness Index of SAT. The following observations can be made from Table 13. Based on the values arrived at, indices are ranked qualitatively as high, medium and low. The ranking is made based on a comparison of two time points, i.e., 2010 and 2018.

1. In the Upstream Index for the year 2010, there were seven indicators in which four are medium, one is high and 2 are low.

2. In the case of Production indicators, as compared to 2010, number of items ranked high has increased from 3 to 4, but medium and low remain more or less unchanged indicating that there has not been any significant change during the last 10 years.

3. For Down Stream Indicators, there is deterioration of readiness indicators as number of items ranked medium has declined from 2 to 1 and the items ranked low has increased from 5 to 6 between 2010 and 2018.

4. In the case of enabling factors, there is an improvement in readiness towards SAT.

Table 11. Readiness Assessment Indicators and Rating

	INDICATOR	2010	Latest	Rating (2010)	Rating (latest)
Upstream	**Development**				
	Existence of law/policy on agricultural finance	Yes	Yes	M	H
	Agricultural insurance penetration ratio	1.21%	25.96% (2017-18)	M	H
	Share of borrowing smallholders and fishers who borrow from formal sources (%)	69	78	H	H
	Technician-to-farmer ratio: public; private	ND	ND	L	L
	Proportion of agricultural land that is irrigated (%)	45%	49% (2016)	M	M
	Digitization				
	Share of extension personnel who are computer-literate (%): public; private	ND	ND	L	L
	Existence of IT-based agricultural insurance product (e.g. remote sensing)	Yes	Yes	M	M
	Development				
Production	Existence of regulatory framework for seed	Yes	220 hybrids, 93 horticultural crops	M	H
	Existence of regulatory framework for agro-chemicals (fertilizer and pesticide)	Yes	Yes	M	H
	Existence of regulatory framework on agri-machinery	Nil	Nil	L	L
	Tractors per 100 km^2 of arable land	ND	27 tractors Per 1000 hectare of agricultural land (2015)	M	H
	Agricultural wage (dollars per day)	$3.51/day	$5.46/day	M	L
	Rural employment in youth employment (%)	76.32	72.28 (2018)	H	L
	Average age of farmer	ND	46	L	L
	Average farm size (ha)	1.15 hectare	1.08 hectare (2015)	M	L
	Share of smallholder (2 ha and below) who is owner-cultivator	85% (farmers) 44.6 % (area)	86.21%, 47.38% (area)	H	H
	Share of agricultural workers who are women (%)	25.8%	27.9% (2015-16)	M	M

	INDICATOR	2010	Latest	Rating (2010)	Rating (latest)
Production	Fertilizer utilization per hectare	128.58 kg/ha	128.02 kg/ha (2017-18)	M	M
	Pesticide application per hectare	32.17 (2001-02)	43.67 (2011-12)	H	H
	Utilization of certified seeds share as percentage of total (%)	117.39 availability as % of requirement (2012-13)	86.46 Availability as % of requirement (2016-17)	M	M
	Agricultural GVA per worker (constant US $ 2010)	1239.991	1712.622 (2018)	L	L
	Total factor productivity (TFP)	121 (index)	140 (2016)	M	M
	Digitization				
	Share of youth in rural employment (%)	17.99	12.46 (2018)	L	L
	Development				
	Existence of law/policy on food safety, traceability	Yes	Yes	M	M
	Infrastructure score in Global Competitiveness Index	3.5 (1-7) rank 86	68.1 (2019) rank 70	L	L
	Logistics performance index	3.12	3.18 (2018)	L	L
	Rural road density (km per sq. km)	.03km/ sq.km (2010-11)	.041 km/ sq.km (2015-16)	L	L
	Stocks-to-production ratio, milled rice equivalent	.213	.181 (2017)	M	L
	Existence of law/policy on e-commerce	Yes	Yes	L	L
	Share of e-commerce in retail sales	ND	ND	L	L
	Share of e-commerce in retail sales	ND	ND	L	L
	Development				
	Existence of law/policy for agricultural S&T	Yes	Yes	L	L
	Share of public sector budget for agriculture in total (%)	2.34%	5.08% (2020)	L	L
	Government budget for agriculture per agricultural worker (USD)	ND	ND	L	L
	Government budget for agricultural R&D, ratio to agricultural GVA (%)	0.49%	0.40 % (2018-19)	L	L
	Literacy rate (working age population)	69.3 (2011)	69.3 (2011)	M	M
	Average years of schooling (working age population)	5.4 (HDI)	6.5 (2018)	L	L

	INDICATOR	2010	Latest	Rating (2010)	Rating (latest)
Production	Prevalence of undernourishment	ND	ND	H	H
	Food Security Index (GFSI)	45.0 (66 rank) 2012	58.9 (72 rank) 2019	M	M
	Digitization				
	Existence of law/policy for digitization of agriculture/related sectors	Yes	Yes	L	L
	Existence of law/policy promoting e-governance	Yes	Yes	L	L
	Existence of IT-based Disaster Risk Reduction and Management system and early warning	Yes	Yes	L	L
	Government budget for digitization of agriculture (USD)	ND	Yes	L	L
	Smartphone penetration ratio: rural	ND	ND	L	H
	Internet penetration ratio: rural	ND	ND	L	H
	Share of primary and secondary schools with access to internet (%)	ND	ND	L	L
	Share of STEM graduates among college graduates (%)	ND	ND	M	M

4.1 Rating: H - High or Existing; M - Medium; L - Low or non-existent; ND – no data available.

Table 12. Readiness Assessment, Hypothesis and Ratings

	INDICATOR	HYPOTHESIS	Rating (2010)	Rating (latest)
Upstream	Existence of law/policy on agricultural finance	Having a law/policy improves business climate for providing agricultural finance.	M	H
	Agricultural insurance penetration ratio	Insurance reduces agricultural risk and increases investment in and credit for agriculture.	M	H
	Share of borrowing small holders and fishers who borrow from formal sources (%)	Shift from informal to formal borrowing reduces borrowing rate.	H	H
	Technician-to-farmer ratio: public; private	Lower number of farmers per technician implies greater access to extension service.	L	L
	Proportion of agricultural land that is irrigated (%)	Shift from rainfed to irrigated technology raises cropping intensity and yields.	M	M
	Digitization			
	Share of extension personnel who are computer-literate	Technicians who are computer-literature and are able to disseminate IT-based services to farmers.	L	L

	INDICATOR	HYPOTHESIS	Rating (2010)	Rating (latest)
	Existence of IT-based agricultural insurance product	Existence of such products imply demand for risk instruments supplemented with latest data	M	M
Production	**Development**			
	Existence of regulatory framework for seed	Existence of regulatory framework improves business climate for investment in agriculture	M	H
	Existence of regulatory framework for agro-chemicals (fertilizer and pesticide)	NIL	M	M
	Existence of regulatory framework on agri-machinery	NIL	L	L
	Tractors per 100 km^2 of arable land	More horsepower implies greater spread of mechanization.	M	M
	Agricultural wage (dollars per day)	Higher agricultural wage increases incentive to adopt labour saving farm machinery.	M	M
	Percentage of youth employed in agriculture	Lower share implies greater need to mechanize farm operations.	H	H
	Average age of farmer	Higher age implies greater need to mechanize farm operations.	L	M
	Average farm size (ha)	Smaller average farm size implies preponderance of smallholders.	M	M
	Share of smallholder (<2 ha) who are owner cultivators	Owner-cultivators are the relevant decision-making units for farm mechanization and digitization.	H	H
	Share of female agricultural workers	Higher share implies greater participation of women in agriculture.	M	M
	Fertilizer utilization per ha	Greater utilization implies more soil nutrients towards higher productivity.	M	M
	Pesticide application per ha	More pesticide application implies low loss from pest infestation (but excesses may be detrimental).	H	H
	Utilization of certified seeds in the total (%)	Higher share implies better chance of reaching potential yield	M	M
	Agricultural GVA per worker (constant US $ 2010)	Higher GVA per worker implies higher productivity and degree of transformation.	L	L
	Total factor productivity (TFP)	Higher TFP means faster rate of technical progress in agriculture.	M	M

	INDICATOR	HYPOTHESIS	Rating (2010)	Rating (latest)
	Digitization			
	Share of youth in rural employment (%)	Greater share implies greater potential to adopt digital technologies.	L	L
Downstream	**Development**			
	Existence of law/policy on food safety, traceability	Existence of law ensures quality of agri-food system.	M	M
	Infrastructure score in Global Competitiveness Index	Higher score implies better state of infrastructure	L	L
	Logistics performance index	Higher index implies better logistics performance	L	L
	Rural road density (km per sq. km)	Higher density implies greater connectivity from farms to markets	L	L
	Stocks-to-production ratio, milled rice equivalent	More stocks imply more storage facilities	M	L
	Digitization			
	Existence of law/policy on e-commerce	Existence of law/policy improves business climate for investor in e-commerce platform.	L	L
	Share of e-commerce in retail sales	Greater share implies better opportunity for online marketing of agricultural products.	L	L
Enabling factors	**Development**			
	Existence of law/policy for agricultural science and Technology	Existence of law/policy improves flow of resources towards Research and Development	L	L
	Share of public sector budget for agriculture in total (%)	Higher share implies greater priority placed for agriculture.	L	L
	Government budget for agriculture, per agricultural worker (USD)	Higher ratio correlates with more benefits per worker in agriculture.	L	L
	Government budget for agricultural R&D as % of agricultural GVA	Higher percentage implies more resources towards developing new technologies in agriculture.	L	L
	Literacy rate (working age population) NSS 71st& 64th round	Higher rate correlates with capacity to adopt latest technologies.	M	M
	Average years of schooling (working age population)	More years of schooling correlates with capacity to adopt latest technologies.	L	L
	Prevalence of under nourishment	Lower prevalence rate implies a more responsive agri-food system.	L	L
	Food Security Index (GFSI)	Higher index implies a more responsive agri-food system.	M	M

	INDICATOR	HYPOTHESIS	Rating (2010)	Rating (latest)
Enabling factors	**Digitization**			
	Existence of law/policy for digitization of agriculture/ related sectors	Existence of law/policy implies greater and more stable commitment to invest in digitization.	L	L
	Existence of law/policy promoting e-governance	Existence of law/policy implies government commitment to adopt digital technologies.	L	L
	Existence of IT-based Disaster Risk Reduction and Management system	Existence implies government commitment to adopt digital technologies.	L	L
	Government budget for digitization of agriculture	Higher budget implies higher commitment towards digital technologies in agriculture.	L	L
	Smartphone penetration ratio: (rural)	Higher ratio implies more readiness to adopt digital technologies.	L	H
	Internet penetration ratio: (rural)	Higher ratio implies more readiness to adopt digital technologies.	L	H
	Share of primary and secondary schools with access to internet	Greater share correlates with greater digital literacy.	L	L
	Share of STEM graduates among college graduates (%)	Greater share implies more human resources available for adopting digital technologies.	M	M

Rating: H - High or Existing; M - Medium; L - Low or non-existent; ND – no data available.

Table 13. Summary of SAT Readiness Index

Indicators	No. of Indices					
	Ratings 2010			Ratings Latest		
	High	Medium	Low	High	Medium	Low
Upstream	1	4	2	3	2	2
Production	3	9	4	4	9	3
Downstream	0	2	5	0	1	6
Enabling Factors	0	3	13	2	3	11

Source: Authors' own compilation

3.2. Case Study

For assessing the Readiness for Smart Agriculture Transformation, a study of two important e-markets for agricultural commodities situated in Rajasthan and Gujarat were selected, viz; Unjha Market in Gujarat and Ramganj Market in Rajasthan. Two important export-oriented seed spices, *viz*., cumin and coriander cultivated mostly in the western arid zone were considered for analysis. These two seed spices accounted for about 25% of spice exports from India[1].The analysis has revealed that farmers use traditional method of cultivation. However, they make use of smart technology for gathering market information and it helps fetch a better price for the produce. The density of specialised markets is relatively low and it dissuades farmers from selling the produce in e-NAM. There is a significant price difference between local markets and e-NAM and the e-NAM price is always higher than local market prices. The case study has been called out from a detailed primary survey conducted in 2018 in areas of crop concentrations and its specialised markets.

For SAT, infrastructure facilities in the market ensures a fair deal for enhancement of income to farmers. Table 14 the shows availability of market infrastructure facilities. On the basis of qualitative grading of facilities, an Index has been constructed for cumin and coriander. Table 15 shows the Market Infrastructure Index availed by farmers of cumin and coriander. These two crops are considered because export-oriented crops fetched relatively more importance than the domestic market dependent crops under new agricultural policy in India. Important observations from Table 15 are: (i) 35% of cumin farmers do not avail any type of infrastructure facility available in the market. It appears to be rather realistic because cumin is grown in arid zone and agriculturally backward regions of Rajasthan and Gujarat. Moreover, the specialised market for the crop is located faraway from its production centres and, therefore, farmers are rather compelled to sell standing crop to agents of specialised markets or sell to the local market nearby; (ii) only 11% of coriander farmers and 3% of cumin farmers make use of all infrastructure facilities available in the market; (iii) Coriander cultivators avail more infrastructure facilities of specialised market as compared to cumin and it is often attributed to the stage of development of farmers cultivating coriander in Rajasthan defined in terms of readiness index in the previous section. (iv) it is found that 10-20 percent of the Market Infrastructure facilities are made use of by coriander and cumin farmers. Table 16 shows the source from where farmers access technical and extension services for crop production and marketing. However, farmers reported that they contacted traders in the specialised market, avail internet facility and depend on media (especially print media) to understand the price situation and accordingly bargain in the market with traders.

Table 14. Farmers' Response to the Status of Infrastructure Facilities in Specialised Markets

(Response in % of the total sample)

Grading	Not Available		Bad		Average		Good	
Weights	0		0.5		1		2	
Facilities	Cumin	Coriander	Cumin	Coriander	Cumin	Coriander	Cumin	Coriander
Go-Down Facilities	59	8.33	3.5	3.92	33	74.02	4.5	13.73
Auction Agreement	60.5	29.90	4.5	2.45	31	50.49	4	17.16
Supervision of sale	62	31.86	1.5	1.47	31	50.49	5.5	16.18
Loading Facilities	37.5	7.35	1	3.43	46	50.49	15.5	38.73
Sorting/ Grading Facilities	71.5	55.39	3.5	0.49	17.5	27.45	7.5	16.67
Cleaning Facility	66.5	44.61	5.5	0.49	20.5	37.25	7.5	17.65
Weighting Facilities	38	6.37	2	0.98	29	51.47	31	41.18
Packing Facilities	62.5	37.25	0	21.57	14.5	40.69	23	0.49
Banking Facilities	62	39.71	2	0.98	14.5	25.49	21.5	33.82
Motorable Roads	38.5	4.90	8.5	5.39	29	48.53	24	41.18
Computer Facilities	62	60.29	2	1.47	15.5	13.73	20.5	24.51
Internet Facilities	66	62.75	2	0.49	14	12.25	18	24.51

Source: Primary Survey -2018-19

Table 15. Comprehensive Index of Market Infrastructure for Cumin and Coriander

MII Score	Farmers Availing Facility (%)	
	Cumin	Coriander
0	35.38	2.11
01 -0 5	18.47	16.02
05 - 10	7.69	19.72
10 – 15	17.95	25.34
15 – 20	17.43	25.36
20 – 25	3.08	11.27
Total	**100**	**100**

Note: The maximum score possible from a farmer is 24 based on weights. In order to maintain the class interval width, 20-25 is given.

Source: Primary Survey 2018-19.

Table 16. Accessibility to Technical Advice for Cultivation of Cumin and Coriander

Source of Technical advice	% of farmers accessed (Cumin)	% of farmers accessed (Coriander)
Agriculture Supervisor(G.P)	19.5	41.50
Extension Agent/Officer from Spices Board	2.50	5.00
Krishi Vigyan Kendra	13.50	15.50
Agricultural University/College	2.00	0.00
Private Agricultural Experts	61.50	35.50
Progressive Farmer	93.50	96.50
Radio	2.00	9.00
Television	5.50	24.50
Newspaper	20.50	46.50
Internet/Computer	2.00	7.00
Smart Phones	3.00	8.00
Mobiles	21.50	29.00
Farmers Organisations	3.50	3.00
Others	1.50	3.00

Note: Column total exceeds 100 because a farmer avail technical advice from more than one source.

Source: Primary survey

SECTION 4

4.1 GAPs Identified in Readiness Assessment

Gaps can also be construed as important challenges for the Indian agricultural and allied sectors in achieving its long-term goal of sustainable and market-driven growth. The gaps may be discussed in the context of the initiatives on the marketing side as a method to enhance farmers' income. There exist significant productivity differences across different states in India and there are agro-climatic constraints in addressing productivity augmentation.

The availability of data for comparison from authorised sources is an important constraint. Viewing the data availability on different indicators of readiness assessment from this perspective shows that information on digitalisation is not available for several indices at the national level.

(i) More than 85% of holdings are under small holders with an average size between 0.38 hectare and 1.41 hectare;

(ii) About half of the area under cultivation is rain fed and the CSA has not yet been practiced sufficiently by small holders;

(iii) A large segment of farmers remains unaware of programmes and schemes on technological upgradation and importance of digitalisation of agriculture and e-marketing facilities;

(iv) Family labour-based farms still constitute a major chunk of the production scenario and, therefore, commoditisation of agriculture is low;

(v) Penetration of risk cover among farmers and its adequate adoption still remain a major challenge;

(vi) Productivity of major crops remain much below the average productivity of major producers in the world. It affects the competitiveness of Indian farmers in the international market;

(vii) Research and Development fund (R&D) for agricultural and allied sectors constituted only 0.3% of the GVA of the sector. It is a major challenge and needs to be raised substantially;

(viii) Gross Capital Formation (GCF) in agriculture is relatively low and it constitutes only 16% of GVA. In the GCF, the share of public sector is still abysmally low at 2.5% of GVA. It poses a major threat;

(ix) Markets for agricultural commodities are not adequately digitalised to ensure free and fair trade;

(x) Trade in agricultural commodities in India is only 2.5% of the world trade and remain stagnant for a long time. Rules and regulations on trade in agricultural commodities needs to be reviewed from the perspective of farmers and conditions of farming.

Interaction with farmers in different markets have revealed that the effective implementation of SAT in India needs to address the bottlenecks in relation to the objective of SAT in other countries.

SECTION 5

Conclusion

India is the largest country in the world in terms of area under cultivation. More than 40% of the workforce in India is engaged in agriculture and allied sectors. However, the contribution of the sector in the Gross Value Added of India (GVA)has been declining and it has reached 18% in 2020-21. It means that more than 40% of India's population shares only 18% of national income implying a relatively low standard of living of the farm dependent population in relation to non-farm workers. After the introduction of economic reforms and trade liberalisation in India in 1991, market for agricultural commodities have become highly volatile, and the price volatility has driven a set of crops into the verge of demise. Another characteristic feature of the Indian agriculture situation is the preponderance of smallholders whose purpose of cultivation is driven by subsistence and bare survival. It is one of the major bottlenecks of introducing technology and digitalisation in agriculture.

There has been a shift in policy paradigm in India from production orientation to doubling farmers' income with a focus on post-production technologies. For the policy on enhancement of farmers' income, various reforms in markets have been introduced and basic component of the shift in agricultural policy package are: (i) digitalisation of trading process; (ii) promotion of online trading; (iii) Uberisation of agricultural commodities; (iv) Construction of e-markets with infrastructural facilities for specialised markets; and (v) Formation of Committees for Specialised Markets in every important agricultural Production Centres.

Analysis of different indicators for assessing readiness towards Smart Agricultural Transformation in India has revealed that more than 50% of essential components of Readiness indicators for SAT are much below the desired level and 25% of the essential indicators are either non-existent or its data for assessment is not available in the public domain. Broadly, it indicates that agricultural transformation and its digitalisation have to be taken forward more in depth and width to address production and marketing of the farm produce. Recent reforms in agriculture and allied activities in India, particularly after the implementation of DFI Committee Report, has focussed more on post-harvest rather than production. Major stakeholders of agricultural transformation, particularly small holders and agricultural labourers, small traders and marketing agents need to be adequately equipped to adopt technological changes and digitalization. It is the primary step towards SAT in India.

Animal husbandry or livestock sector is the second largest sector in terms of contribution to GVA of agriculture and allied sectors. Major bottlenecks with respect to the sector are: (i) cow accounted for 63% of total milch animal population in India. The share of Buffalo population is 37%. Relatively large size of cattle population becomes a bottleneck because of the low productivity of non-descript cow in India; (ii) There exists significant differences across states in the composition of milch animal population. In many states, relative share of cow population is much higher than buffalo population; (iii) a major share of cow population is non-descript or indigenous and its productivity is relatively low; (iv) unproductive cow population causes strain

on resources such as water, fodder and feed; (v) differences in the composition of milch animal population influence per capita availability of milk and the market for liquid milk will be catered through imports of manufactured milk (powder). It poses threat to the existence of the livestock sector and livelihood of more than 2 million dairy farmers in India.

For the current status of SAT, interventions by the state on production and marketing of agricultural produce is required while it has not been happening for quite some time now. It is the major challenge for SAT in India.

Appendix-1.

Photo 1. A coriander and cumin auction market in Gujarat, India (2019)

Appendix-2.

Photo 2. Modern agricultural commodity market in Rajasthan, India, 2019 (commodity auction process)

Appendix-3.

Photo 3. An agricultural market in Rajasthan, India, 2019

Photo 4. Coriander processing in a factory in Rajasthan, India, 2019

Appendix-4.

Photo 5. Traditional cleaning of *Isabgol* (psyllium) in an agricultural market in Rajasthan, India, 2019

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Notes

[1]Cumin and Coriander crops have relatively small share in GVA from the crop production sector in India. However, these two crops assume significance in the light of the policy change in agriculture as export oriented products.

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