Remandating Indian Agriculture: Pathways for Transformation

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This book began with a short description of the challenges facing global and Indian agriculture, and highlighted India's commitments to the Sustainable Development Goals (SDGs) and climate change. Underlining the changes that the agriculture sector in India has gone through and that more can be expected, the first chapter emphasised the need for a transformative vision that should prepare the sector for the next decade. The chapters that followed detailed the contours of this transformative vision, focusing on the following themes: structural reforms and governance issues; sustainable use of water; science and technology; dietary diversification; nutrition and food safety; pests, pandemics and preparedness; and managing climate risks. This chapter will now present the pathways for transforming the Indian agri-food system. Before doing so, it will briefly dwell upon the demand and supply responses of the Indian agri-food system, with a focus on how the consumption patterns and production portfolio of major food commodities are changing and what the key enablers and hurdles in the transformation of the agri-food system are.

1 Demand and Supply Aspects of the Indian Agri-Food System

The Indian agri-food system is going through a lot of changes, with both the demand and supply side responding to demographic changes, economic growth, government policies and institutions.

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R. Chand et al. (eds.), *Indian Agriculture Towards 2030*,
India Studies in Business and Economics,
https://doi.org/10.1007/978-981-19-0763-0_10

1.1 Historical Trends in Consumption Patterns

Three broad trends can be seen in India's food consumption patterns: (a) share of food in total expenditure is declining, (b) consumption of food items is diversifying in rural and urban areas and (c) calorie consumption is rising while that of protein is declining.

The share of food in consumption expenditure has fallen from 62.7% in 1983 to 46% in 2011 (Joshi et al., 2016). The food consumption diversity index increased from 0.43 in 1983 to 0.55 in 2011, with the diet diversity being more among urban consumers than rural consumers (Joshi et al., 2016). Food consumption trends show that the demand for cereals-based commodities is declining, while those of high-value commodities (such as fruits, vegetables, dairy, meat and fish) is rising. At the all India level, the per capita annual consumption of cereals declined from 168 kg in 1983 to 133 kg in 2011 and the share of cereals in food expenditure fell from 42.7 to 23.5% over the same period. In contrast, the per capita annual consumption of fruits and vegetables increased from 49 kg in 1983 to 68 kg in 2011 and that of milk rose from 45 to 64.9 kg over the same period. Within food grains, there is a steep fall in the consumption of coarse cereals (−82.5%), followed by pulses (−15.65%) during the same period (Joshi et al., 2016).

This changing dietary pattern is leading to imbalance in nutrient intake, with the consumption of fat rising while those of calories, protein and iron is falling. This is leading to undernourishment as well as obesity.

1.2 Drivers of Changes in Consumption Pattern

The change in consumption patterns has several drivers: consumer's income, prices of commodities, urbanisation, globalisation, changing tastes and preferences and social safety net programmes.

Joshi et al. (2016) observe that income of consumers is one of the key factors influencing consumption patterns, with high income consumers consuming more food and also having a more diverse diet than low income consumers. There is also a rural–urban divide. Barring staples, the urban consumer consumes higher quantities of food than rural consumers. The annual per capita rice consumption is higher in rural areas (85.45 kg) than in urban areas (71.50 kg), though the difference in wheat consumption is a negligible 1.78 kg. However, in the case of vegetables, the annual per capita consumption in urban areas is 57.86 kg against 55.75 kg in rural areas. Urban consumers consume 71 kg of milk and milk products per capita per year while rural consumers consume 61 kg.

Kumar and Joshi (2016) find that (a) low income consumers are more responsive to prices than high income consumers, and (b) both groups are more responsive to high-value commodities than staple food commodities. The price elasticity of rice and wheat for poor consumers is −0.469 and −0.508, respectively, while that for rich

consumers it is −0.200 and −0.303. The corresponding elasticities for vegetables are −0.729 and −0.397, and for fruits these are −0.801 and −0.562 for poor and rich, respectively.

Globalisation is integrating food markets and influencing consumption of different food items. Food habits are changing due to imports, migration and easy access of information about different cuisines. Supermarkets are bringing food from other parts of the world to Indian homes. Pingali and Khwaja (2004) report that the Asian countries, including India, are gradually transforming their dietary pattern from cereals to high-value and processed commodities.

1.3 Projected Demand and Supply of Food by 2030

Future demand for different food commodities depends on a range of factors: population, income, price elasticities, the indirect demand for feed, industrial uses and seed as well as expected wastages. Kumar and Joshi (2016) take all these factors into consideration and project the demand for different food commodities for 2030 under three different scenarios of gross domestic product (GDP) growth: (i) business as usual (BAU), (ii) pessimistic scenario: 25% lower than BAU and (iii) optimistic scenario: 25% higher than BAU. The projections of food grains requirement under the different scenarios range from 303.9 million tonnes to 318.4 million tonnes in 2030.

On the other hand, the requirement for high value commodities is expected to grow much faster in the future than was the case in the past. The projected demand for fruits and vegetables is expected to be in the range of 295.04 million tonnes to 315.83 million tonnes in 2030 and that of milk between 184.91 million tonnes and 201.30 million tonnes.

However, land, water and other resources needed to produce sufficient quantities to meet this future requirement are limited, and efforts need to be made to produce more from less. The role of improved technology will be a key factor in this.

The authors also projected the supply of food commodities by 2030 under (a) BAU; (b) 50% acceleration in total factor productivity (TFP) growth over the baseline; (c) 50% deceleration in TFP growth over the baseline. India will be surplus in rice, wheat and coarse cereals by 2030 but deficit in pulses and edible oils. It is expected to be surplus in high-value commodities if appropriate measures are taken to minimise losses in perishable commodities.

1.4 Supply Side Transformation of Agriculture

Indian agriculture has gone through a significant trajectory of transformation over the last six decades—from a food deficit country to one that is self-reliant and, now, one with surpluses seeking to increase exports. The marketable surplus of a majority

of non-perishable crops is now 80–90%. In short, Indian agriculture has gradually commercialised, mechanised, diversified and globalised.

Food grain production nearly quadrupled between 1970–71 and 2018–19, the most notable gains being made in rice and wheat, while yield levels almost trebled. Though the performance of nutri-cereals and pulses is not as impressive, the yield gain is about three times.

Among commercial crops, there has been an impressive increase in the production of sugarcane and cotton. Production of sugarcane trebled between 1970–71 and 2018–19 and that of cotton saw a six-time increase over the same period. The story is similar in the case of horticulture (production of fruits and vegetables nearly trebled between 1991–92 and 2017–18), milk (India is the world's largest producer of milk) and poultry. These impressive gains notwithstanding, food safety and quality standards are still an area of weakness.

Use of animal and human power in agriculture and related activities has reduced significantly, from about 66% in 1971 to about 12% in 2013–14 (Chapter "Transforming Indian Agriculture"), while the use of mechanical and electrical sources has increased from about 34% to about 88% over the same period. Tractors account for about 48% of total farm power in 2013–14 and a large acreage of rice and wheat is harvested using harvesters and combines.

In line with the dietary diversification noted earlier, agricultural production has also diversified and is becoming more commercial. Gulati and Juneja (2020) note that the share of food grain crops in total cultivated area is declining (from 73% in the triennium ending (TE) 1982–83 to 62% in TE 2016–17) and those of commercial crops (or cash crops) is rising. Earlier, Joshi et al. (2006) estimated that agricultural diversification was the main source of agricultural growth during the 1990s, followed by agricultural prices; it used to be yield during the 1980s.

Indian agriculture is now in the early stages of integration with the global market, with both exports and imports of agricultural commodities showing exponential growth. Export growth has been faster—from INR 586 billion in 2006–07 to INR 2835 billion in 2018–19, while imports grew from are INR 296 billion to INR 1619 billion. The trade surplus from agriculture increased from INR 290 billion to INR 1216 crore over the same period.

2 Pathways for Transformation of the Agri-Food System

The seeds of the Green Revolution were sown in India against the backdrop of a drastic fall in agricultural production,[1] forcing India to rely on imported wheat from the United States of America, under the PL-480 programme, to meet its food requirement. The Green Revolution, which relied on high yielding varieties of wheat

[1] It fell by 17 million metric tonnes (MMT) from 89.4 MMT in 1964–1965.

and rice, complemented by a host of other support services, led to Indian agriculture growing rapidly and enabled India to become a global player.[2]

A serious imbalance, however, has emerged between output and employment, requiring urgent attention to be paid to the need to create jobs in manufacturing, services and construction. For example, over time, while the headcount of the poor has gone down, more than 189.2 million remain undernourished in 2017–19.[3] Similarly, growing population, increasing urbanisation and climate change are putting pressure on agricultural land for cultivation and adversely affecting soil and water quality. There is, therefore, a need to remandate Indian agriculture building upon the success it achieved in past five decades while aiming at making it more productive, efficient, resilient, resource-conserving, nutrition-centred and globally-focused. This section focuses on the pathways that will help achieving these outcomes.

2.1 Increased Investment in Agriculture

The growth rate of investment and capital formation in agriculture, which is essential for its progress, has seen an unhealthy trend in recent years, falling from close to 10% per year during the 2002–03 to 2011–12 period to 2% between 2010 and 2020. The private corporate sector accounts for less than 2% of the total investment in agriculture and less than 0.5% of the total annual investments of the corporate sector in the Indian economy. There is a pressing need to revive investments in agriculture in order to modernise the sector. Such investments should mainly focus on increasing productivity and making Indian agriculture more efficient. The key areas that would require substantial boost in investments are briefly described below.

In most of crops, increase in productivity has been accompanied by an increase in the average cost of production, which necessitates an increase in output prices to keep incremental production profitable. There is a need for shift in strategy from 'growth' to 'efficient growth', such that any increase in productivity is associated with a reduction in the average cost of production. This requires upgradation of agricultural technology, application of modern skills in farm practices, new innovations in farming and lowering wastages in the use of fertiliser, water and other inputs (Chand, 2019).

The adoption of improved technologies by Indian agriculture is still far below the potential. This can be gauged by the fact that the seed replacement rate and use of certified quality seed distributed by various agencies is quite low. Fertiliser use in most states is also sub optimal (Pavitra & Chand, 2015). Less than 50% of the area under cultivation has more than one crop grown on it. The fact that more than 30% area under cereals is still under traditional varieties shows that improved technology has not yet reached a large number of farmers. The main reasons for this

[2] With wheat production of 106.2 MMT and rice production of 117.5 MMT in 2019–20, India is the second largest producer of both these commodities. It also has become the largest exporter of rice (12.7 MMT, USD 7.7 billion in 2017–18).

[3] FAO et al. (2020).

are poor extension, missing links with the supply chain of quality seed and quality plant propagation material and low availability of institutional credit in many states.

Efficiency is driven by strong and vibrant research and development (R&D), whether by the public sector or private sector. Public sector R&D is showing fatigue and suffers from resource constraints, disciplinary fragmentations and lack of drive and inspiration. Private sector investment in agri R&D is also low due to the prevailing intellectual property regime. Consequently, the gap between domestic and global agricultural innovations is increasing and many interesting developments in global agriculture have bypassed India. There is a need to facilitate farmers' access to global technology, seeds, germplasm and other knowledge products.

Reorientation of agricultural science, technology and innovation focusing on greater use of new scientific developments and scaling of innovations is needed to accelerate agricultural GDP growth, as Chapter "Science, Technology and Innovation", has described. These may include:

1. genetic resource management and crop improvement through germplasm enhancement/pre-breeding using wide gene pools and molecular breeding techniques;
2. adopting genomics and gene editing as preferred technologies for precision breeding;
3. using genome editing in livestock to achieve enhanced prolificacy and reproductive performance, improved milk production and increased disease resistance;
4. increased application of genetically modified (GM) technology without compromising biosecurity; and
5. adopting protected cultivation to increase productivity and income.

Similarly, application of digital solutions and Artificial Intelligence can help ushering in an Evergreen Revolution, using big data for creating support systems. Precision agriculture holds out even more promise. Indeed, there are several innovative technologies ready to be scaled up and scaled out. India is making rapid advances in the use of non-fossil fuels and these can easily account for 20% or more of its total fuel use. While the use of solar power in Indian agriculture is still limited, it can account for a significant share of renewable energy.

Concern has been raised about inadequate investment in agriculture extension and the consequent decline in all aspects of extension. This is also evident from the gap between the existence and adoption of improved technologies, and between attainable and actual farm yields. Use of information communication technology and digital technology will go a long way in filling the gaps in extension and knowledge dissemination.

The diversified Indian agroecosystems and sectors are plagued by pests and pandemics, which affect the edifice of India's biosecurity, threatening food, nutrition, health, livelihood, biodiversity and ecosystem services. Rapid, large-scale movement of people and material in a globalised world, climate change and inadequate surveillance will exacerbate pandemics in the future. Research-cum-developmental organisations and industries dealing with the health systems of human, livestock, poultry and fish have the paraphernalia needed for effective preparedness and management

of pests and pandemics. However, their operational success is hampered by lack of coordination and collaborations.

Slight adjustments and reorientation in the functioning of different programmes interlinked through a common hub under the One Health concept would raise the standards of diagnostics, preparedness and pest management. For India to be a part of this preparedness, transformational changes in transboundary pest surveillance, strict quarantine, rapid molecular diagnosis, anticipatory research and training are essential. Transparency, political commitment, investment in research and development, analysis and interpretation of big data, meta-analysis, multilateral institutional/international cooperation is the way forward for preparedness and biosecurity. It is also important to note that pandemics need a united regional and global approach rather than mere national focus.

Indian agriculture has also witnessed greater levels of mechanisation. However, since the average farm size is low at 1.08 ha (hectares) (only 0.57% farms have holding size above 10 ha), farmers often end up adopting technologies which are not scale-neutral. One obvious solution to this challenge is to enable consolidation of small farms into larger tracts by enabling land leasing—though this comes with its own set of challenges relating to land titles. As farm mechanisation and precision farming could benefit small farmers, custom hiring centres can be promoted extensively. Similarly, aggregation of transactions through the use of computing/mobile devices or affordable rental of farm equipment is a promising option.

2.2 Making Indian Agriculture Globally-Focused

Though Indian agriculture has shifted from being a subsistence-oriented one to a market-oriented one, it is yet to be viewed as an enterprise and treated holistically as being part of a larger value chain. India currently processes less than 10% of its agri output. The share of high value and value-added agriculture produce in India's agri-export basket is less than 15%, against 25% in the case of the United States of America and 49% in the case of China. Given the globalisation of value chains, it is imperative that the country make concerted efforts to boost exports of high margin, value-added and branded processed products. The food processing sector has been exhibiting robust growth and constitutes as much as 8.83% of gross value added in manufacturing and 10.66% of gross value added in agriculture sector (CII, 2019). Changing consumption patterns due to urbanisation, changes in the gender composition of the work force and growing consumption have all contributed to the increase in the size of the domestic processed food market. Backed by progressive policies, fiscal incentives and an enabling regulatory environment, the Indian market size for food is expected to reach USD 544 billion by 2020–21 (CII, 2019). This will be amply complemented by a very high export growth target set by the new Agriculture Export Policy (AEP), 2018.

India is the eighth largest exporter of agricultural produce, with export earnings of USD 38.5 billion in 2018–19.[4] There is immense potential to increase agricultural exports, given the immense diversity and quantum of agricultural production, the fact that India's share in global agricultural export is only 1.8%,[5] European Union exports are as high as USD 181 billion and United States of America exports are USD 172 billion. A 2010 report by the World Trade Organization (WTO) states that India might become the world's fifth-largest exporter of agricultural commodities, surpassing Thailand and Indonesia.[6] Given the untapped potential and against the backdrop of the government's commitment to double farmers' income, the AEP aims to double agricultural exports to about USD 60 billion by 2022 and USD 100 billion in the next few years thereafter.[7]

In order to achieve these targets, it is important that India:

1. gears its agricultural development objective from heavy emphasis on self-sufficiency to providing quality products for export markets;
2. re-orient the role 715 *Krishi Vigyan Kendras* (agricultural science centres) towards enhancing the growth of crops that are in demand in global markets;
3. educate farmers on the prudential use of pesticides and other chemicals to eliminate the chances of rejection of Indian consignments; and
4. lay more emphasis on developing horticulture crops.[8]

[4] Agricultural exports accounted for 12.6% to total merchandise export (USD 303.7 billion) in 2018–19. Indian agricultural commodities and processed foods are exported to more than 200 countries. The top ten destinations for exports are Vietnam, Iran (Islamic Republic of), Saudi Arabia, the United Arab Emirates, the United States of America, Indonesia, Nepal, Bangladesh, Malaysia and Iraq. Commodities with export value of above USD 1 billion include: basmati rice (USD 4.71 billion), buffalo meat (USD 3.59 billion), spices (USD 3.31 billion), non-basmati rice (USD 3 billion), cotton (USD 2.1 billion), oil meals (USD 1.5 billion), marine products (USD 1.5 billion) and sugar (USD 1.3 billion). See, Hitul Awasthi, *India Agricultural Exports and Market Analyses*, Krishi Jagran, 17 June 2020. https://krishijagran.com/agripedia/indian-agricultural-exports-and-market-analysis/.

[5] Despite being the largest producer of papayas, lemons and limes, India meets only 3.2% of the world papaya demand, 0.5% for lemons and limes. However, the country has outperformed in exports of capsicum chilly, castor oil, tobacco extracts and sweet biscuits. It also has well established in the export market of basmati rice, meat and marine products. See Gurmeet Kaur, India Can Become Top Five Agriculture Goods Exporters in the World: WTO Report, Grain Mart. https://www.grainmart.in/news/india-can-become-top-five-agriculture-goods-exporters-in-the-world-wto-report/.

[6] https://www.grainmart.in/news/india-can-become-top-five-agriculture-goods-exporters-in-the-world-wto-report/.

[7] These targets are to be achieved by maintaining a stable trade policy regime accompanied by: (i) diversification of the export basket; (ii) promoting novel, indigenous, organic, ethnic, traditional and non-traditional agricultural products; (iii) providing an institutional mechanism for pursuing market access, tackling barriers and deal with sanitary and phytosanitary issues; and (iv) enabling farmers to get the benefit of export opportunities in the overseas market.

[8] Emphasis on horticultural crops is important also because the current level of minimum support prices make some crops like wheat uncompetitive in global markets.

2.3 Increasing the Efficiency of Water and Other Resources

India has made phenomenal progress in the development of irrigation and this played a key role in transforming Indian agriculture and making the country self-sufficient in food. Water also made agriculture more resilient to drought and climate variability over the years. Irrigated area increased from 20.9 million ha in 1950–51 to 67.30 million ha in 2015–16. The gross irrigated area went up from 22.6 million ha in 1950–51 to 96.62 million ha in 2015–16—almost half of the land under food grains is irrigated. Around 40% of total agricultural land in India is reliably irrigated and the remaining 60% is still rainfed and dependent on the monsoon. Groundwater is the source of almost 65% of the irrigated area. Over the years, area irrigated by groundwater increased much faster than the area irrigated by surface water.

The excessive use of groundwater, however, has led to steady decline in the water table and water quality. At least 60% of India's districts are either facing a problem of over-exploitation or severe contamination of groundwater (Vijayshankar et al., 2011). The Central Ground Water Board revealed that many parts of India are witnessing a steep fall in the groundwater table in many parts of India. It is estimated that the groundwater table in as many as 30% of total blocks in the country is either over-exploited or in a critical and semi-critical stage. The over-exploitation is more pronounced in north-western India, western India and southern peninsular India. There is also evidence of fluoride, arsenic, mercury and even uranium and manganese contamination in groundwater in some areas. The over-exploitation of groundwater is largely attributed to power being supplied free or at low tariff rates. Improved water management practices and micro-irrigation (drip and sprinkler) are available and can be used for improving water use efficiency and enhancing agricultural production.

It is in the above context that Chapter "Symbiosis of Water and Agricultural Transformation in India", argues for a paradigm shift in Indian agriculture. The way forward it suggests involves adopting an agroecological approach, changing the cropping pattern, applying improved technology in conserving water, reversing the neglect of the rainfed areas and introducing radical changes in the way in which water is managed, including the adoption of participatory management in both surface and groundwater systems.

2.4 Making Agriculture Climate Resilient

Climate change has become a major challenge to agricultural production. There are several projections about the varying impact of climate change on the agriculture sector in different regions. According to the Indian Network for Climate Change Assessment (INCCA) Report (INCCA, 2010), the rice crop (which is the major food grain crop), would suffer yield loss of 4–20% under irrigated conditions and 35–50% under rainfed conditions as early as 2030. Pal et al. (2019) reported that these projections are much more alarming than earlier ones, and tally with Cline's

estimates of 30–40% yield loss (Cline, 2007). More worrying is the revelation that what was expected to happen in 2080 may happen in 2030 itself. The negative impact of climate change on milk production has been estimated at about 1.6 million tonnes in 2020 and more than 15 million tonnes in 2050 (Upadhyay et al., 2009). An IPCC (2014) report indicates that climate change is occurring faster than earlier predicted. Small farm holdings, which are the main source of food, nutrition and livelihood security in India, are more prone to climate change impacts (Joshi & Tyagi, 2019). Small farm holders, who have the least capacity to overcome the consequences, as they have fewer resources to adapt socially, technologically and financially, are likely to be the worst affected.

Besides climate change, climate variability—including extreme events such as tropical storms, sudden rise and fall in temperature—is also expected to affect production of all food commodities. Kumar et al. (2014) point out that an increase in drought intensity will lead to fall in production, thereby pushing up the prices of food commodities. The authors estimated that a 10% increase in drought during the monsoon period will lead to the price of rice surging by 23%, maize by 16%, sorghum and millets by 13% and *tur* by 10%. The higher prices of food commodities will lead to fall in demand for them—approximately 5.5% in the case of rice and 2–4% in other commodities.

Agriculture is both part of the problem and part of the solution to climate change and sustainability. It is necessary to seize every opportunity available to move away from inefficient farm practices and towards long-term sustainability, efficiency and resilience. Of all sectors of the economy, agriculture offers the best hope for environmentally sustainable green growth. It is in this context that Chapter "Managing Climatic Risks in Agriculture" mentions several technological and institutional options that are now available to build resilience in Indian agriculture to current as well as future climate change. Most of these are no-regret options with mitigation co-benefits linked to SDGs. However, more targeted and detailed research is necessary to identify exact strategies.

The intelligent use of climate information services and big data analytics can facilitate the efficient use and targeting of increased public and private investment in natural capital through the management of water, energy, soil quality and natural resources and climate change literacy. A bottom-up farmer level consultation is equally, if not more, important, if only to indicate an equitable path, going forward. More research is also needed to understand risk profiles, the implications of various agricultural service delivery models for various social groups to strengthen resilience and finally to reduce loss and damage by investing in climate proof agricultural system. There are immense opportunities in targeting climatic services, advisories, insurance and precision agronomy, but there is a need for sound business models in order to take these to scale. There is a growing need for right partnerships, science-based actions, policies, market/non-market incentives, investments and institutional changes. Investments in natural resources, infrastructure, knowledge and human resource and social and institutional capital, and valuing their impact for creating green jobs in these sectors and impact on various dimensions of human wellbeing are becoming imperatives in policy planning.

2.5 Tackling Dietary Diversity, Nutrition and Food Safety

India is faced with a triple burden of malnutrition, namely, under-nutrition, micronutrient deficiency and over-nutrition. In 2017, about 68.2% of the deaths of children under five years of age in India was due to malnutrition (Chapter "Dietary Diversity for Nutritive and Safe Food"). The prevalence of stunting among children under five years of age was high, at 34.7% during the 2016–2018 period (CNNS, 2019). The body mass index of 23% of women in the 14–49 age group was below normal in 2015–16 (NFHS, 2017). Moreover, two-thirds of India's population is estimated to be deficient in micronutrients (Rao et al., 2018). The deficiency of micronutrients exists despite good economic growth (6% in 2018–19), a high level of food grain production, an increase in the per capita net availability of food grains (MoA&FW, 2020) and a significant decline in the percentage of population below the poverty line. Along with undernutrition, overweight and obesity have emerged as severe public health challenges, leading to an increase in non-communicable diseases (NCD). In 2017, about 63% of all deaths in India were attributable to NCDs (WHO, 2018).

It is vital to address the issue of malnutrition, especially in children and women, in order to ensure proper cognitive growth, overall health and productivity. Inadequate access to food, inadequate care for children and women, inadequate education, insufficient health services and unhealthy environment are the underlying factors behind this dismal situation.

The pathways for safe and healthy diets for nutritional security in India consist of the following:

1. improving dietary diversity,
2. reducing post-harvest losses,
3. bio-fortification of staples,
4. empowerment of women,
5. enforcing standards of food safety, packaging and labelling,
6. improving the Water, Sanitation and Hygiene (WASH) environment and
7. food safety awareness and nutrition education.

The need of the hour is expedited implementation of food safety and nutrition programmes, adopting a multi-pronged strategy with increased coverage, better targeting, change in the design, higher allocations of funds and coordination between different policies and programmes to achieve SDG2 targets. This should be accompanied by an effective use of digital technology. Additionally, food and nutrition security initiatives will need to be harmonised with changing demographics, livelihood patterns, environmental sustainability, health-specific needs and overall development activities.

2.6 Strengthening Institutions

India is dominated by small holdings and the future of agriculture depends upon them. The smallholders suffer from scale disadvantage, resource constraints and, typically, have small marketable surplus. However, various studies show that small farmers, especially in Asia, are more productive than large farmers (Chand et al., 2011). They have a significant labour advantage which can be tapped into for producing skill-based labour intensive products with institutional support like farmer producers' organisations (FPO) or cooperatives. Contract farming has also been very successful in addressing the resource constraints and market challenges that small farmers face and enabling them to diversify towards high value crops. Impressed by the success of such initiatives, the Government of India has implemented important policy reforms and launched an initiative to promote 10,000 FPOs.

A sharper focus on the role of three I's—Innovations, Incentives and Institutions—could help produce more, diversified and nutritious food economically, and in an environmentally and financially sustainable manner (Chapter "Transforming Indian Agriculture"). The major innovations in production technologies that can significantly impact overall productivity and production in India include climate resilient seeds and protected and sustainable agriculture. An incentive structure needs to be put in place for farmers to encourage them to adopt new technology and augment production. Possible interventions include direct income/cash transfer and incentives for water and energy conservation. In the case of the land institution, there is an urgent need to reform land laws, free up the lease market and revoke all restrictions, like ceilings on land holdings. In order to regulate the unsustainable extraction of water for irrigation, the government needs to create an institution that regulates spacing of tube wells, identification of aquifers, size of pumps and the overall rate of exploitation. This should be accompanied by institutional arrangements governing rights over water, land tenure, users' relationships and financial incentives.

2.7 Adopting Appropriate Policies and Improving Governance

An increase in agricultural production is essential, but is not sufficient to yield a substantial increase in farmers' income. Farmers need help to get higher prices and some of them need to be moved to non-farm occupations. Prices at the farm level can be raised in two ways—by ensuring farmers get minimum support prices (MSP) and by creating competitive markets. In many states, farmers get prices that are 10–20% lower than MSP. This is true even for paddy and wheat, where a large part of the marketed surplus is procured by the government. Ensuring MSP in such cases will raise farmers' income by 13–26%. It needs to be noted that the Green Revolution happened in only those states where farmers got remunerative prices. Recently, this has also been noted in in central and eastern India. At the same time, it is important to

emphasise that procurement at MSPs that are higher than open market prices causes many distortions. There is a need to think of alternative mechanisms, like deficiency price payment, which are less costly, more equitable and non distortionary (Chand, 2018).

Reforms in the system of marketing is a more effective means of ensuring better prices to farmers, without putting pressure on consumer prices. The current markets system and its infrastructure are outdated and exploitative. Rather than evolving, agricultural markets have decayed and serve the interest of intermediaries rather than of farmers and consumers. Competitive and modern markets and other reforms in the agriculture sector can make the sector vibrant, self-reliant and economically attractive.

The key areas for policy reform (Chapter "Structural Reforms and Governance Issues in Indian Agriculture") include:

1. accelerating rural infrastructure in a manner that targets specific regions as well as small and marginal farmers (including women farmers), and creating a competitive environment that stimulates investment, productivity and marketing efficiency;
2. giving state governments more autonomy and flexibility to draw up 'fit for purpose' action plans relating to production and marketing so as to encourage both the farmers and the agripreneurs;
3. enabling women farmers to form farmer producer organisations, women self-help groups and women-headed enterprises with the objective of easing the hurdles they face in getting loans from the banking system, mainly because of lack of land titles in their names;
4. ensuring adequate investments in rural and marketing infrastructure, credit flow and extension services while formulating and implementing innovative and inclusive market reforms; and
5. expansion of contract farming in a way that encourages the production of better quality and high value produce and provides farmers sufficient incentive to enter into contracts for export-oriented agricultural and horticultural products which meets international standards of quality and food safety.

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