NITI
Working Paper
02/2023

From Green Revolution to Amrit Kaal

Lessons and Way Forward for Indian Agriculture

Ramesh Chand
and
Jaspal Singh

NITI Aayog
National Institution for Transforming India
Government of India, New Delhi

July, 2023

NITI Working Paper 02/2023

From Green Revolution to Amrit Kaal

Lessons and Way Forward for Indian Agriculture

Ramesh Chand and **Jaspal Singh**[1]

NITI Aayog
National Institution for Transforming India
Government of India, New Delhi

July, 2023

[1] Ramesh Chand and Jaspal Singh are Member and Consultant, NITI Aayog, respectively

Contents

Tables

Figures

Box

Disclaimer

Views expressed in the paper are personal.

Acknowledgement

Authors thank Sumedha Bajar for her valuable comments and for editing the paper.

ABSTRACT

When India attained independence, the agriculture sector was in a poor state. The situation was aggravated by the fact that the more productive and largely irrigated areas fell in the newly-created Pakistan[2]. The first two decades after Independence did not see any improvement in overall food availability – per capita annual production of total food remained unchanged at 296 kg till 1966-67. The adoption of Green Revolution technology led to an improvement in the situation, and per capita food production reached the level of 365 kg (around 1 kg food per person per day) in the early 1970s. Annual production of food has now reached 683 kg per person, or 1.87 kg/person/day. The twenty-first century has seen an acceleration in growth in per capita food production, marking a significant departure from the trend growth rate of the first 50 years after Independence. India recorded a 50 per cent increase in per capita food production in the 50 years after 1950-51 (that is, till 2000-01). The next 50 per cent increase has been recorded in less than 25 years, that is, half of the previous period. A further 50 per cent increase is likely to be achieved in less than 25 years.

However, several challenges – some old and some new – remain. Growth of the agriculture sector has led to the unsustainable use of natural resources like land, water and bio diversity, spread of insects and pests, indiscriminate use of agro chemicals and adverse impact on ecology and environment. Despite noteworthy increase in per capita food production, some sections of the population still suffer from undernutrition and malnutrition. These challenges necessitate a paradigm shift in agriculture. In the meantime, new opportunities have arisen in the sphere of science and technology, information communication technology (ICT) and agri business which have the potential to transform agriculture production and post-harvest activities. There is a significant change on the demand side, with consumer preferences shifting towards healthy, safe, trait-based and quality food and bios. These changes indicate that the future of agriculture (and those engaged within) will face profound transformation in the coming decades. There is a need to create an enabling environment for this transition, through appropriate policies and institutions, an enabling regulatory environment, development of frontier technologies, as well as public and private investments in agriculture and agri-business. This will enable agriculture to play a key role in achieving the goal of Viksit Bharat, inclusive development, green growth and gainful employment during Amrit Kaal.

[2] Productivity of rice, wheat, maize and gram and total foodgrains in Pakistan was 40 per cent higher than in India in 1945-46. Source: Estimated from data taken from Bansil P.C. (1990). Agricultural Statistical Compendium, Vol. I, Foodgrains. Pp. 431-2., Techno Economic Research Institute, India, New Delhi.

INTRODUCTION

In August 2022, India completed 75 years of Independence from colonial rule, making this year a momentous one. It provides a advantage position to assess the nation's achievements, reflect on the progress made in socio-economic indicators and to draw lessons for the future. Coinciding with this historical milestone, the Hon'ble Prime Minister Shri Narendra Modi has described the next 25 years as Amrit Kaal (leading to 2047, when India will complete 100 years of Independence) and set a goal of making India a developed nation or Viksit Bharat.

As is widely acknowledged, the agriculture sector continues to play a vital role in the country's socio-economic development and progress. Despite the relatively higher growth of the non-agriculture sector, it is the agriculture sector that remains the principal source of employment, with 45 per cent of the workforce engaged in agricultural and allied activities. The sector contributed 18.6 per cent of the national income at current prices during 2021-22.

This paper is organised in two parts. The first part discusses the achievements of India's agriculture in terms of (a) output growth at the aggregate and disaggregated levels, (b) food and nutrition (c) agricultural income and (d) trade, since 1950-51. It also analyses changes in the structure of agriculture output and their implications for the future of Indian agriculture. The second part visualises the likely changes in the agriculture sector during Amrit Kaal. The picture of agriculture during the next 25 years that is portrayed is based both on the underlying trend in agriculture as well as the role that agriculture is expected to play in addressing the goals of food and nutrition security, inclusive development, sustainability and climate change. It also takes cognizance of the emerging challenges in agriculture, new opportunities for the sector, the operating environment and the needs and goals of the nation and society. This is followed by a suggested way forward for agriculture during Amrit Kaal.

1

ACHIEVEMENTS IN AGRICULTURE DURING LAST 75 YEARS

1.1 Agriculture, Economy and Population Between 1951 and 2021

Credible data on most economic indicators for the post-Independence period is available only from 1950-51 onwards. Between 1951 and 2021, India's population increased from 35.9 crore to 136.9 crore. Food production increased from 106 million tonnes to 936 million tonnes[3] over the same period. Thus, the increase in food production was more than twice the increase in human population during the last seven decades (Table 1). Income from the agriculture sector, at 2011-12 prices, increased 7.2 times over this period, with an underlying annual trend growth rate of 2.83 per cent. The non-agriculture sector witnessed higher growth than agriculture, resulting in overall national income increasing by 28.4 times, with an average annual growth rate of 4.83 per cent. However, the number of agriculture workers increased from 9.72 crore in 1950-51 to 25 crore in 2021-22[4].

Table 1: Broad changes in Indian agriculture and economy between 1950-51 and 2021-22

Indicator	Unit	1950-51	2021-22	Increase times	Compound growth rate %
Population	Person crore	35.9	136.9	3.81	1.90
Food production	Million tonne	106	936	8.83	3.12
Agri sector income	Rs. lakh crore at 2011-12 prices	2.91	21.15	7.27	2.83
Total economy	Rs. lakh crore at 2011-12 prices	4.79	136.24	28.44	4.83
Agri workers	crore	9.72	24.67	2.58	1.34
Total workers	crore	13.95	54.27	3.87	1.92

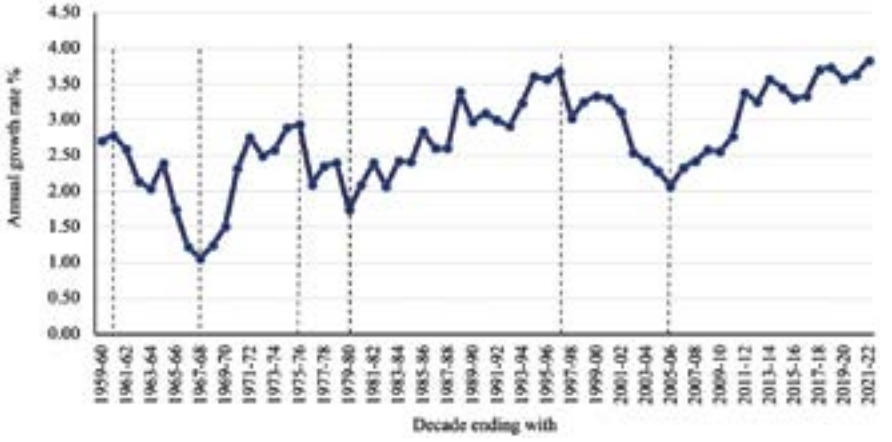
Source: 1. Economic Survey, Ministry of Finance.
2. National Accounts Statistics, MoSPI, GOI.
3. Agricultural Statistics at a Glance, Ministry of Agriculture and Farmers Welfare, GOI.
4. Annual Report, Periodic Labour Force Survey, July 2021 to June 2022, NSO, MoSPI, GOI.

During the seven decades since Independence, the agriculture sector witnessed phases of high and low growth. This can be seen from Figure 1, which presents ten yearly moving averages of annual growth rates in gross value added (GVA) in agriculture and allied sectors at 2011-12 prices. Based on this growth trajectory, the entire period of 72 years can be divided into seven broad phases (Figure 2). Each phase represents the period between two successive turning points towards either acceleration or deceleration. The first phase covers the period from 1950-51 to 1961-62 – the first decade of planned development. Agriculture GVA showed annual growth rate of 2.77 per cent in this period. The main source of growth was expansion in area under cultivation. This was followed by a deceleration in growth, which continued till 1968-69. The adoption of Green Revolution technology, which started around 1966, reversed the deceleration in growth rate in a short span of three years. The initial phase of the Green Revolution propelled growth in certain well-endowed regions, which had irrigation facilities or where irrigation could be easily developed. This phase continued till 1975-76 and registered a growth rate of 2.27 per cent. However, as the Green Revolution technology, in the initial phase, remained confined to a few regions, growth in agriculture output could not be sustained beyond a short period of time. The four years between 1975-76 and 1979-80 witnessed a decline in agriculture and allied sectors GVA at constant prices.

[3] Food includes all cereals, pulses, edible oil (eight edible oilseeds, cotton seed and coconuts multiplied by oil per cent), sugar (11 per cent of sugarcane), milk, fruits, vegetables, eggs, meat and fish. Some oilseeds like groundnut are eaten as seed; their entire quantity was converted into oil.

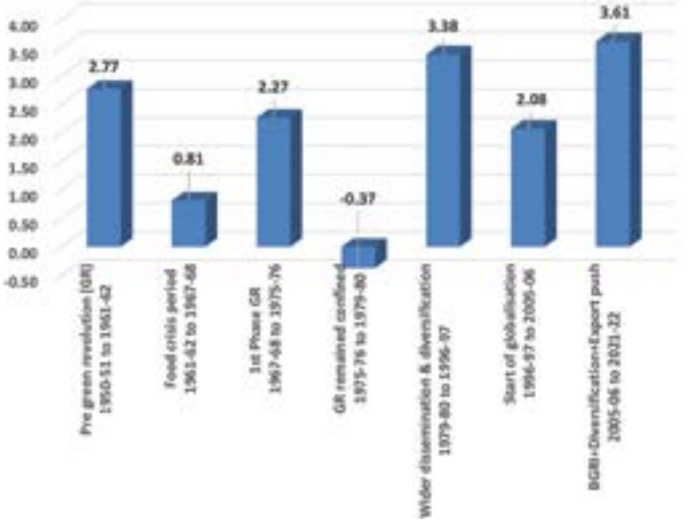
[4] Based on PLFS data for the year 2021-22.

Figure 1: Decadal moving average of annual rate of change in GVA in agriculture and allied sectors (1950-51 to 2021-22)



Source: Estimates based on National Accounts Statistics, MoSPI, GOI, 2011-12 series.

Figure 2: Trend growth rate in various phases of growth in Gross Value Added in agriculture and allied sectors (1950-51 to 2021-22)



Source: Same as in Figure1.

Note: BGRI: Bringing Green Revolution to Eastern India

Serious efforts were then undertaken by the Union and States for wider dissemination of Green Revolution technology and towards diversification in favour of high value crops. Along with this, technological developments like cross breeding in the dairy sector and improved poultry breeds also started yielding results. This was assisted by the spread of dairy co-operatives. This phase – combining the wider spread of the Green Revolution in terms of area and crops and the White Revolution – delivered rich dividends over a long period of 17 years from 1979-80 to 1996-97. The agriculture sector achieved a record growth rate of 3.38 per cent during this period.

The next phase started one year after the World Trade Organization (WTO) Agreement on trade was signed in 1995. This marked the beginning of the active globalisation and liberalisation of agriculture trade, which led to the growing integration of domestic and global markets. Initially, this had a negative impact on agriculture growth mainly due to increased competition and a decline in the international prices of agricultural commodities, leading to a deterioration in the terms of trade (ToT) for agriculture in the country. This phase continued till 2005-06, after which international prices started rising. The growth rate of agriculture dropped to 2 per cent during this phase. As international agricultural prices started rising from 2006-07, the growth rate of Indian agriculture also picked up. The phase of rising global commodity prices culminated in the global food price crisis between 2008 and 2011. There were substantial hikes in domestic prices through policy interventions in order to align them with international prices, while open market prices also moved up in sync with international prices. The ToT of trade for agriculture relative to the non-agriculture sector (with base 2011-12=100) increased from 85 in 2005-06 to 128 in 2020-21[5]. The growth rate of the agriculture sector also accelerated steadily in response to the higher and rising ToT for the sector. The growth rate for agriculture during the 15 year period ending 2021-22 is estimated at 3.61 per cent, which is the highest among all the phases so far.

The trajectory of agriculture growth presented in Figures 1 and 2 reveals the following important policy messages:

- Agriculture growth during the first two Five Year Plans (1951-56 and 1956-61) was not sustainable due to the absence of improved technology that was required for productivity-driven growth. This created huge food shortages and culminated in the food crisis during the mid-1960s.
- Green Revolution technology was the key in taking Indian agriculture out of the declining productivity phase, and putting it on a respectable growth path in a short period.
- The accelerated growth rate after the initial adoption of Green Revolution technology could not be sustained for long, as this technology was restricted mainly to the irrigated and well-endowed regions of Punjab, Haryana, Western Uttar Pradesh and the deltaic regions of the Deccan Plateau.
- The wider dissemination of technology and diversification towards horticulture and livestock played a significant role in raising and sustaining agriculture growth during the 1980s and the first half of the 1990s.
- The liberalisation of agriculture trade that was undertaken as a result of domestic economic reforms as well as the requirements of the WTO Agreement was very favourable for the sector during the initial years, when international prices were higher. However, due to their inherent cyclical nature, international prices started falling after 1998 and their transmission to domestic prices pulled down the ToT for agriculture for some years around the early 2000s. This, in turn, led to a deceleration in agriculture growth, which continued till 2006-07, when international prices started moving up sharply.

1.2 Performance at Sub Sector Level

Agriculture is a diverse sector and its major sub sectors are (i) crops, (ii) livestock, (iii) fishery and (iv) forestry. The crops sub sector has always dominated the agriculture and allied activities sector, though its share in agricultural output and income and in the agriculture and allied sector has seen a significant decline post the mid-1990s. It, however, continues to account for 55 per cent of the total income generated

[5] Terms of trade is computed by taking the ratio of implicit price deflators of GVA agriculture and allied sectors and GVA non agriculture.

in the agriculture and allied sectors. Livestock constitutes around 30 per cent, fishery 7 per cent and forestry and logging about 8 per cent of the sectoral income at current prices.

The crop sector is further divided in two groups – fruits and vegetables, and other crops. Table 2 presents the performance of these segments during various phases of growth of aggregate agriculture sector. Instead of using GVA as a metric of growth, the paper uses the value of output at constant prices to estimate growth rates in various sub sectors, because the back series data on GVA (before 2004-05) was found problematic, especially for separate series of crop and livestock.

Growth in the output of the crop and forestry sectors showed very high variation over the several phases of growth of Indian agriculture mentioned earlier. In contrast, the output of the fishery sector showed much smaller variation over time. Within the crop sector, horticulture picked up pace as early as the 1960s. The output of fruits and vegetables showed a very high growth rate of 6 per cent from 1961-62 to 1967-68, though this was from a very low base. The period from 1975-76 to 1979-80 was particularly adverse for all segments of agriculture, except livestock and fruits and vegetables. After the adoption of Green Revolution technologies, the performance of the livestock sector turned out to be much better compared to that of the crop sector in all the phases. This points to the fact that the White Revolution has had a much stronger impact than the Green Revolution in terms of output growth (Chand, 2023).

The fishery sector, growing at 7.10 per cent, has topped in growth in output during the period from 2005-06 to 2020-21. Livestock comes second, with an annual growth rate of 5.4 per cent. The output of the crop sector after 2005-06 showed a growth rate of 2.55 per cent, mainly supported by fruits and vegetables, which registered a 4.5 per cent trend growth rate. Excluding fruits and vegetables, the growth in the output of the crop sector was below 2 per cent. The output of the forestry sector either recorded a decline or miniscule growth in various phases after 1975-76.

Table 2: Growth rate in value of output of various sub-sectors/segments of agriculture and allied sector during various phases since 1950-51

Sub sector/ segment	Pre-Green Revolution	Food crisis period	1st phase of Green Revolution	Green revolution in restricted area	Wider adoption and diver-sification	Start of global-isation	BGRI+ Diversi-fication +Export
	1950-51 to 1961-62	1961-62 to 1967-68	1967-68 to 1975-76	1975-76 to 1979-80	1979-80 to 1996-97	1996-97 to 2005-06	2005-06 to 2020-21
1. Crop sector	3.09	0.78	2.19	-0.01	2.88	1.60	2.55
1.1 Fruits and vegetables	0.96	6.15	5.43	1.96	3.25	2.86	4.53
1.2 Other crops	3.36	0.09	1.65	-0.41	2.81	1.27	1.91
2. Livestock	1.45	0.49	2.70	4.45	4.41	3.44	5.36
3. Fishery	5.43	4.25	4.34	0.54	6.12	2.90	7.10
4. Forestry	0.68	4.25	2.03	-4.51	0.20	1.64	1.53
5. Total (1 to 4)	2.29	1.61	2.27	-0.24	2.88	2.07	3.44

Note: Output at 2011-12 prices.

BGRI: Bringing Green Revolution to Eastern India

Source: Estimates based on National Accounts Statistics, MoSPI.

1.3 Changes in Composition of Agriculture Sector

Due to differing growth rates registered by different items within agriculture commodities, the composition of the agriculture (crop + livestock) sector has undergone significant change over the decades (Table 3). These changes are largely driven by technology and market (demand), though government intervention has also been a major determinant.

Table 3: Changes in composition of agriculture sector

Agri commodity/ group	Share (%)		
	1970-71	1995-96	2020-21
Cereals	37.1	25.3	16.7
Pulses	4.7	4.2	3.9
Oilseeds	8.2	8.2	5.2
Fruits and vegetables	12.4	14.6	19.4
Other crops, by products	22.6	22.0	17.9
Milk group	10.2	17.4	24.3
Meat group	1.6	3.8	8.1
Eggs	0.5	0.9	1.2
Other livestock products	2.8	3.5	3.3

Source: Estimates based on National Accounts Statistics data, MoSPI.

Cereals constituted the largest commodity group within the agriculture sector in the early 1970s, with a 37.1 per cent share in the value of total agriculture, that is, crop and livestock products. Their share declined by one-third between 1970-71 and 1995-96 and by another one-third in the next 25 years. A similar decline is also seen in the share of pulses and oilseeds and other crops. Fruits and vegetables are the only group which show an increase in their share over time. It is interesting to note that in value terms fruits and vegetables are almost as large as all cereals and pulses taken together.

The milk group constituted one-tenth of total agriculture output at the beginning of the Green Revolution. This share increased to one-fourth over a span of 50 years because of significantly higher growth of the dairy sector compared to the crop sector. Clearly, the White Revolution has played a much stronger role in growth of the dairy sector than the Green Revolution has in the crop sector. These changes point to a very clear trend in diversification towards horticulture and livestock products and away from cereals, pulses and oilseeds throughout the period since 1970.

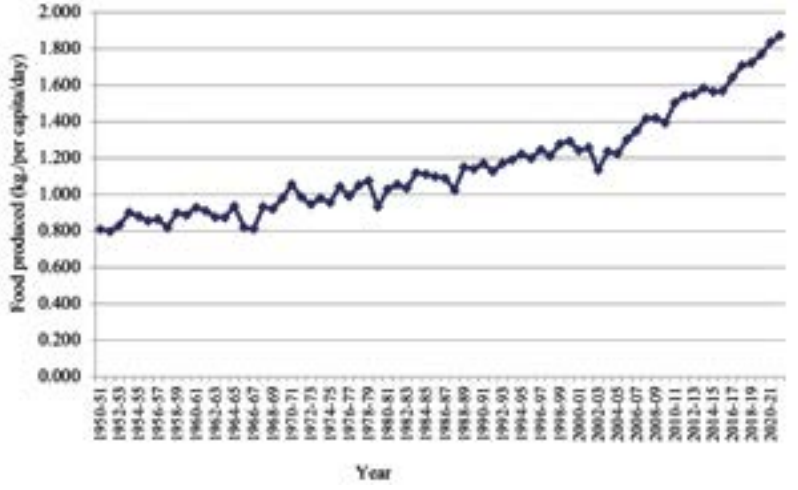
1.4 Achievements in Food Production

India's progress and achievements in the food sector can be captured by three types of indicators representing (i) quantity of aggregate food, (ii) composition and (iii) quality. The progress made in the quantity of aggregate food produced in the country between 1950-51 and 2020-21 has been presented in Table 1, while the growth trajectory of GVA in the agriculture and allied sectors has been presented in Figure 1. Food commodities constituted 62 per cent of the total value of output of the agriculture and allied sector in 1950-51, which gradually increased to 80 per cent around 2019-20. This shows that the dominance of food in the agri-food sector has increased over time.

The ultimate goal of food production is to provide food security and nutrition to the human population. This can happen only if the growth rate in food production remains above the growth rate in human population. Therefore, achievements in food production are better represented by per capita food production. This is presented in Figure 3 for the period from 1950-51 to 2021-22.

During the initial years following Independence, food production[6] in the country was sufficient to supply 0.81 kg of food per person per day or 296 kg per year. This increased marginally to reach 0.936 kg by 1964-65. However, in the next two years, food production dropped to the level that prevailed in 1950-51. Thereafter, per capita food production got on to a rising trend and touched 1.258 kg/person/day or 459 kg/person for the whole year around 2000-01.

Figure 3: Per capita per day food produced in India, 1950-51 to 2021-22 (kg)



Source: Authors' estimates based on production of food and population data.

The twenty-first century has seen an acceleration in growth in per capita food production, marking a departure from the trend growth rate of the first 50 years after Independence. India recorded a 50 per cent increase in per capita food production in the first 50 years after 1950-51. The next 50 per cent increase has been recorded in less than 25 years, that is, half of the previous period. This is the result of two factors: (a) slowdown in population increase and (b) acceleration in the growth rate of food production, especially after 2006-07. The next 50 per cent increase in per capita food production is likely to be achieved in less than 25 years.

Table 4 depicts disaggregated data on per capita production of various food commodities during various decades since 1960-61. Over a period of six decades, per capita production of all commodity groups, except pulses, followed moderate to high increase. Per capita production of cereals in the last five decades increased by 80 per cent and oilseed production by 60 per cent. Per capita production of pulses during the 2011–20 period came down to 15.7 kg from 23.3 kg during the decade of 1960s. Per capita production of fruits, vegetables, meat and fish and milk tripled between the 1960s and the decade after 2011, while egg production recorded an eight-fold increase over the same period. These changes show that there was a clear shift in the composition of food output in the country in favour of horticultural commodities and livestock commodities.

[6] See footnote 2 for items included in food.

It clearly emerges from Table 4 that growth in the quantity of food produced in the country was accompanied by changes in the composition of food. Food production and the food basket show significant diversification over time, especially after 1981. The share of livestock products in the total value of agri-food output increased from 17.6 per cent in 1980-81 to 27.4 per cent in 2001. This increased further to 36.9 per cent in 2020-21. A similar story is seen in the case of fruits and vegetables. Their share in the crop sector doubled twice in the last 70 years and the current share is around 30 per cent.

Table 4: Per capita production of major food commodities since 1960s (kg/year)

Item	1961–70	1971–80	1981–90	1991–00	2001–10	2011–20
Cereals	121.0	135.1	151.8	169.0	173.1	215.0
Pulses	23.3	18.4	16.3	14.6	12.3	15.7
Oilseeds	15.3	15.3	16.8	23.2	21.6	24.1
Sugar	24.1	24.5	26.0	30.3	27.9	29.5
Fruits	23.2	31.8	33.1	41.2	49.7	69.7
Vegetables	47.6	68.9	72.4	77.3	97.7	133.5
Egg	0.4	0.7	1.0	1.4	2.1	3.3
Meat & Fish	4.3	4.6	5.0	6.9	8.3	13.3
Milk	43.2	42.1	55.6	70.8	88.0	121.2

Source: Authors' estimates based on production data of Directorate of Economics and Statistics and population data of National Accounts.

While major food groups indicate diversification towards broad-based food, which is considered healthier, intra-group diversity shows a decline in some cases like cereals and vegetables. Both these food groups present different stories. The story of cereals is a matter of serious concern, as it shows not only a steep decline in the share of millets in total cereals but also in per capita production. Per capita millet production declined from more than 30 kg during the early 1970s to 13 kg in recent years; this brought down their share in total cereals from more than 20 per cent to 6 per cent over the last 50 years.

In the case of vegetables, potato accounted for 15.8 per cent and onion constituted 5.2 per cent of total vegetable output in the country during the decade of 1970s. Their share during 2011–20 increased to 27.1 per cent and 11.9 per cent, respectively. Thus, potato and onion together constitute close to 40 per cent of total vegetable production in India. However, the saving grace is the fact that despite this increase in the concentration of these two items in the total vegetables basket, the per capita production of other vegetables increased after 2000-01.

The long-term trend in commodity composition shows that, except for pulses and millets, the production of all other commodities exceeded growth in human population. Between 1950-51 and 2020-21, the highest growth was achieved in eggs followed by meat, fish and milk. Cereals have shown a steady increase throughout this period. Production of oilseed crops in the country barely matched the growth in population between 1961 and 1980. However, their production picked up after 1981. The per capita production of pulses became less than half during the 50 years ending with 2001. However, there has been a significant improvement in per capita production of pulses after that. Nevertheless, on a per capita basis, India produces much less pulses now than in 1951.

Per capita production, though an important indicator of food adequacy, does not reveal the true status of food intake, as it does not factor in import, export, industrial use, feed, change in stocks, wastage etc. The per capita net availability of cereals in India has stabilised around 168 kg for several years now and much of the increase in the production of cereals is now being exported. India has seen an extraordinary increase in the per capita usage of edible oil plus vanaspati, which first doubled from 4 kg to 9 kg in the 25 years between the early 1970s and the mid 1990s. It had doubled again in the next 20 years ending 2015. The current net availability of edible oil plus vanaspati has reached 20 kg per person, which is far higher than the domestic output of vegetable oil. As a result, around half of the total demand for edible oil in the country is met through imports.

1.5 Sources of Growth

Indian agriculture has achieved a long-term growth rate of 2.74 per cent between 1950-51 and 2020-21. Within this period, the growth rate accelerated to 3.5 per cent between 2000-01 and 2020-21. The overall performance of the sector is considered satisfactory, though some challenges remain. The main factors underlying this growth are:

- Favourable policy environment and timely institutional reforms initiated by the Union and State Governments.
- Agriculture research and development (R&D) and extension for improved technology generation and its dissemination.
- Public and private (farmers') investments in building irrigation capacities.
- Use of modern farm inputs, including seeds.
- Institutional credit supply.
- Output price and market support.
- Input subsidies.

1.6 Subsidies and Investments

Input subsidies and investments in various types of infrastructure and institutions are important policy instruments contributing to the growth and development of the agriculture sector and the income of producers. Both the Union and the State Governments have used these instruments to promote agriculture as well as the welfare of producers and consumers. Initially, input subsidy was provided mainly for fertilizers. The primary aim of this was to encourage the use of chemical fertilizers, which was found to significantly enhance growth in productivity and output. Fertilizer subsidy is mainly provided by the Union Government. The other major subsidies provided to the agriculture sector are: interest subvention on institutional agricultural credit, subsidy on crop insurance and subsidy on power supply to agriculture (which is borne by State Governments). The second policy instrument – public investment in agriculture – includes public expenditure on medium, major and minor irrigation, agriculture R&D and extension, cooperative institutions, and land and soil improvement programmes.

Table 5 gives figures on both subsidies and public investment in agriculture. Subsidies to the agriculture sector have more than doubled between 2011-12 and 2020-21. Subsidies on power have risen the fastest, as more and more States provide subsidised or free electricity to farmers. While public investments have also increased at almost the same rate as subsidies, their level has remained around one-third of

subsidies. Subsidies constitute close to 7 per cent of income generated in agriculture and allied sectors. In contrast to this, only a little more than 2 per cent of sectoral income is spent on public sector capital formation. Fertilizer subsidy forms the biggest component of total subsidies for the agriculture sector, closely followed by power subsidy. Fertilizer subsidy is estimated to reach Rs. 2.25 lakh crore in financial year 2022-23 due to skyrocketing international prices of plant nutrients following the Russia-Ukraine war.

Table 5: Public investments and subsidies in agriculture, 2011-12 to 2020-21 (Rs. crore)

Year	Public investment	Subsidy including power	Public investment as % GVA agri & allied	Subsidies as % GVA agri and allied
2011-12	35576	118063	2.37	7.86
2012-13	39617	131996	2.37	7.88
2013-14	40467	127600	2.10	6.62
2014-15	47004	138689	2.25	6.62
2015-16	55870	164130	2.51	7.37
2016-17	66362	158994	2.63	6.31
2017-18	66786	194689	2.36	6.88
2018-19	79473	205678	2.63	6.82
2019-20	72696	220666	2.16	6.57
2020-21*	76852	250195	2.13	6.93

Note: The data on investments and subsidies, except power subsidy, is available from the National Accounts Statistics of MoSPI, and budget documents. The amount spent on power subsidy was computed from the data provided by the Power Finance Corporation.

Several studies have pointed out that the level of input subsidies and the manner in which they are dispensed is reaching unsustainable levels and leading to a lot of adverse effects. The fertilizer subsidy, for example, is highly skewed in favour of urea, a nitrogenous fertilizer, and this has resulted in imbalance in the use of major plant nutrients, nitrogen-phosphorus-potassium (NPK). This affects the efficiency of fertilizer use and the quality of soil as well as output.

In most States, power supply for agriculture use is either totally free or highly subsidised. Some States charge a flat rate, irrespective of electricity consumed by the farmers. This has resulted in the over exploitation of ground water almost everywhere in the country. Free power has also distorted cropping patterns towards water-intensive crops, showing disregard for agro-climatic conditions of various States and regions. Withdrawal of groundwater beyond recharge capacity is on the rise and the severity of this problem is increasing.

Data from groundwater monitoring wells at the level of blocks/mandals/talukas indicate that water withdrawal exceeded sustainable levels in 28.7 per cent area in 2004. In 2020, this had increased to 36.4 per cent area. Excessive withdrawal is also affecting the quality of groundwater, due to the intrusion of salt from aquifers having brackish water and higher arsenic content in some areas.

About 80 per cent of investments in agriculture comes from private sources – mainly farmers. The share of the corporate sector in total public and private investment in agriculture[7] has remained meagre, below 0.2 per cent, pointing towards the scope of expansion available for the corporate sector. The rest of the investment comes from public sources.

[7] Investments in agriculture mainly refers to land, input and production related investments. It does not include investments in markets, storage, transport, grading and other post-harvest infrastructure.

1.7 Price Support and Output Growth

The system of minimum support prices (MSP), which was started in 1965 for wheat, now covers 24 crops (barring sugarcane). The Union Government announces a fair and remunerative price (FRP) for sugarcane, which is a statutory minimum price. The system of guaranteed prices to producers has been implemented through procurement by public agencies. For a long time, MSP was effectively restricted to rice and wheat in the states which were early adopters of Green Revolution technology. However, MSP operations in wheat, rice and cotton have now been expanded to many other parts of the country. Similarly, output price support has been extended, through the Price Support Scheme and Price Stabilization Fund, to pulses and oilseeds in many producing states.

Experience shows that MSP, supported by public procurement, provides a very stable price environment and protects producers against any market and price risk. Over time, MSP has been made more remunerative by including new items of imputed costs and by raising margins over the cost of production. In 2018, the Union Government ushered in a significant shift in the MSP structure by making it mandatory to keep a margin of at least 50 per cent over A2 cost (all paid out costs) plus the imputed value of family labour. This has resulted in MSP being higher than open market prices in many cases.

Agricultural commodities can be divided into five groups in terms of price support, subsidies and other government support measures (Box 1). The first group comprises rice, wheat, sugarcane and cotton. Of these, rice and wheat derive maximum benefit from the MSP regime as well as input subsidies, because of the higher use of fertilizers and higher proportion of area under irrigation, both of which are highly subsidised. The second category comprises coarse cereals, oilseeds and pulses. Though they are covered by MSP, only a small quantity of the produce is procured under this regime. The subsidy benefit for these crops is insignificant as they are mostly rain-fed and use lower amounts of fertilizers. Horticultural crops (fruits and vegetables) belong to the third group, which is not covered by MSP or any other price assurance scheme and hardly benefits from price intervention measures by the government. However, they benefit from subsidies on irrigation, power and fertilizers. The fourth group comprises the livestock sector, for which there is no price intervention by the government, nor is any input subsidy provided. The dairy segment of the livestock sector benefits in terms of institutional support through co-operatives which procure milk from producers at assured prices, linked to the percentage of fat. The fifth group comprises fishery (inland and marine), which also gets no price support and hardly any subsidy on inputs.

The last column in the box presents the annual rate of growth in output of these five groups of commodities during the 2011-12 to 2020-21 period. Rice, wheat, sugarcane and cotton, which get highest input subsidy and output price support among all agri commodities, show an annual growth rate of 1.39 per cent in this decade. Even coarse cereals, oilseeds and pulses put together show much higher growth than the much vaunted crops like wheat and rice. On the other hand, horticultural crops, for which there is no price intervention by the government, experienced annual growth of 3.47 per cent. The output of the livestock sector increased at the rate of 5.84 per cent per annum, which is four times the growth in crops highly supported by the government. The highest growth rate is achieved in the fishery sector, which is largely free from government intervention in the form of input subsidies and output price.

Box 1: Classification of agricultural commodities in terms of public intervention and output price support and input subsidies

Commodity	Support on output side	Input subsidy	Total direct support	Growth rate during 2011-12 to 2020-21
Rice, wheat, cotton and sugarcane	Very strong MSP and procurement.	Very high.	Very high	1.39
Coarse cereals, pulses, oilseeds	MSP for some produce.	Small	Small	2.44
Fruits and vegetables	Nil	High	Small	3.47
Dairy and other livestock products	Institutional support through cooperative marketing of milk	Nil	Little	5.84
Fishery	Nil	Nil	Nil	8.97

A clear picture emerges from this that the commodities receiving higher government support in the form of input and output prices are witnessing a lower rate of growth in their output. On the other hand, the segments of agriculture not receiving much government support and intervention are registering much higher growth. Thus, it is not wrong to infer that Indian agriculture has now reached a stage where government intervention in the form of output price support and input subsidies is not leading to higher growth in output. The underlying reason for this is that the power of demand side factors in pulling growth is much stronger than the power of government support in pushing growth. The shift in dietary preference towards horticulture, livestock and fishery produce, in both the domestic and overseas markets, is offering producers a more remunerative environment to raise production.

MSP was a major factor in improving the economy of wheat, rice and sugarcane in the early stages of adoption of improved technology, when the market was under-developed and suffered from several imperfections. Over time, as markets developed and started passing on demand signals to producers, the demand side factors have been stronger than public support in helping realise the growth potential of various commodities. This trend has strong implications for policy intervention in the agriculture sector. While the paper is not advocating for free market solutions, it does point to inefficiencies within the existing system/institutions that call for greater scrutiny. This can help provide efficient public intervention to existing groups and opportunities to expand support where it is most required.

1.8 Growth at State Level

The State-level experience further corroborates what is observed at the national level. This is revealed by the level of land productivity (value of crop output/hectare) and growth rate of the crop sector being achieved across States (Table 6). Surprisingly, the States with highest productivity of land are not the States with highest productivity of rice and wheat. Productivity of wheat and rice is highest in Punjab, followed by Haryana, while the top three States in aggregate land productivity are West Bengal, Himachal Pradesh and Andhra Pradesh. Similarly, the crop sector in Andhra Pradesh is growing at more than 4.8 per cent as compared to 0.5 per cent in Haryana and Punjab. The key takeaway from this is that States which have shifted their area allocation and crop pattern in tune with changing demand patterns perform much better compared to those States which have remained more or less rigid.

It is also pertinent to point out that the top three States in per hectare crop productivity have much lower coverage of irrigation as compared to Punjab, Haryana and Uttar Pradesh.

Table 6: Growth rate of Gross State Value Added by sub sector, agricultural land productivity, area under fruits and vegetables, and irrigation coverage among States/Union Territories

State	Annual trend growth rate during 2011-12 to 2020-21						Crop productivity (Rs./ha) TE 2019-20	Area share F&V (%) TE 2018-19	GIA as % of GCA
	Crops	Live-stock	Forestry	Fishery	Agri-culture (C+L)	Agri-culture and allied			
Andhra Pradesh	4.81	8.26	0.68	19.57	6.05	8.33	195211	10.64	49.40
Assam	5.40	20.98	-1.15	6.62	6.36	5.79	140016	8.75	11.89
Bihar	-2.15	8.89	4.14	8.32	1.32	1.95	126772	5.87	71.96
Chhattisgarh	3.48	7.68	4.70	9.95	4.00	4.58	72495	2.53	33.82
Goa	-0.01	-1.48	24.16	2.01	-0.41	2.66	157411	49.79	23.13
Gujarat	2.93	5.90	18.11	4.78	3.29	4.28	122036	8.94	50.57
Haryana	0.53	7.51	0.41	9.09	3.21	3.08	174538	1.14	91.03
Himachal Pradesh	1.54	8.83	1.61	8.46	2.96	2.26	204321	15.86	22.45
Jharkhand	4.15	6.33	11.02	11.49	4.35	4.68	180552	6.14	13.67
Karnataka	4.73	9.67	2.35	1.59	5.83	5.33	107750	5.92	31.82
Kerala	-4.80	0.87	0.70	0.90	-2.66	-2.01	151751	18.70	20.07
Madhya Pradesh	7.79	14.74	4.63	14.60	8.68	8.28	154041	1.63	45.99
Maharashtra	4.10	6.35	6.58	0.71	4.46	4.58	86299	7.37	21.12
Odisha	4.83	4.49	4.60	10.76	4.42	4.77	133326	0.11	27.13
Punjab	0.51	5.44	1.07	6.51	2.17	2.11	183565	2.31	98.62
Rajasthan	1.71	11.14	3.50	8.82	5.35	5.12	60204	0.73	42.34
Tamil Nadu	1.38	11.58	5.95	3.65	5.18	4.99	183181	10.27	56.26
Telangana	6.45	8.32	0.39	7.54	6.44	6.23	122217	4.68	52.32
Uttar Pradesh	2.50	2.70	1.52	6.78	2.49	2.48	136348	4.57	80.46
Uttarakhand	-1.40	5.15	1.42	4.30	0.92	0.99	163176	4.75	51.27
West Bengal	2.29	4.59	2.03	2.72	2.87	2.79	269607	16.77	65.46
Andaman & Nicobar Islands	-1.66	3.40	20.46	1.80	0.04	1.84	NA	20.02	0.72
Arunachal Pradesh	-0.53	6.89	7.41	5.65	0.16	3.08	144009	12.40	17.75
Chandigarh	1.61	1.65	32.84	6.36	1.43	2.47	137310	2.93	5.05
Delhi	-11.68	-4.28	-12.13	0.49	-5.93	-5.93	265660	40.15	64.02
Manipur	10.56	2.06	3.46	3.14	7.51	5.77	112770	21.98	16.19
Meghalaya	2.85	3.24	6.61	18.14	2.91	3.47	122964	30.03	45.72
Mizoram	3.33	14.27	46.73	4.20	7.43	14.84	122172	52.82	15.76
Nagaland	4.21	-8.67	2.64	3.62	0.92	1.14	128439	16.39	23.35
Puducherry	-5.12	1.16	0.83	2.72	-0.32	0.46	319156	3.90	84.01
Sikkim	6.32	8.55	7.09	10.45	6.44	6.47	296474	34.75	9.90
Tripura	7.56	19.57	6.84	16.48	8.72	8.83	372625	17.82	24.04

C+L: crops + livestock **F&V:** Fruits and vegetables **TE:** Triennium ending
GIA: Gross irrigated area **GCA:** Gross cropped area

Source: Estimate based on Land Use Statistics, and National Accounts Statistics data.

1.9 Structural Changes in Output and Employment

The theory of economic development clearly states that the share of agriculture in the total economy declines with economic progress or growth of the economy. This share refers to both share in national income (output) and total employment (workforce). In 1950-51, 69 per cent of the total workforce of the country was engaged in agriculture and they contributed 53 per cent of the national income. Thus, a worker in agriculture earned half of the income earned by a worker in the non-agriculture sector at the time of Independence. By 1970-71, the share of the agriculture sector in employment turned out to be slightly higher, but its share in national income declined by close to 20 per cent. This raised the disparity in per worker income between agriculture and non-agriculture to 1:3 in 1970-71.

The next 40 years witnessed faster structural change in the economy, in which the share of agriculture declined in both employment as well as national income. The decline in agriculture's share in national income was faster than the decline in its share in the national workforce and this meant that disparities in per worker income between agriculture and non-agriculture further widened. In 2010-11, the income of one agricultural worker turned out to be less than one-fifth of the average income accruing to a non-agriculture worker. This trend in rising income disparity reversed after 2010-11, as the share of agriculture in the workforce fell much faster than the drop in its share in national income. As a result, income per agriculture worker in 2020-21 turned out to be 29 per cent of the income of a non-agriculture worker – significantly higher than the 19 per cent registered in 2010-11. A major factor in this has been the relatively faster increase in agricultural prices, translating into faster growth in nominal income of the agriculture sector in recent years. In 2020-21, agriculture constituted one-fifth of the Indian economy at current prices and 16.3 per cent at constant (2011-12) prices (first revised estimates (RE), 2020-21).

Table 7: Share of agriculture and allied sectors in national income and employment 1950-51 to 2020-21

Year	Agri. share in workforce %	Agri. share in national income %		Ratio of income of agriculture worker to non agri. worker
		At constant prices	At current prices	
1950-51	69.2	61.7	53.2	0.51
1970-71	69.7	49.6	43.1	0.33
1990-91	59.0	35.1	29.8	0.29
2010-11	54.6	18.3	18.4	0.19
2020-21	46.5	16.3	20.0	0.29

Source: Based on Population Census data, NSO-PLFS data and National Accounts Statistics data

The key reasons for the very wide sectoral disparities in income between agriculture and non-agriculture are low productivity of agriculture in the country and failure of the non-agriculture sector, especially the manufacturing sector, to absorb the extra workforce from the agriculture sector by offering remunerative employment opportunities.

1.10 Agriculture Trade

Over the last 50 years, agricultural trade has seen two varying patterns. The first two decades beginning 1970-71 did not show any clear trend in net trade – exports exceeded imports in some years while it was the opposite in others. This appears to have been the result of very high year-to-year instability in domestic production and inward-looking trade policies. However, beginning 1990-91, exports exceeded imports by a sizeable margin, and the difference only increased over time. This was a result of (i) steady and accelerated growth in agriculture production, (ii) slow-down in population growth which affected growth in domestic demand and (iii) liberalisation of agriculture trade – first, following the economic reforms initiated in 1991 and, subsequently, as a result of the WTO agreement. Not only did exports and imports increase in dollar terms, they also increased as a proportion of value of output.

In the beginning of the 1990s, exports constituted 2.80 per cent of the value of domestic production, while imports constituted only 0.56 per cent of the value of agricultural output. Recent data shows that the fraction of output exported by India increased to 6.98 per cent in 2020-21. Imports constituted 3.49 per cent of output in the same year. The agriculture sector fetched net foreign exchange earnings of $20.79 billion in 2021-22, which is another significant contribution of agriculture to the Indian economy.

Agri exports and imports now constitute more than 10 per cent of total production in the country. The trade share in the produce that enters market is much higher, as producers retain some part of production for self-use. There is now strong integration of the domestic market with global markets and changes in global prices are promptly transmitted to the domestic market. This necessitates careful regulation of agricultural trade to safeguard domestic producers and consumers against the normal volatility in global prices without causing adverse effects on exports.

Figure 4a: Trend in import and export of agriculture including fishery, 1970-71 to 1990-91

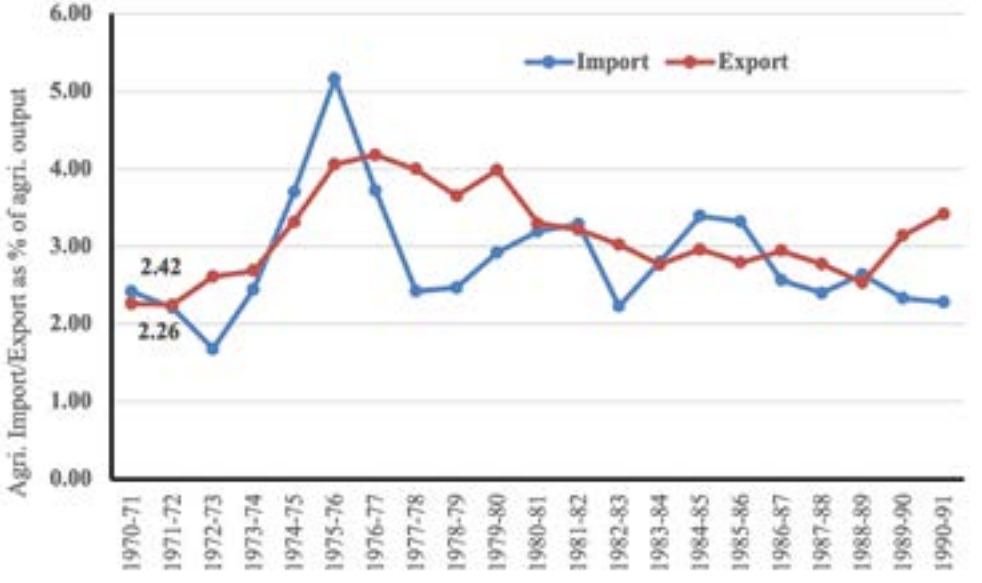
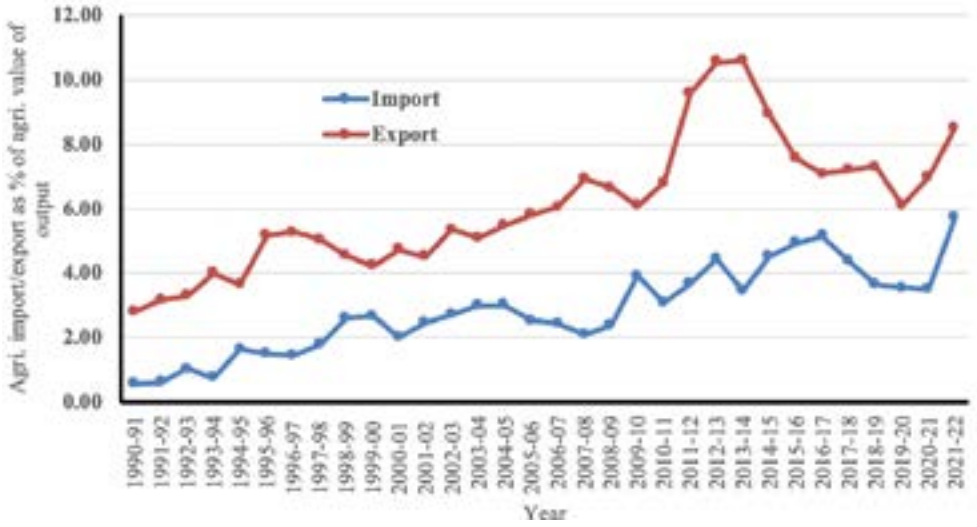


Fig 4b: Trend in import and export of agriculture including fishery, 1990-91 to 2021-22.



Source: Agricultural Statistics at a Glance, Ministry of Agriculture and Farmers Welfare, GOI, various issues. National Accounts Statistics, MOSPI, GOI.

1.11 Nutrition and Health

Nutrition and health have remained important goals of development policy in India. Comparable and up-to-date estimates on nutrition outcomes are available from country-wise estimates from the Food and Agricultural Organization of the United Nations (FAO) of the number of persons who are undernourished and prevalence of undernourishment. FAO also refers to undernourishment as hunger and uses the term undernourished and hungry interchangeably. According to this data, which is available from 1979 onwards, the number of undernourished persons in India declined from 262 million in the 1979 to 1981 period to less than 200 million around 2010. The prevalence of undernutrition also shows a steady decline. According to FAO, more than 38 per cent population of India was undernourished in the early 1980s. The prevalence of undernourishment dropped to below 14 per cent during 2015–2019 (Table 8). There was some deterioration in hunger indicators during the Covid-period (2019-20 and 2020-21), but that cannot be attributed to food shortage, as food production remained normal during this time.

Table 8: FAO Estimates of number and prevalence of under nutrition, 1979 to 2021

Year: 3 years period	Number of people undernourished (million)	Prevalence of undernourishment (per cent)
1979-81	261.5	37.95
1990-92	215.6	25.03
2000-02	198.3	18.40
2001-03	219.3	20.10
2002-04	239.3	21.50
2003-05	249.6	22.10
2004-06	247.8	21.60

Year: 3 years period	Number of people undernourished (million)	Prevalence of undernourishment (per cent)
2005-07	228.8	19.60
2006-08	207.2	17.50
2007-09	199.0	16.60
2008-10	198.0	16.30
2009-11	195.9	15.90
2010-12	193.1	15.40
2011-13	189.0	14.90
2012-14	190.8	14.90
2013-15	192.0	14.80
2014-16	190.5	14.50
2015-17	184.1	13.90
2016-18	176.3	13.20
2017-19	180.2	13.30
2018-20	200.0	14.60
2019-21	224.3	16.30

Source: FAO-State of Food Insecurity various issues.

The second source of data on nutrition and health is the National Family Health Survey (NFHS). This data is available from 2005-06 to 2019–21. The main findings of NFHS related to nutrition and health are presented in Table 9. It shows a steady improvement in child stunting and the number of underweight children in the last 15 years, though the incidence is still high. Similarly, there is consistent and significant improvement in health indicators for women – the percentage of women with Body Mass Index below normal has almost halved from 35.5 per cent to 18.7 per cent over this period. However, the incidence of anaemia is found to be very high and even shows an increase after 2015-16 – two-thirds of children under the age of five years and 52.2 per cent pregnant women in the age group of 15-49 years are reported to be anaemic in the country.

Table 9: Incidence of nutrition indicators 2005-06 to 2020-21

Indicator	NFHS year		
	2020-21	2015-16	2005-06
Children under 5 years who are stunted (%)	35.5	38.4	48.0
Children under 5 years who are underweight (%)	32.1	35.8	42.5
Women whose Body Mass Index (BMI) is below normal (%)	18.7	22.9	35.5
Women who are overweight or obese (%)	24.0	20.6	12.6
Children under 5 years who are anaemic (%)	67.1	58.6	69.4
Pregnant women age 15-49 years who are anaemic (%)	52.2	50.4	57.9

Source: National Family Health Survey (India fact sheets of different years)

2
PLAN FOR AMRIT KAAL

The first part of this paper highlighted how the Indian agriculture story in the post-Independence period – especially after 1970 – was largely one of success. The growth went through various phases, and the highest growth in agricultural output and income has been realised in the phase that began in 2005-06. The country is now planning for the next 25 years, which will conclude with 100 years of India's Independence. This period has been described as Amrit Kaal. Planning and policy formulation for agriculture during this period should be based on the following factors:

1. Future demand for agri-food.
2. Lessons from past experience, especially relating to drivers of growth.
3. Challenges facing the sector and those arising from the sector.
4. Emerging opportunities and changes in the operating environment of agriculture.
5. Needs and goals set for the society and the nation.

2.1 Meeting Future Demand

There are four main sources of demand for agricultural produce: (i) food for human population, (ii) feed and fodder for livestock, (iii) feedstock for energy and (iv) raw material for industrial and non-agricultural uses.

Demand for food is driven by population, rural-urban population distribution, per capita income and consumers' tastes and preferences. According to United Nations population projections of 2019[8], India's population will increase from 1.38 billion (138 crore) in 2020 to 1.5 billion (150 crore) in 2030 and 1.59 billion (159 crore) in 2040. These estimates imply that the population will increase at the rate of 0.857 per cent per year between 2020 and 2030 and 0.577 per cent between 2030 and 2040. Besides meeting the demand for the additional population, there is also a pressing need to increase per capita intake of food to address issues relating to hunger and undernutrition.

Growth in per capita income is another important factor affecting demand. The expenditure elasticity of food is estimated to be around 0.45 (NITI Aayog, 2018)[9], based on the consumer expenditure data of 2011-12. Expenditure elasticity tends to decline with increase in per capita income. The per capita income in India in real terms (2011-12 prices) increased by 41 per cent between 2011-12 and 2021-22 and is expected to increase at a much faster rate in the coming years. This implies that expenditure elasticity for the period beyond 2023 will be much lower than 0.45. Corresponding to these parameters, a 5 per cent rate of increase in per capita expenditure will translate into a growth in demand of around 2 per cent. With population growth of 0.85 per cent per year, growth in overall demand for food commodities is projected to be around 2.85 per cent in the short term and is likely to decline with the passage of time.

2.2 Drivers of Output Growth

The experience of the last 50 years clearly highlights the fact that Indian farmers strongly respond to market signals. These signals could come from public policy (like MSP, procurement) or emanate from demand side changes. Demand-driven factors are also found to have much a stronger effect on

[8] https://population.un.org/wpp/Publications/Files/WPP2019_Volume-I_Comprehensive-Tables.pdf . p. 27 medium variant.

[9] Expenditure elasticity for aggregate food was taken as the weighted average of the elasticities estimates for cereals, pulses, edible oils, fruits and vegetables, milk and meat reported in The Working Group Report on Demand and Supply Projections constituted by NITI Aayog. It worked out to be 0.51 for rural, 0.28 for urban and 0.45 for combined population. Expenditure shares and rural and urban population were used as weights.

growth of output, as compared to the effect of price support. This is evident from the fact that fruits and vegetables, milk, eggs, meat and fish experienced much higher growth than cereals and sugarcane, both which are heavily supported by the government and covered under effective price support.

The policy message emerging from this is that the strong and healthy growth of the agriculture sector is predicated on changes in production in tune with the changes in demand. This approach should avoid price distortions and ensure well-functioning markets to transmit demand signals to producers.

2.3 Challenges Facing and Related to Agriculture

Soon after the spread of modern technology in Indian agriculture, there was much discussion on the first-generation problems of the Green Revolution. These problems became more severe over time and some were aggravated by government policies. These challenges are related to sustainability of natural resources, efficiency, the plight of farmers with small holdings, food safety, profitability, fiscal effect and equity. Agriculture policy should address these challenges during Amrit Kaal. These are briefly described below.

2.3.1 Sustainability and Climate Change

The way agriculture is practised has significant bearing on the quality of air, water and land, which are the pillars of sustainability. The bulk of water usage in the country is for agriculture, and more than 40 per cent of land area is under agriculture. Agriculture growth in India has led to the over exploitation of natural resources, especially water, across the country.

Water withdrawal far exceeds water recharge. As a result, the groundwater table shows small to very high decline in 36 per cent blocks of the country. This is happening even in the high-rainfall, water-rich, middle Indo-Gangetic region. Farmers in some parts of the country are chasing groundwater beyond 1,000 feet below ground level. This has increased the cost of irrigation and also led to deterioration of water quality in many regions, due to the ingress of brackish water and arsenic content into good quality water.

The indiscriminate use of fertilizer and other agro-chemicals is contributing to the degradation of land, water and air. Free or subsidised power to agriculture has promoted the cultivation of water-intensive crops and use of excess water for agriculture. The decline in the water table in some of the regions has reached alarming levels and there is a serious danger of water shortage for future generations. The distortions in output and input prices has led to India exporting water-intensive crops like rice and sugar and importing crops that are less water consuming like pulses and edible oil. Even with its small share in global exports, India is now the biggest exporter of virtual water, that is, the water embedded in exported agri food products. On the other hand, large sections of the population do not get adequate water for drinking and other uses.

Greenhouse gases (GHG) emitted from agricultural activities are generally not visible. The emission results from the application of organic and inorganic inputs to the soil, decomposition of biomass and dead plant residues, plant respiration, livestock rearing, enteric fermentation in ruminants, manure handling and burning of crop residues. Agriculture is responsible for about 17 per cent of GHG emission in India, which is almost same as its share in gross domestic product (GDP). This share will increase significantly if the burning of crop residue, which is now spreading to all states, is taken into account fully.

2.3.2 Low Efficiency and Price Led Growth

Growth in India's agriculture sector – though impressive in most products and states – still suffers from low productivity levels, especially when compared with growth in other major agricultural countries. The pace of modernisation is slow. The much-needed changes in technology, method of production and post-harvest value addition are not visible at a large scale. Agricultural practices involving the prolific use of inputs like flood irrigation and broadcasting of fertilizer have not shown any significant change. For many crops, the increase in productivity has been accompanied by an increase in the average cost of production (Srivastava, et al., 2017), which necessitates increase in output prices to maintain profitability levels. The dependence of the agriculture sector on government support is rising. Consequently, the sector is losing its competitive edge.

While non-price factors create potential for growth, remunerative prices incentivise farmers to harness this potential. Thus, both sets of measures are crucial for the future growth and development of the agriculture sector. Over time, the focus of various farmers groups has moved towards better price support and subsidies and little attention is being paid to non-price factors like extension, R&D, market regulation and infrastructure which create opportunities for growth in output and farm income. Excessive reliance on price factors and subsidies also has implications for the fiscal burden of Union and State Governments.

The policy shift towards price factors is visible from the trend in prices in agriculture relative to prices in the non-agriculture sector – also called terms of trade (ToT) for agriculture (Figure 5). The ToT was taken as the ratio of the implicit price deflator of the agriculture sector relative to the implicit price deflator of the non-agriculture sector using data series with a 2011-12 base. The ToT did not follow any clear trend during the 1970-71 to 2006-07 period. After that, ToT for agriculture moved on a steeply rising trend (Figure 5). This implies that price trends have become more and more favourable for agriculture and farmers during the 15 years following 2006-07.

Figure 5: Movement in terms of trade for agriculture computed from ratio of implicit price deflator of GVA agriculture and non-agriculture sectors (base 2011-12=100), 1970-71 to 2021-22.

Source: Author's estimate derived from data on Macro Economic Aggregates in National Accounts Data, Back Series with base 2011-12, MoSPI, GOI.

Increase in real prices for the agriculture sector in the recent period has played an important role in the growth of the sector. This option may not always be available during the Amrit Kaal. The country would need to depend more on yield-enhancing and cost saving technologies to sustain past growth trends.

2.3.3 Linking Food to Health and Nutrition

According to the National Family Health Surveys, the incidence of stunted and underweight children as well as prevalence of anaemia among children and women remains high. At the same time, India has achieved very high increase in per capita net intake of all types of foods, except cereals, which include fruits, vegetables, milk, eggs, meat and fish after 2005-06 (Table 4 and Figure 3). The per capita production of all food items taken together has registered a 50 per cent increase between 2004-05 and 2020-21. There is a need to explain why this increase in per capita food availability is not adequately reflected in nutrition and health outcomes. The fact that the percentage of women who are overweight doubled between 2005-06 and 2020-21 raises serious questions about the low availability of food as the reason for undernutrition and anaemia. The Ministry of Agriculture and Farmers' Welfare and the Ministry of Health need to reconcile the contradiction between high growth in food availability and slow improvement in nutrition and health indicators.

There is need for a country-wide survey to ascertain the true status of health and nutrition, as well as the role of food availability, food distribution, awareness about nutrition, eating habits and preferences, hygiene and food diversity in determining nutrition intake and health outcomes.

As the country has moved from a situation of food shortages to that of food surplus, the focus of production should be on nutritive and healthy food. There should be emphasis on bio-fortification of major foods and increased dietary diversity. The promotion of millets and green and leafy vegetables is very important in order to improve the nutrition and health of all age groups.

2.3.4. Export Competitiveness

India has remained a net exporter of food since 1988-89. Net exports have shown an increase, even as a percentage of domestic production. This implies that domestic production has been growing at a faster rate than domestic demand. A similar trend is expected to continue for a decade or so.

The dependence on export markets to dispose of domestic surplus will be much greater for some commodities like rice and sugar. India already exports more than 12 per cent of the domestic production of rice. The expenditure elasticity for cereals in the country is reported to be negative (-0.10). This implies that low growth in domestic demand for cereals – attributed to growth in population – necessitated the need for their export. Similarly, the per capita production of milk and dairy products has crossed the level recommended by nutrition authorities like the Indian Council for Medical Research (ICMR) and the National Institute of Nutrition (NIN). With production growing at more than 5 per cent, India would be surplus in milk. Export markets are also very important for a large number of horticultural commodities, condiments and spices and beverage.

On the supply side, Indian agriculture is poised to move on a growth trajectory of 3-4 per cent in the next decade, as there is still large untapped potential to raise the productivity of crops and livestock as well as crop intensity. Aggregate food demand is projected to increase around 2.85 per cent per year. These estimates imply that food surplus in India will witness accelerated growth. At present, exports constitute more than 7 per cent of the value of total production of the agriculture and allied sector. This

must increase in coming years. This requires agri exports to be more competitive and action is needed in three areas:

- prices in primary markets should be sufficiently lower than international prices;
- the price spread in various stages of marketing should be reduced; and
- producers should be integrated with global value chains.

2.3.5. Technology Dissemination and R&D

Agricultural problems are becoming more complex and research is turning more capital intensive. Climate change, the share of agriculture in GHG emissions and sustainability concerns add to the challenges, which need to be tackled by a robust R&D system. The scope for spill over from research in the developed world is shrinking, as intellectual property rights issues are complicating matters and making it costly for the transfer of technology from abroad and the private sector. Thus, India needs to enhance domestic strength in agricultural research.

Agriculture is also becoming more competitive globally, with the emergence of many innovations. However, the rate of adoption of improved as well as frontier technology in the country remains low, mainly due to poor extension. Taking technology from laboratory to land and advisory services to farmers were primarily undertaken by the States. Of late, State-level extension systems have considerably weakened, both in terms of resources and manpower. Effective mechanisms like digital technology need to be put in place for speedy and cost-effective extension.

Of late, R&D in agriculture in India is not keeping pace with that of major agricultural countries. This is evident from the rising yield gap, lack of adoption of precision and smart farming techniques, and lower application of advance sciences in agriculture. Except in the case of rice and wheat, India is not able to keep pace with the world yield. Major crops like cotton, soybean, groundnut, and rapeseed mustard are crying for breakthroughs in yield that have already been witnessed at large scale in many countries.

Though agricultural research and higher education is largely a responsibility of State Agriculture Universities (SAUs), the Indian Council of Agriculture Research (ICAR) is required to respond to any challenges and issues concerning the agriculture sector. Public opinion at large holds ICAR responsible for any adverse development in the agriculture sector. As a result, the portfolio of ICAR has been getting bigger and bigger over time. Its load has risen manifold, with the responsibility to operate Krishi Vigyan Kendras throughout the country. Many questions are raised about effectiveness of ICAR to play the larger role it has been assuming and is expected to play in the field of agriculture R&D, education and extension. Several committees have been formed over the years for organizational reforms in ICAR. Similarly, many policy documents have recommended an increase in agriculture R&D spend to at least 1 per cent of agriculture GDP. However, the allocation (by Union and State Governments together) remains below 0.5 per cent. This is highly inadequate to address the needs and challenges of the agriculture sector. India needs a vibrant and future-ready national research system for agriculture. R&D by private sector also needs to be encouraged. The agri R&D policy and R&D system in the country need radical changes to serve the goals set during Amrit Kaal.

2.3.6. Viability of Smallholders

Agriculture in India and most of the Asian countries is dominated by small land holdings. According to Agricultural Census for 2015-16, 68 per cent farm holdings operate on less than 1 hectare land area.

Further, 85 per cent of farm households undertake farming on land holdings of less than 2 hectares. Though small holders are found to be more efficient than large sized farms (Chand, et al., 2011), small farm holdings operating within the usual agricultural practices and products do not generate adequate income for good living.

There are two paths to raise the income of such farm holdings. One, to enable these farmers to go for high value crops and livestock activities where they can make optimum use of the workforce in their families. Two, supplement agriculture income with income from non-agriculture sources like wages and salaries, some kind of business and trade. Small holders also face the problem of scale economy in both input and output markets, which require a different type of institutional help.

Income from non-farm sources constitutes an important part of the income of farm households. According to the Situation Assessment of Agricultural Household 2019, published by NSO, on an average, an agricultural household earns 47.35 per cent income from non-agricultural economic activities. This share was 40 per cent in 2012-13. This shows that the importance of non-agriculture sources of income is increasing. Therefore, in order to increase the income of farm households at a faster rate, both agriculture as well as non-agriculture sources need to be tapped.

2.4 Emerging Environment and Opportunities

There are immense opportunities for new ways of doing agriculture, for creating new types of products, accelerating the sector's growth, value addition and employment, thanks to technological breakthroughs, e-commerce, newer uses of agri-food commodities, trait-based demand and employment etc. There is a growing opinion that farms will become factories of the future for meeting various needs of consumers.

The industry and services sectors are becoming increasingly capital intensive and deploying labour saving and labour displacing technologies like artificial intelligence (AI), robotics and machine learning. Therefore, the labour shift from agriculture to industry, as envisaged in the classic work of Lewis (1954), is not taking place at the pace it was expected to (Chand, et al., 2017). Consequently, employment is emerging as the biggest challenge in developing countries. This necessitates exploring the scope for remunerative and decent jobs in and around agriculture – in secondary agriculture, processing, packaging, value chains and value addition.

There is an increasing preference for bio-based products for uses such as alternative sources of energy, building material, chemicals, polymers, medicines, cosmetics, insect/pest control, fertilizer and nutrition, among other things. The use of agri produce like grains, oilseeds and sugarcane as biofuel is growing. These sources of energy are renewable, and emit much lower levels of GHG compared to hydrocarbons.

India produces more than 650 million tonnes of crop residue, only a part of which is used as dry fodder for livestock; the rest just goes waste. A relatively recent phenomenon has been that of farmers burning a part of the crop biomass, like paddy and wheat stubble and scrubs, in order to clear the fields quickly for the next crop. Not only is this a waste of biomass, but it is also detrimental to the environment, air quality and human health. Initially, this practice was limited to the States of Punjab and Haryana, but it is now spreading across the country.

Recent studies have demonstrated the utility of lignocellulosic crop biomass – which has low or no economic use – for the production of gaseous biofuel, using anaerobic digestion by microorganisms. This offers a win-win situation for crop producers, cattle owners and the environment.

For example, the residue or slurry left after anaerobic digestion is very good manure for plants. In addition, producing compressed bio gas (CBG) from crop residue creates market value for the latter, and gives farmers an additional source of income. Public sector oil companies buy the CBG at an assured price within a 25 km radius of their production units. There are already around 300 units producing CBG and the target is to raise this number to 5,000 by 2025. Thus, gases like carbon monoxide and nitrous oxide present in crop biomass become a source of green energy, rather than harming the environment.

All these are excellent examples of the circular economy and of the concept of waste to wealth, and offer opportunities for improving the economic viability of cattle and other livestock.

A strong sentiment against chemicals in general, and agro chemicals in particular, has emerged in recent times. Health hazards like anti-microbial resistance are necessitating the search for alternatives, like the use of bio molecules as substitute for antibiotics. Globally, strong markets are emerging for bio-based industrial products. Bio-based products include commodity and specialty chemicals as well as fuels. Similarly, demand for new attributes in food commodities like specific tastes, aroma, immunity, therapeutic value and special health effects is on rise.

2.4.1 Quality and Food Safety

Consumers are increasingly becoming fastidious about food quality and showing preference for food with specific attributes. This requires integrating demand with supply through well designed supply chains and direct linkages between producers and consumers.

Food safety is emerging as a major concern among consumers, with increasing reports of excessive and unsafe use of chemicals and hormones in crops, livestock and fish food and the presence of chemical residue in food. This requires the framing of rigorous regulations and their strict enforcement at both the production and post-harvest stages. Awareness should be created among producers, middlemen in the value chain and processors about safe levels and methods of usage of agro chemicals in the entire food system.

New interest has emerged in the therapeutic values of food and its proper usage in order to maintain overall immunity and for good health. As a result, the demand for medicinal plants and varieties with specific attributes is on the rise. Some entrepreneurs are connecting consumers and producers through innovative value chains for the supply of such products. Large-scale supply of such products will require the creation of value chains with traceability and labelling.

2.4.2 Market Reforms and E-commerce

The existing market infrastructure is inadequate to handle the increasing marketable surplus. Almost half of this surplus is sold outside Agricultural Produce Marketing Committee (APMC) markets. The traditional market system involves bulk selling and buying through a large number of intermediaries and transactions. This system has some serious disadvantages and, therefore, alternative options and systems of marketing need to be developed. Agri-produce with specific attributes and traits (like high zinc or iron content or

high protein levels), which cannot be ascertained by the naked eye, require special market chains with traceability and labelling. This is not possible through bulk buying, selling and pooling. Many producers/ groups directly market such produce to consumers to meet the latter's preferences and earn much higher price compared to prices in APMC mandis. App-based sale of farm produce by farmers or farmers groups, e-commerce and digital commerce are also opening up new avenues for marketing. This requires a new ecosystem of agriculture marketing where the APMC system and alternative markets compete with each other and offer farmers choices to earn the best price for their produce.

2.4.3 Frontier Technology and Agri Start-ups

There are many fascinating technological changes taking place in agriculture in developed countries, with machines replacing humans in various operations. This is helping to improve efficiency, precision, safety, apart from other gains. However, the pace of diffusion of these frontier technologies in developing countries is very slow, when the need for technology-led transformation of agriculture is much greater in these countries.

Agriculture in developing countries is in dire need of improved efficiency and productivity, food safety and quality, enhanced profitability, lowering vulnerability and improving sustainability of the environment and natural resources, among other things. An effective response to these challenges is not possible with the current tools available to agricultural sciences like agronomy, soil science, entomology, etc.

Frontier technologies, offering immense benefits available for ready application in agriculture can be classified as: (i) biotechnology, (ii) digital technology, (iii) nanotechnology, (iv) space science and global positioning system (GPS) tools and (v) advance engineering technologies, including sensors and unmanned aerial vehicles (UAV). Breakthroughs in these fields have immense potential for application in crop production, animal husbandry, fishing and agri-business. These technologies have immense potential to benefit producers, consumers, society, economy and ecology by contributing towards:

- productivity enhancement,
- cost reduction,
- higher efficiency levels,
- better decision making in production and marketing,
- lowering pre and post-harvest losses,
- reducing drudgery,
- quality enhancement,
- lowering emissions and
- fostering climate change mitigation and adaptation.

Most of these emerging technologies with vast potential for application in agriculture are being developed in non-agricultural disciplines and institutes. Since their application is expected to help usher in future revolutions in agriculture, there is a need to create an enabling environment within agriculture for absorbing these. Agri start-ups have emerged as significant players in introducing innovations in the entire agricultural chain.

2.4.4 Agro Chemicals Based Farming to Natural Farming

Following the adoption of the Green Revolution, the application of agro chemicals and inorganic fertilizers has seen rapid increase, at the expense of traditional methods of farming based on bio resources and inorganic fertilizers. Since 1970, the use of chemical fertilizers has grown seven times faster than that of

farm yard manure, compost, etc. Though the per hectare use of agro chemicals in India is still much lower than in most developed countries, there has been growing awareness about the adverse effect of agro chemicals on human health, soil, environment and sustainability and the overall safety and benefits of food grown using natural inputs or organic products. Some consumers are willing to pay higher prices for food produced without using agro chemicals. Many countries are promoting the use of bio control methods against pests and diseases. The Government of India has started several initiatives to promote alternative methods of production like organic farming, natural farming and zero budget farming to reduce and replace dependence on agro chemicals. While this looks desirable, there are concerns about the reduced or zero use of agro chemicals, including inorganic fertilizers leading to a fall in yield.

Agro chemicals play a productive role (in terms of enhancing yield) as well as a protective role (against attacks by insects, pests and diseases). There is adequate and credible scientific evidence in India and globally about non-use of agro chemicals or their replacement by natural and organic inputs and methods of production leading to reduction in yields. A review article, based on meta-analysis of a large number of peer-reviewed articles, published in Archives of Agronomy and Soil Science (Roberto, 2021) conclude that "the yields under organic farming were on average 25 per cent lower than the conventional ones, reaching a yield gap of 30 per cent for cereals. The intensity of soil use was also lower in organic systems. Combining the yield gap with the reduction in the number of crops harvested in rotation, a productivity gap of 29 per cent to 44 per cent was estimated depending on the type of crops included in the rotation" (Roberto, 2021). Similar findings are reported for India for crop yield and income without application of synthetic fertilizer (Ghasal et al., 2023). In addition, there is concern about the source of growth in organic and natural farming. The food and economic crisis in Sri Lanka caused by the ban on synthetic fertilizer and agro chemicals in 2021 underscores the need for adopting a cautious approach in curbing the use of agro chemicals.

Striking a balance between the production of safe, healthy, quality and environmentally sustainable food on the one hand and adequate food on the other, is indeed a challenge. Food demand in India is projected to grow between 2.5 per cent and 3 per cent per year. Past trends and future potential indicate that food output is likely to register a 3.5 per cent growth rate in the next decade. These growth parameters indicate that India can afford to shift some area from conventional methods of farming to organic or natural farming (ONF) without causing imbalance between domestic demand and supply. Assuming a growth rate of 3.5 per cent in output, 2.8 per cent growth rate in demand and 30 per cent yield penalty in organic farming, India can safely shift 2 per cent area each year from conventional farming to organic farming without creating any shortfall in supply to meet domestic demand. This will mean sacrificing some exports, as some surplus over demand will be lost due to lower yields under ONF. These numbers imply that India has scope to replace around 20 per cent of area from conventional farming to ONF by 2030, while maintaining the balance between growth in demand and supply of agri-food.

2.5 Way Forward

Agriculture is vital for livelihood, food and nutrition security, sustainability of the natural resource system, health of the environment, climate change, employment and growth. In addition, the United Nations' Sustainable Development Agenda 2030 cannot be achieved without paying attention to agriculture, as 11 out of the 17 Sustainable Development Goals (SDGs) are directly linked to agriculture.

The two biggest challenges facing the planet are climate change and overexploitation and degradation of natural resources. The type and methods of farming have a significant bearing on these. All this has led to a renewed interest in agriculture and the future of agriculture remains a core concern for all the countries, regardless of the level of development. In India, agriculture has to play a key role in achieving the goal of Viksit Bharat, inclusive development, green growth and gainful employment during Amrit Kaal. A roadmap to achieve these goals is suggested below.

- Significant and sustained increase in farmers' income and transformation of agriculture requires a paradigm shift in the approach towards the agriculture sector. Changes in old regulations and liberalisation of the sector are necessary for creating an enabling environment for a modern and vibrant agriculture during Amrit Kaal. Advancement in science-led technology, an enhanced role for the private sector in both pre and post-harvest phases, liberalised output markets, an active land lease market, and emphasis on efficiency will equip agriculture to address the challenges of the twenty-first century and contribute towards the goal of Viksit Bharat.
- Competition among States to improve "Ease of doing Farming and Farm Business" needs to be promoted.
- The future progress of agriculture requires action on several fronts involving Union and State Governments. A well-coordinated action and strategy between the two levels of government is needed to ensure that agriculture marches to the next stage of development, along with other sectors.
- The shift towards modernisation of agriculture will involve the introduction and promotion of knowledge and skill intensive practices within agriculture, private and corporate sector investments in agriculture, new institutions of producers, integrated food system-based mechanisms, and new types of linkages between producers and end users. These changes, in turn, require liberalisation of the agriculture sector in the form of providing a facilitating regulatory environment and responsible public and private investments in and for agriculture.
- India has done well in achieving growth targets but lags when it comes to efficiency gains. The emphasis should shift from growth to efficient growth – cost effective increase in production. This requires deployment of state-of-the-art technology in agriculture, smart farming and maximising the value of main and by-products.
- The main yardstick to measure progress of agriculture is yield per unit of land. This ignores other more limiting and cost-related factors like water usage, fertilizer application and labour intensity. Along with yield, the productivity of other inputs should also be maximised.
- The system of MSP for farm produce is essential to guard against poor competitiveness and malpractice in agri markets. MSP also becomes important during periods of glut, even if markets are competitive. However, the system of MSP should not cause distortions in market signals and incentives. India should use a combination of two instruments, namely procurement and price deficiency payment, to pay MSP to farmers. Public procurement should be linked to the quantity needed for the public distribution system, price stability and strategic stocks. Other than this, MSP in mandated crops should be implemented through price deficiency payment. This system was earlier attempted in Madhya Pradesh and is currently being successfully implemented for a few crops in Haryana.
- Indian agriculture is heading towards increase in surplus in many products. This necessitates disposal of more quantity through exports. However, if MSP is higher than exportable price and implemented through the system of procurement, then their export without subsidisation becomes impossible. Many competing countries object to this on grounds of violation of the WTO Agreement. The best

solution to such situations is to pay farmers the difference between MSP and average market price at the State level, as is the practice in many countries (Chand 2019). This practice is also WTO compliant.

- Agriculture markets are characterised by large price spreads, large number of intermediaries operating on small quantity of produce, several imperfections and poor infrastructure and storage facilities (Chand, 2012). They need to be upgraded, modernised and liberalised. They should be equipped with grading, packaging, storage and assaying facilities, digital transactions and e-marketing options. Alternatives like electronic platforms, direct marketing, contract farming are the need of the hour. Market innovations should be encouraged through agri start-ups, farmers producer organizations (FPOs) and cooperatives.
- The private corporate sector is sensing several opportunities for expanding agribusiness. This will bring modern capital in warehousing, logistics, cold chain, food processing and integrated value chain development and, will, in turn, increase competition and improve market integration over time and space. State Governments should facilitate producers to take advantage of these opportunities.
- There is a strong shift in preference towards "bios" and plant-based medicines, therapies, nutraceuticals, cosmetics, disinfectants, pesticides, insecticides, and a range of other consumer products. Popular sentiment is turning away from chemicals and synthetics towards natural products. Bio control measures are expected to replace chemicals for crop protection to a significant extent. Some experts feel that many chemicals-based industries will turn towards bio-based products to be used as raw material and final products in the future. This points towards Amrit Kaal witnessing the emergence of a new type of industry in agriculture, with the possibility of making farms as factories.
- States must undertake comprehensive reforms in agriculture and replace restrictive regulations with a new set of regulations that are in tune with the new reality of agriculture, emerging opportunities, capacity and willingness of modern capital to invest in pre and post-harvest processes and changes in the investment environment, new institutional mechanisms, ICT and consumers' preferences.
- Indian agriculture will continue to be dominated by small holders in the foreseeable future. They should be empowered through self-help groups, FPOs, cooperatives and agri start-ups to access credit, new knowledge and better markets. Some of these small holders will leave farms for better opportunities in other sectors, while others would like to expand their base by leasing land from other farmers. This is already happening on a large scale in some States. Due to various issues relating to tenancy, the land lease market operates in an informal setting, which deprives both the lessor (land owner) and the lessee (tenant) farmers of various benefits and opportunities. States must liberalise the lease of agricultural land to encourage land owners to rent out their land formally without any fear of losing title or control of land.
- India should plan for skill development and employment opportunities for part-time farmers, so they can get some work opportunity in non-agriculture activities near their home and also operate their small farms.
- Realising the adverse effects of the use of agro chemicals in agriculture and shifting consumer preference towards safe and healthy food, India has taken several steps to promote natural farming and organic farming. These methods are slowly gaining popularity among farmers. However, there are concerns related to yield penalty in natural farming, compared to farming practices using agro chemicals and modern inputs, at least in the short run. Given the present surplus in food production and projected trends in food supply and demand, India can afford to put one-fourth of area under natural farming and similar practices by 2032-33, without any threat to food security at the aggregate level. However, it will entail diverting some exportable surplus to meet domestic demand. In the

meantime, the country should invest in R&D in natural farming and explore possibilities of higher yield and growth using the system of natural farming. Any further decision on promoting natural farming should be taken based on the experience of these ten years.

- Data on cost of cultivation shows nil use of agro chemical on 6 per cent of total area under cultivation. Further, fertilizer use is below 8 kg/acre on 7.6 per cent area. These areas should be given priority for promoting natural farming, which will also enhance production and farm incomes.
- There is immense scope to reduce the use of agro chemicals, and its consequent adverse effects, through their judicious use. This requires educating and helping farmers on correct diagnosis, treatments, dosages and methods of use. Methods like Integrated Pest Management and bio control are also useful in reducing the use of agro chemicals.
- Regulation and its effective implementation are very important in enforcing the proper use of insecticides, pesticides, preservators, weedicides, growth hormones and other agro chemicals. Agriculture and farmers suffer from low quality, sub-standard and spurious products and inputs. Strict regulation is needed to check these.
- Conscious efforts should be made to promote production patterns and practices in various geographies that are consistent with their agro-climatic characteristics and natural endowments. Rather than sacrificing long-term gains for short-term gains, a balance should be struck to maintain sustainability.
- There is huge scope for raising tree plantations and agroforestry on arable land and culturable waste lands. Complete removal of restrictions on tree felling on private lands, timber marketing and wood-based industry will pave the way for greening India, environment improvement as well as raise employment and income.
- Employment is becoming a serious challenge, with the manufacturing sector increasingly adopting labour displacing or labour saving capital-intensive technologies and automation. Industry 4.0 is deploying technologies and options like robotics, AI, internet of things (IOT), machine learning, cloud computing and analytics, advance sensors and digital twins to revolutionise manufacturing and distribution. This has already affected the structural transformation of developing economies, as the employment share of manufacturing is not keeping pace with its share in output. As a result, labour is stuck in low productivity, low paying and seasonal employment in the agriculture sector. India and other emerging economies have to find a mechanism in the normal development process to suitably employ the excess labour[10] in agriculture which is not finding employment in the non-agriculture sector. One possibility is to develop post-harvest value chains and small manufacturing facilities around farms to produce various types of bio-based industrial products to meet the rising preference for such products.
- Technologies have now become available to produce bio energy (CBG or ethanol) from crop and livestock bio mass and waste. Already around 300 units of public sector oil companies are producing CBG and the target is to raise this number to 5,000 by 2025. This is a good example of circular economy and the Government of India is supporting this practice through the GOBAR-dhan (Galvanising Organic Bio Agro Resources) scheme and SATAT (Sustainable Alternative Towards Affordable Transportation) scheme. Such schemes should be expanded to cover more rural areas.
- In order to check further overexploitation of water resources, there is need to create a policy environment that leads to crop patterns and practices consistent with the natural resource endowment of various agro ecological zones. Further, the country cannot address the issue of stress on water resources and meet future water requirements without improving the efficiency of water

use in agriculture through modern methods of irrigation (drip, sprinkler, sensors).

- Free or highly subsidised power to the agriculture sector is known to be the main cause of overexploitation of groundwater and unsustainable use of water resources. Despite this, the phenomenon of providing free power to agriculture is on the rise. The issue is considered politically sensitive as it has a strong effect on farm income. One solution is to pay the subsidy amount to farmers directly and shift to metered power supply, which will be paid for.
- During the last five decades, the usage of chemical fertilizers has increased by 1,100 per cent, whereas the use of farm yard manure has increased by a mere 75 per cent. As a result, organic matter in Indian soils is getting depleted and soil fatigue is occurring in many places. Promoting the use of organic and bio fertilizers, compost, farm yard manure and green manuring need to be given top priority in order to restore and sustain soil fertility.
- Digital technology can play a significant role in improving the efficiency of agriculture through easy dissemination of technology and knowledge to farmers. Digital technology is particularly important, given the weakening of the conventional extension system for agriculture. Some States are already advancing in this direction. Agri start-ups are playing a significant role in the application of digital technology and other transformative innovations in the entire chain of agriculture. Their participation can bring game changing solutions to the agri food systems.
- The agriculture sector offers some useful experiences to fulfil India's dream of becoming a developed country by 2047. The dairy, poultry and fishery sectors are close to the growth rate required to make India a developed country. Such growth is also possible in horticulture and agro-forestry. The country needs to liberalise these sectors to unleash their potential. While the non-farm sector can give higher growth than agriculture, the latter is important for inclusive growth, employment generation, renewable energy resource and sustainability – all of which are an integral part of the goal to become Viksit Bharat. Thus, we must plan for Viksit Bharat by according a central role to the agriculture sector during Amrit Kaal.

References

Bansil P.C. (1990). Agricultural Statistical Compendium, Vol. I, Foodgrains. Techno Economic Research Institute, India, New Delhi. Pp. 431-2.

Chand, Ramesh (2012). Development Policies and Agricultural Markets, *Economic and Political Weekly*, **47**(52): 53-63.

Chand, R., Prasanna, P. L., and Singh, A. (2011). Farm size and productivity: Understanding the strengths of smallholders and improving their livelihoods. *Economic and Political Weekly*, **46**(26&27): 5-11.

Chand, R., Srivastava, S.K., and Singh, J. (2017). Changes in rural economy of India, 1971 to 2012: Lessons for job-led growth. *Economic and Political Weekly*, **52**(52): 64-71.

Chand, Ramesh (2019). Innovative Policy Interventions for Transformation of Farm Sector. Presidential Address at 26th Annual Conference, Agricultural *Economics Research Review,* 32(1): 1-10. **DOI: 10.5958/0974-0279.2019.00001.6**

Chand, Ramesh (2023). *India's White Revolution: Achievements and the Next Phase* (NITI Working Paper No. 001/2023). National Institution for Transforming India Government of India, New Delhi.

Ghasal, P.C., Mishra, R. P., Choudhary, J., Dutta, D., Chandra, B., Meena, A. L., N. Ravisankar, Kumar, A. & Azad, P.S. (2023). Evaluation of integrated crop management, organic management and natural farming in basmati rice-wheat system under Upper Indo-Gangetic Plains. *Journal of Plant Nutrition*, Pp: 1-11. **DOI: 10.1080/01904167.2023.2209117**

Lewis, Arthur (1954). Economic Development with Unlimited Supplies of Labour. *The Manchester School*, **22**(2):193-191. **https://doi.org/10.1111/j.1467-9957.1954.tb00021.x**

NITI Aayog (2018). Demand and Supply Projections Towards 2033: Crops, Livestock, Fisheries and Agricultural Inputs, The Working Group Report.

Roberto, Alvarez (2021). Comparing Productivity of Organic and Conventional Farming Systems: A Quantitative Review. *Archives of Agronomy and Soil Science*, **68**(14): 1947-1958. **DOI: 10.1080/03650340.2021.1946040**

Srivastava, S.K., Chand, R., and Singh, J. (2017). Changing Crop Production Cost in India: Input Prices, Substitution and Technological Effects. *Agricultural Economics Research Review*, **30**(Conference Number):171-181. **DOI: 10.5958/0974-0279.2017.00032.5**

ABBREVIATIONS

AI	Artificial Intelligence
APMC	Agriculture Produce Marketing Committee
CBG	Compressed bio gas
FAO	Food and Agricultural Organization of the United Nations
FPO	Farmers Producer Organization
FRP	Fair and Remunerative Price
GDP	Gross Domestic Product
GHG	Green-house Gases
GOI	Government of India
GPS	Global Positioning System
GVA	Gross Value Added
ICAR	Indian Council of Agriculture Research
ICMR	Indian Council for Medical Research
ICT	Information and Communication Technologies
IPR	Intellectual Property Rights
MoSPI	Ministry of Statistics and Programme Implementation
MSP	Minimum Support Price
NFHS	National Family Health Survey
NIN	National Institute of Nutrition
NPK	Nitrogen-Phosphorus-Potassium
NSO	National Statistical Office
ONF	Organic or Natural Farming
PLFS	Periodic Labour Force Survey
R&D	Research and Development
SAUs	State Agriculture Universities
SDG	Sustainable Development Goal
ToT	Terms of Trade
UAV	Unmanned Aerial Vehicle
WTO	World Trade Organization

NITI Aayog