Strategic Policy Choices for Agriculture toward *Amrit Kaal*

Investment in Agriculture Research, Development, and Education: A Pathway toward *Amrit Kaal*

Feeding India in a Changing Climate during *Amrit Kaal*

India’s Food and Nutrition Security toward 2030 and beyond
The first quarter of 2022 has been unsettling for the entire world with the spread of contagious Omicron variant, surging inflation, and the ongoing war between Russia and Ukraine causing misery to millions of Ukrainian refugees. The impact of these events is still unfolding and most of the countries are likely to be impacted, including India. Amidst these uncertain and difficult times, the much-awaited Union Budget for financial year (FY) 2022-23 was released in February 2022 by the Government of India.

The budget had a long-term vision, setting the alley for “Amrit Kaal”, the upcoming 25 years – from India at 75 to India at 100. The term Amrit Kaal was first coined during the celebration of the 75th year of India's independence by the honourable Prime Minister Narendra Modi in the context of his long-term vision and plan of action for the country. The strategy aims at significantly improving the lives of Indian citizens, reducing the rural-urban divide, and infuse latest technologies in various sectors.

In this fourth issue of ICRIER-APSI’s quarterly bulletin, AF-TAB is conceptualized against the backdrop of strategic policy choices to make Indian agriculture globally competitive and sustainable over the next 25 years. This year's budget was an attempt to present a blueprint for the economy toward that goal of higher economic growth, sustainability, productivity enhancement, crowding-in private investment along with an energy transition that is green and can help fight the challenge of climate change.

The budget also proposed a long-term vision for the sector by making provisions for policies that can help make agriculture more sustainable while augmenting farmers' incomes. Some strong promises were made in the budget around promotion of chemical free natural farming on both sides of river Ganga, development of technologies and infusion of hi-tech inputs such as drones in agriculture. To tackle the problem of malnutrition, a scheme to fortify rice and wheat in India's public distribution was also announced.

The importance of private agri-tech players and stakeholders was highlighted and an upcoming scheme in public private partnership mode was also suggested. All this sounds great, and if implemented properly, can go a long way in making Indian agriculture more resilient to climate change and help address the big issue of malnutrition amongst Indian masses.

In the words of José Graziano da Silva, former Director-General of the Food and Agriculture Organization of the United Nations, “Agriculture is at the heart of the solution of the sustainability issue, contributing from the environmental, economic, and social sides. If we improve agricultural and food systems, we can improve the livelihoods and health of people, and produce healthier ecosystems as well. The dominant agricultural model we inherited from the Green Revolution of the 1960s, with its emphasis on a narrow range of crops and its heavy use of chemicals, energy and capital, cannot meet the challenges of the new millennium.”

The current AF-TAB issue comes at a critical time when the country is grappling to augment farmers' incomes, making agriculture environmentally sustainable and ensuring nutritional security for its people. This issue also highlights budgetary allocations in the Union budget for FY23 and asks a fundamental question whether overloading subsidies and safety nets vis-à-vis developmental expenditures for agriculture is the right policy for ‘Amrit Kaal’ to achieve a sustainable and inclusive growth. I hope the readers will find it useful and exciting.

Deepak Mishra
Director & Chief Executive
ICRIER
From the Director’s Desk

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Deepak Mishra
Director & Chief Executive
ICRIER
I n February, the Finance Minister presented the Union budget for FY 2022-23 with a view to achieve sustainable growth with a long-term vision for the next 25-years-long leadup to India@100 (Amrit Kaal). The budget rested on the pillars of growth and all-inclusive welfare, promoting technology-enabled development in agriculture but also promoting chemical free agriculture all along the Ganges river, signalling the need for a more sustainable and climate resilient agriculture.

This issue of AF-TAB contains three main articles that are critical for long term sustainable growth of agriculture as also making more nutritious food available to vulnerable sections. This is important for India, to achieve not just food security but also nutritional security for its large population and making agriculture more environment friendly and sustainable. The first article briefly talks about how agriculture research, development and education can transform the agriculture sector by raising the total factor productivity and making agriculture more competitive and resilient. It highlights, how expenditure on development schemes and projects is lagging behind while the safety nets and income support/input subsidies continue to receive a much larger share of financial resources of the Union government. At the margin, there is a case for India to focus on investments that make Indian agriculture globally competitive by raising its productivity. Such investments are to be in the fields of agri-R&D, irrigation, roads, and value chain developments. Enhanced agri-R&D can help not only making agriculture more competitive but also climate resilient and more nutritious.

Against this backdrop, the second piece of this issue discusses how budget announcements for agriculture fall short in containing the GHG emissions. It discusses how the subsidization policies of key inputs such as water (power) and fertilizers coupled with assured procurement of paddy and wheat in some selected states such as Punjab-Haryana is playing havoc with their water table and GHG emissions. It also discusses the policy options to get out of this messy and inefficient state of affairs in agriculture.

The third piece talks about the issue of malnutrition and what role has the budget played in making the food basket of the Indian population more nutritious. Despite achieving a high growth rate in the past decade, a large section of the population remains malnourished. India needs to work on striking a balance between demand and supply of major food items being produced in a competitive manner while also targeting the objective of nutritional security. Prime Minister Narendra Modi in his 75th Independence Day speech announced that by 2024, rice distributed through PDS and other schemes will be fortified. The piece also highlights the innovation and importance of biofortified foods and how they can contribute to improved nutritional status. Such bio-fortified foods can be cheaper and more effective in reducing malnutrition than the scheme of fortification announced by the government. However, bio-fortification of staple crops requires higher investments in agri-R&D than are being currently made, but it can go a long way in helping to alleviate malnutrition amongst vulnerable groups.

The government has also proposed interventions in the context of managing natural resources and making agriculture more digitally advanced in this year’s budget speech. This issue covers the existing policies, implementation and long-term vision of the pilot plan for launching a chemical-free natural farming zone by creating 5-km wide corridors along the river Ganga with a view to reduce the level of pollutants in river Ganga. We then move on to the upside of introducing drones in the agriculture sector. This piece captures the steps taken by the government and the way forward for the wider implementation of modern technology in Indian agriculture.

Historically, the policy agenda for the agriculture sector has targeted achieving higher production and attaining food security, but now the Indian agrarian sector is facing second-generation issues like degradation of natural resources (water, soil, and air) and vulnerability to climate change. India needs to come up with technologies and policies which target the core problem of growing burden on limited natural resources and GHG emissions. India could create carbon markets and reward farmers for saving on precious groundwater and lowering its GHG emissions, moving gradually toward ‘net zero’ status by 2070.

I hope this compilation of articles is helpful to policy makers and awakened readers who want India to achieve food and nutritional security while also making it climate resilient.

Ashok Gulati
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Many studies in economic literature highlight the importance of research and development (R&D) and technological progress in a country’s economic growth. In particular, Romer (1990) talks about how expenditure on R&D by a country has a positive impact on its ability to innovate. And it is the innovations all across the food systems that can raise total factor productivity, improve its global competitiveness, and if guided in the right direction, it can also make Indian food system climate resilient. But innovations can’t come out of thin air. A country has to invest good amount of resources into agri-research and development, and education. According to the Comptroller and Auditor General of India (CAG), the country spent a total of Rs. 17,515.07 crores on agriculture research and education (ARE) in FY 2018-19 which was only 0.59 per cent of the agriculture gross value added (AGVA) during the year. Even though the absolute expenditure on ARE has been marginally increasing over the last few years, its share in AGVA has been hovering between 0.50 per cent to 0.60 per cent. It has been generally agreed that developing countries need to invest at least 1 percent of AGVA in ARE, if they want to ensure food and nutritional security on a sustainable basis. By that standard, India’s allocations toward ARE fall short by 40 percent. With this meagre investments in ARE, can India achieve its dream of ‘Amrit Kaal’ remains an open question.

ARE has a monumental role in overcoming the current challenges of Indian agrarian setup and developing an environmentally sustainable agriculture model for the country. It has the ability to develop and improve agriculture inputs to ensure optimum management of natural resources (land, air and water), ensure food and nutritional security and increasing farm income by cost minimization and yield maximization (Economic Survey 2021-22). Green revolution is the perfect example of a major technological breakthrough backed by R&D which transformed India from a net importer of basic staples like wheat under P.L.480 to a net exporter of cereals. It was followed by subsequent rainbow revolutions (white (milk), blue (fisheries), golden (fruits and vegetables) which transformed Indian agriculture. As a result of all these, in FY22, India exported agri-produce worth more than USD 50 billion. In cereals, India exported 20 million metric tonnes (MMT) of rice and more than 7 MMT of wheat.

However, the need of the hour has now shifted from achieving food security to adapting sustainable agriculture which is resilient to climate change and provides adequate nutrition to the country. R&D can indeed be a stepping stone towards developing innovations and technologies which offer long-term solutions and making Indian agriculture more robust.

India’s agriculture R&D structure is considered one of the largest and most complex systems in the world. It is driven by the need to achieve self-reliance in food production, feed an ever-growing population, overcome issues related to climate change and thrive with limited natural resources. The current expenditure on agriculture R&D of India is much lower in comparison to other agriculture-based developing countries like Brazil, Indonesia, China, and South Africa. As per the estimates of Agricultural Science and Technology Indicators (ASTI)1, released by the International Food Policy Research Institute, the above-mentioned countries spend anywhere between 0.60 per cent to 2 per cent of their AGVA on agriculture research and development. Even the Indian government has recognized the need to increase expenditure on ARE significantly, as was mentioned in the Committee on Agriculture in 2014 which recommended that the research funding should be increased to at least “1 per cent of the AGVA". However, so far, this has not materialized.

In Union budget 2022-23 speech, the Finance Minister expressed her intent to make Indian agriculture more environment friendly and sustainable. The first article briefly talks about how agriculture research, development and education can transform the agriculture sector by raising the total factor productivity and making agriculture more sustainable and climate resilient. Investment in Agriculture Research, Development, and Education: A Pathway toward Amrit Kaal

Ayushi Khurana and Ashok Gulati

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1Estimate given by ASTI includes expenditure done only on agriculture research and development. It does not include any expenditure done on agriculture education
agriculture sustainable and more resilient by shifting its focus on R&D. The Economic Survey (2021-22) explicitly highlighted the direct impact of spending on agricultural research on agricultural growth. According to Gulati et al., (2018), every rupee spent on agricultural research and development, yields much better returns (11.2), compared to returns on every rupee spent on fertilizer subsidy (0.88), power subsidy (0.79), education (0.97), or on roads (1.10). But regardless of the intent, the budget estimate (BE) for the Department of Agriculture Research and Education (DoARE) in financial year (FY) 2022-23 stood flat at Rs. 8,513.62 crore, identical to the BE and revised estimate (RE) for FY 2021-22.

In general, budgetary allocations within the agriculture space and rural sector were skewed heavily towards safety net programs, income support, and input subsidies. The safety net program includes food subsidy (Rs. 2,06,831.09 crore) and Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) (Rs. 73,000 crore) which together had the highest aggregate allocation of Rs. 2,79,831.09 crores in FY 2022-23’s union budget. This was followed by allocations for income support and input subsidies for the farmers which included schemes and programs like Pradhan Mantri (PM) Kisan (Rs. 68,000 crores) along with allocations for input subsidies on fertilizers (Rs. 1,05,222 crore), credit (Rs. 19,500 crores) and crop insurance (Rs. 15,500 crores). Safety nets along with income support and input subsidies utilized a large chunk of the centre’s financial resources with very limited finances left for development schemes and projects (see Figure-1).

Figure 1: Budgetary Allocations in FY 2022-23 for Safety Nets, Income Support/Input Subsidy and Development Expenditure

The budgetary resources designated to different development programs and schemes under the Department of Agriculture and Farmers Welfare, Ministry of Fisheries, Animal Husbandry and Dairying (MoFAD) along with development expenditures on infrastructure and irrigation projects and DoARE added up to only Rs. 67,609 crores for FY 2022-23. These expenditures fall under the development expenditure of India which includes popular schemes like the Rashtriya Krishi Vikas Yojna (RKVY), PM - Krishi Sinchai Yojana (PMKSY), PM - Gram Sadak Yojana (PMGSY), major and medium irrigation projects. Over the past few years, many new schemes like Kisan Urja Suraksha Evam Utthan Maha Abhiyan (KUSUM), National Beekeeping Honey Mission (NBHM), and Fortification of Rice and its Distribution under the Public Distribution System have been introduced but the overall structure of the budget remains unchanged.

There is no doubt that the budget allocations are hugely tilted towards subsidies and safety nets. Such a mechanism in allocating scarce resources is driven by short sighted political populism and does not bode well for prosperous and sustainable agriculture for ‘Amrit Kaal’. They tend to drain the financial resources of the government and only provide instant relief to the farmers and consumers without creating strong assets and infrastructure for the long run. Expenditure on development projects and infrastructure projects like roads, power and irrigation have a direct and indirect correlation with agricultural growth as it facilitates agricultural production and productivity growth (Fan et al.
2022). This calls for revisiting the allocations under various heads with a clear understanding of where can one get the biggest bang for the buck.

One of the biggest challenges in India’s ARE model is the limited number of private companies which run their independent R&D programs focussing on advanced agriculture inputs including seeds, fertilizers, pesticides, and irrigation equipment. In 2017-18, Rs.13,311.76 billion was spent on the Development of Agriculture, Forestry, and Fishing in India out of which the state government had a share of 48 per cent followed by the central government which had a share of 40.5 per cent (DST, 2020). Only 11.5 per cent (Rs. 15.25 billion) of the expenditure was done by the private sector which also included expenditure done by Scientific and Industrial Research Organizations (SIRO). As suggested by Finance Minister Nirmala Sitharaman, in her budget speech, “crowding in private investment” in the technology sector can be a game-changer for the development of new technologies in the country. Currently, the share of the private sector in Indian ARE is very low and is highly contingent on the policy imperatives they are likely to face in the market. There are only a few large private players2 like Syngenta, Bayer, MAHYCO, Jain Irrigation, and Mahindra who spend a reasonably good amount of their turnover on R&D programs and developing high tech agriculture inputs. The USP of these companies is to develop technology which increases productivity while addressing the current challenges of limited net sown area, depleting water resources, vulnerability to climate change, and the need to produce nutrient-rich food. These companies have the propensity to dispose a large share of their revenue on R&D expenditure and the government should ensure that an enabling policy environment is created for these companies.

The need of the hour is to focus on increasing expenditure on ARE and other development projects which can aid in the sustainable growth of the agriculture sector for the ‘Amrit Kaal’. India’s budget allocations in the agri-food space should thrive on creating “More from Less”. The financing should focus on altering the current atmosphere of a high incidence of hunger and malnutrition, keep a check on the mismanagement of natural resources and mitigate the challenge of climate change issues. There is a need to work on building long-term sustainable solutions which have an aggressive approach to implementing relevant policies and developing new ones. The future and the journey of India’s agricultural sector in ‘Amrit Kaal’ should prosper on real drivers of growth which help India achieve a higher productivity on sustainable basis, augment farmers’ income, protect our natural resources and make India globally competitive. Right policy choices are required which reorient India’s current budgetary allocation and shift financial resources from safety nets and input subsidies to development expenditures. In addition to this, government should come out with policies which incentivises private companies to expand their R&D programs and invest more financial resources on development projects which have the potential to overcome the challenges of current agrarian setup of India. This requires a more rational Intellectual Property Rights (IPR) policy that gives assurance to private sector players for bringing in their best products and incentivises them to investment in ARE ushering in an era of innovations across the food system. Only then we can hope to reap the fruits of this in ‘Amrit Kaal’.

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1ICRIER and this Bulletin do not endorse explicitly and implicitly, any commercial enterprise.
Feeding India in a Changing Climate during Amrit Kaal
Reena Singh, Ashok Gulati, Purvi Thangaraj

The rising temperatures across the world and the resultant climate change has become a matter of global concern. Global surface temperatures rose above pre-industrial levels (1850-1900) by +1.1 °C in the last century, and are predicted to exceed +1.5 °C above pre-industrial level in all scenarios in next two decades (IPCC, 2022). There are aspirations to limit this temperature rise within +1.5 °C by reducing anthropogenic greenhouse gas emissions, but current global warming trends presents 127 key risks including risks to food security and water security. The latest IPCC report warned us that, “The rise in weather and climate extremes has led to some irreversible impacts as natural and human systems are pushed beyond their ability to adapt.” India has started experiencing average temperature rise; erratic rainfall and droughts, rise in extreme temperature, and resulting increase in sea levels due to melting of glacier; and increased intensity of severe cyclones, and other changes in the monsoon system since the middle of the twentieth century (MoES, 2020), India ranks 7 on the Climate Risk Index 2021 released by Germanwatch.

As per the IPCC February 2022 Working Group-I report, climate change events can affect crop yields, livestock, fisheries, and have likely economic impacts on agriculture sector. Yield of rice, wheat, pulses and coarse cereals in India are projected to decline by 2.3 per cent (by 2030) and 8.62 per cent (by 2050). The report also pointed that the northern part of the Indian subcontinent to be climate change-induced hot-spot of heat stress and the cropping areas could be reduced in these regions.

Being a signatory of UN Framework Convention on Climate Change (UNFCCC) in 1992, Kyoto Protocol in 2002, and Paris Agreement in 2015, India is an active member in international climate change negotiations and actions. With Conference of Parties (CoP26) commitment of “Carbon neutrality by 2070”, India has taken aggressive climate friendly and cleaner energy path to propagate sustainable way of living. The country has undertaken regulatory and fiscal measures, to achieve its Nationally Determined Targets (NDC) and is the only G-20 country whose Paris pledges for 2030 are compliant with a 2°C pathway. The country is also leading on climate action internationally with initiatives like the International Solar Alliance (ISA) and Coalition for Disaster Resilient Infrastructure (CDRI).

In this light, the Union Budget for financial year (FY) 2022-23 has allocated a “green budget” of Rs. 3,030 crores to the Ministry of Environment, Forests and Climate Change (MoEFCC). This is a marginal increase of Rs. 160 crores from FY 2021-22, when the amount stood around Rs. 2,870 crores. However, the allocations for Climate Change Action Plan were only Rs. 30 crores followed by Rs. 60 crores towards National Adaptation Fund, which is same as previous year’s allocation. This year, the Department of Water Resources, River Development, and Ganga Rejuvenation received a budget of Rs. 18,967.88 crores from the Ministry of Jal Shakti. For agriculture sector, Finance Minister in her budget speech announced chemical-free natural farming on farmers’ lands in 5-km wide corridors along river Ganga throughout the country, support for millets, increased domestic production of oilseeds, Kisan drone, etc. While these are welcome steps taken by the government, they do not give enough comfort that these actions can overcome the environmental damage done by the sector.

Indian agriculture sector contributes 73 per cent of the total country’s methane (CH4) emissions, 72 per cent of the total nitrous oxide (N2O) emissions and 14 per cent of the total green house gas (GHG) emissions (MoEFCC, 2021). The main sources of GHG emission are animal husbandry and crop production. Enteric fermentation contributes 54 per cent of the total GHG emissions in agriculture sector, followed by agricultural soils (19 per cent) and rice cultivation (17.5 per cent). Other notable sources of emissions are manure management (6.68 per cent) and field burning of agricultural residues (2.17 per cent). The technologies to reduce emissions from livestock are still at nascent stage and if India is serious about its commitment for “Sustainable Farming” during CoP 26, then it would need to take decisions about reduction of emissions from crop cultivation (particularly from rice), based on its own development priorities and needs.
Rice is India’s main staple crop followed by wheat and it is also a water guzzler as it requires approximately 4,000 cubic meters of water per ton of rice for irrigation (Gulati and Singh, 2022). India is the second largest producer and topmost exporter of rice globally and has a major influence on the country’s water, food, and energy security. The continuous rice cultivation with traditional method imposed serious threats to natural resources (underground water table depletion, groundwater pollution, soil degradation, GHG emissions and air pollution) and agricultural sustainability (declining crop response, water productivity and factor productivity). The government policy environment consists of market-distorting policies of free power, highly subsidized urea, and minimum support prices (MSP) backed by open ended procurement of rice and wheat in some selected states which adds on to the growing agronomic and environmental problems.

Food Subsidies

There are two types of food subsidies in India – minimum support price (MSP) to the farmers and the distribution of food grains through targeted public distribution system (TPDS). Food grains are procured for TPDS by Food Corporation of India (FCI), at an MSP from the producers, which are distributed through Fair Price Shops (FPS) in India. However, as per the report of Shanta Kumar Committee (2015), only 6 per cent of the farmers benefit from procurement, and over 45 per cent of TPDS-grains get leaked out from the system. ‘Leaked’ grains find their way in the open market or are exported to other countries at prices that are lower than MSP. Price incentives in the form of MSP minimise the price risks for farmers. As a result they prefer producing that (paddy and wheat) at least in those states where procurement is open ended and quite entrenched. This is irrespective of the fact that FCI is already overloaded with stocks way above the buffer stock norms, indicating huge inefficiency in the operations of food system of rice and wheat in India. This system has also discouraged farmers from crop diversification. The procurement is also concentrated from few states. Rice is procured majorly from Haryana, Punjab, Andhra Pradesh, Telangana, Odisha and Chhattisgarh states and wheat from Madhya Pradesh, Punjab and Haryana. This has led to an increase in area under water-guzzling rice in low-rainfall areas such as Punjab, which got shifted from its traditional agro-climatically suited wheat-maize system. Procurements of these grains also resulled in stocks much above the buffer norms. In January 2022, the financial value of these excessive grain stocks was Rs. 2.14 lakh crores, out of which Rs. 1.66 lakh crores was just because of excess rice stocks, estimated at economic cost of rice and wheat as given by FCI (Gulati & Singh 2022).

Power and Irrigation Subsidies

Power and irrigation subsidies are provided in agriculture – to ensure low rates for the electricity supplied and irrigation facilities to the farmers. This has, however, led to growth in electricity and its consumption in agriculture, particularly for energizing irrigation pump sets leading to depletion of ground water level and high carbon dioxide emissions. As per Central Ground Water Board (2021), the general depth to water level of the country ranges from 5 to 10 meters below ground level (mbgl) during pre-monsoon 2019. However, levels in Punjab (with zero electricity tariff) ranged from about 20 to more than 40 mbgl. 103 blocks (out of 138) of Punjab come under over-exploited category. Excessive usage of irrigation pumps leads to continuous flooding in the rice fields resulting in high methane emissions.

Fertilizer Subsidies

Fertilizer subsidies ensure distribution of cheap chemical or non-chemical fertilizers among the farmers. This has, however, encouraged farmers to apply fertilizers (even higher than the recommended dose), which is causing water pollution (water table recharge from farms pollutes ground water, making it unfit for drinking), soil degradation and higher GHG. Subsidies have lowered the relative price of urea with respect to other fertilizers, leading to skewed over-application of urea hence disturbing nutrient balance and higher nitrous oxide emissions. (Economic Survey, 2015-2016)

Policy Recommendations for ‘Amrit Kaal’

Present agricultural policies and subsidies are largely based on political-economy considerations and do not account for their impacts on GHG emissions and carbon pricing for monitoring and decision making. By incorporating climate change costs into economic decision-making, carbon pricing can help play a role to incentivize low-carbon action and avoid locking in more GHG-intensive investments. India does not
have an explicit or an implicit carbon price mechanism. Estimating carbon prices of policy instruments such as fertilizer, irrigation, power and food subsidies would be a useful step toward decarbonizing economies.

The farming sector also needs to capitalize on the carbon market for carbon sequestration and emission reductions. The process involves developing voluntary/verified emission reduction (VER) projects that support sustainable farming by encouraging farmers to adopt practices that are GHG reducing while at the same time improve soil carbon content (sequestration). This is done through reduced tillage, precision fertilization, anaerobic composting, using organic fertilizers, mulching, intercropping, multi-cropping, controlled irrigation, system of rice intensification (SRI), direct seeding of rice (DSR), diversification from rice, planting and protecting fuel, fodder and fruit trees and a horde of techniques specially designed for a particular region, populations and climatic zones. A carbon unit (carbon credits) measured as a tonne over a period of time can be sold for a price in the open market. Consequently, a project with a reasonable size can effectively cater to a large number of farmers, providing a steady incentive to practise low carbon farming.

There are voluntary net zero commitments by corporates that are driving credit carbon demands. Many of these companies rely partially on carbon offsetting to achieve their targets. In 2019, sustainable agriculture sector emerged as opportunity for carbon storage at global level and transacted 0.1 metric ton of carbon dioxide equivalent (Mt CO2e) with average price of US$ 12.52 (2020) per credit (Figure 1), which is second highest market price after livestock methane.

The sustainable agriculture carbon credit program can be launched in India to unlock both national and international carbon market for smallholder farmers and help local rural communities combat climate change, land degradation and food insecurity. Farmer groups and private sector can be mobilized for developing carbon markets in agriculture, both at national and international levels, which can reward farmers in cash for switching from carbon intensive crops such as rice to low carbon intensive crops or improving farming practices in rice to low carbon intensive crops or improving farming practices in rice systems to lower GHG emissions. Such a move towards ‘net-zero’ agriculture for the Amrit Kaal will give India a ‘climate smart’ agriculture. However, care needs to be taken that other sectors’ emission reduction responsibilities are not getting redistributed to agriculture sector through carbon credits. There is a need to work on protecting productivity levels with low carbon footprint, which is likely to help India to access global markets too.

Figure 1: Volumes transacted and prices per sector (2019)

<table>
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<tr>
<th>Sector</th>
<th>Volume transacted (MtCO₂e)</th>
<th>Price transacted (2020, USD)</th>
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<tr>
<td>Wind</td>
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<td>0.1</td>
<td>0.4</td>
</tr>
<tr>
<td>Improved forest management</td>
<td>0.1</td>
<td>0.4</td>
</tr>
<tr>
<td>Top sectors in:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume transacted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price transacted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume &amp; price transacted</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: World Bank 2021
corporates that are driving credit carbon

There are voluntary net zero commitments by

steady incentive to practise low carbon farming.

cater to a large number of farmers, providing a

a project with a reasonable size can effectively

sold for a price in the open market. Consequently,

measured as a tonne over a period of time can be

climatic zones. A carbon unit (carbon credits)

designed for a particular region, populations and

fruit trees and a horde of techniques specially

from rice, planting and protecting fuel, fodder and

(DSR), direct seeding of rice (DSR), diversification

controlled irrigation, system of rice intensification

mulching, intercropping, multi-cropping,

anaerobic composting, using organic fertilizers,

through reduced tillage, precision fertilization,

carbon content (sequestration). This is done

GHG reducing while at the same time improve soil

VER) projects that support sustainable farming by

developing voluntary/verified emission reduction

The farming sector also needs to capitalize on the

instruments such as fertilizer, irrigation, power and

have an explicit or an implicit carbon price

Volume transacted (MtCO₂e) and average price (USD)

Source: World Bank 2021

<table>
<thead>
<tr>
<th>Sector</th>
<th>Volume transacted (MtCO₂e)</th>
<th>Average price (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>REE - Combined</td>
<td>23.3</td>
<td>12.6</td>
</tr>
<tr>
<td>Wind</td>
<td>1.43</td>
<td>6.2</td>
</tr>
<tr>
<td>Solar</td>
<td>2.21</td>
<td>5.4</td>
</tr>
<tr>
<td>Landfill methane</td>
<td>2.16</td>
<td>4.5</td>
</tr>
<tr>
<td>Clean cookstove</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Run-of-river hydro</td>
<td>1.71</td>
<td>1.9</td>
</tr>
<tr>
<td>Large hydro</td>
<td>0.55</td>
<td>4.50</td>
</tr>
<tr>
<td>Water purification</td>
<td>1.78</td>
<td>0.3</td>
</tr>
<tr>
<td>Biogas</td>
<td>5.75</td>
<td>0.3</td>
</tr>
<tr>
<td>Blue carbon</td>
<td>8.68</td>
<td>0.1</td>
</tr>
<tr>
<td>Livestock methane</td>
<td>7.69</td>
<td>3.0</td>
</tr>
<tr>
<td>Afforestation</td>
<td>4.27</td>
<td>2.1</td>
</tr>
<tr>
<td>Energy efficiency</td>
<td>8.03</td>
<td>2.1</td>
</tr>
<tr>
<td>Improved forest mgmt</td>
<td>6.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Energy efficiency</td>
<td>8.03</td>
<td>2.1</td>
</tr>
</tbody>
</table>


https://openknowledge.worldbank.org/handle/10986/35620 License: CC BY 3.0 IGO.”

India to access global markets too.

with low carbon footprint, which is likely to help

a need to work on protecting productivity levels

agriculture sector through carbon credits. There is

responsibilities are not getting redistributed to

'climate smart' agriculture. However, care needs

zero' agriculture for the

lower GHG emissions. Such a move towards 'net-

improving farming practices in rice systems to

practices in rice to low carbon intensive crops or

switching from carbon intensive crops such as rice

levels, which can reward farmers in cash for

agriculture, both at national and international

be mobilized for developing carbon markets in

climate change, land degradation and food

farmers and help local rural communities combat

and international carbon market for smallholder

can be launched in India to unlock both national

highest market price after livestock methane.

12.52 (2020) per credit (Figure 1), which is second

equivalent (Mt CO2e) with average price of US$

transacted 0.1 metric ton of carbon dioxide

opportunity for carbon storage at global level and

demands. Many of these companies rely partially

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India's Food and Nutrition Security Toward 2030 and Beyond
Shyma Jose and Ritika Juneja

India will be the most populous country by 2028 with a population of some 1.45 billion (United Nations Population Fund, 2019). And by 2030, it is likely to have almost 600 million people living in urban areas. In the next 25 years, the period of ‘Amrit Kaal’, feeding burgeoning population with nutritious and safe food from limited cultivable land and water is going to be a major challenge for the country’s food system. There is an urgent need to design an optimal strategy to be able to strike a reasonable balance between demand and supply of agriculture commodities. In addition to this, it is also important to augment production of more nutritious food. Improving nutrition particularly amongst children and pregnant women is critical because India still faces relatively high levels of malnutrition, despite the food surpluses. As per the latest National Family Health Survey (NHFS-5), 32 per cent of children under 5 years of age are still underweight, 35.5 per cent are stunted and 19.3 per cent are wasted during 2019-21 (NHFS-5, 2021).

In this context, the latest Economic Survey (2021-22) raised the need for interventions in food systems that are targeted to push-up India's nutritional security status to higher levels. For this, the government introduced the centrally sponsored pilot scheme ‘Fortification of Rice and its Distribution under Public Distribution System’ for a period of 3 years beginning 2019-20 (Government of India, 2022), which, we feel, is a step in the right direction. Further, it was announced in the Union budget that the supplementary nutrition programme and the Poshan Abhiyan will be merged and relaunched as the Mission Poshan 2.0. Provision of Rs. 20,263 crores have been made for the integrated programme for 2022-23.

Changing consumption preferences

In India, a steady decline in the per capita consumption of food grains is witnessed coupled with the shift in the consumption demand towards high-valued and nutritious agri-commodities like livestock products, fruits and vegetables (Kumar, Joshi and Birthal, 2009). A summary of long-term trend in the per capita consumption pattern at the household level based on NSSO unit data is presented in Figure 1. It shows that the per capita consumption of cereals has been declining whereas that of livestock products like fish and meat and eggs has increased over the years. Decline in the per capita consumption of cereals from 12.71 kg per capita per month in 1993-94 to 10.42 kg per capita per month in 2011-12 can be attributed to factors like diversification of food basket, changes in the taste and preferences of people, changes in the price of relative food commodities and rise in income (Mittal, 2008). Per capita consumption for high-valued commodities like egg increased from 0.86 eggs per capita per month in 1993-94 to 2.32 eggs per capita per month in 2011-12. During the same period, the per capita consumption for milk increased from 4.18 litres of milk per month to 4.67 litres of milk per capita per month.

Demand and supply projections of major agricultural commodities till 2030

Given that the food basket has registered significant change over the years, a forthcoming ICRIER-NABARD report has estimated the demand for selected major agricultural commodities using the absorption approach. Assuming per capita income growth as 5.1 per cent per annum and scaling up the population projections using the estimates provided by the United Nations (UN) World Population Prospects (2019), the future demand of food grains (rice, wheat, coarse cereals and pulses), fruits, vegetables, milk and meat have been projected up to 2030-31.

The authors of the forthcoming report have estimated that the cereal demand by the end of 2030-31 will increase only marginally from 249.1 million tonne (mt) in the base year (TE 2019-20) to 257.6 mt under the assumption of 5.1 per cent income growth using the demand elasticity of cereals (-0.102) as given in Working Group Report of Niti Ayog (2018). However, using demand elasticities of rice (0.0245), wheat (0.0746) and coarse cereals (-0.1249) as given in Kumar et al. (2011), we find the demand for cereals will increase up to 272.7 mt in 2030-31. Similarly, the demand for pulses will increase up to 40.05 mt in 2030-31 using demand elasticities as

<table>
<thead>
<tr>
<th>Year</th>
<th>Cereal (mt)</th>
<th>Fish (mt)</th>
<th>Meat (mt)</th>
<th>Milk (mt)</th>
<th>Edible Oil (mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019-20</td>
<td>249.1</td>
<td>340.5</td>
<td>304.6</td>
<td>102.6</td>
<td>614.7</td>
</tr>
<tr>
<td>2020-21</td>
<td>257.6</td>
<td>357.1</td>
<td>314.8</td>
<td>107.5</td>
<td>650.6</td>
</tr>
<tr>
<td>2030-31</td>
<td>272.7</td>
<td>377.2</td>
<td>325.0</td>
<td>112.3</td>
<td>686.5</td>
</tr>
</tbody>
</table>

Source: Computed using data from NSSO Household Consumption of Various Goods and Services in India Surveys, various rounds (Note: For more detailed analysis refer to “Prospects of India’s Demand and Supply for Agricultural Commodities towards 2030” by Gula, A, Jose, S et al. (2022))
given in Niti Ayog (2018) whereas the demand for fruits and vegetables will increase from 298.3 mt in the base year (TE 2019-20) to 465.2 mt under the assumption of 5.1 per cent income growth by the end of 2030-31. The livestock product is estimated to be 304.6 mt for milk and 11.8 mt for meat in 2030-31. Evidently, the growth in the demand for non-cereals and high valued commodities is expected to exceed the population growth rate and increase at a faster rate than cereal commodities simply because of high expenditure elasticities of these commodities compared to cereals.

![Graph: Trend in the per capita consumption of food commodities (cereal and non-cereal) in India](image)

**Source:** Computed using data from NSSO Household Consumption of Various Goods and Services in India Surveys, various rounds

(Note: For more detailed analysis refer to "Prospects of India’s Demand and Supply for Agricultural Commodities towards 2030" by Gulati, A, Jose, S et al. (2022))

Considering the trend of the last 10 years, cereal production is estimated to increase up to 342.3 mt whereas the foodgrains are estimated to increase up to 377.2 mt by the end of 2030-31. The production of pulses is estimated to increase from 24.4 mt in 2020-21 to 29.2 mt in 2025-26, further increasing to 35 mt up to 2030-31, if we consider the last decade’s growth period. In the case of fruits and vegetables, the production of fruits is expected to increase from 102.6 to 145.2 mt between 2020-21 and 2030-31 whereas the vegetables will increase from 190.8 to 253.5 mt during the same period. Further, the milk production between 2020-21 to 2030-31 is expected to increase from 197.9 mt in 2020-21 to 340.5 mt in 2030-31 during the same period.

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1 Adopted from a forthcoming ICRIER-NABARD study on “Prospects of India’s Demand and Supply for Agricultural Commodities towards 2030” by Gulati, A, Jose, S et al. (2022).
Way forward

- Piecemeal approach of the governments' various food distribution programmes, seems to have surpassed its goal of improving the nutritional status of the population. Hence, leveraging research and development (R&D) to attack the complex challenge of malnutrition, particularly for low-income and vulnerable sections of the society, who cannot afford balanced diversified diets, can be a good intervention. Innovation in biofortification can accelerate production and improve access of the poor in India to iron rich pearl millet and zinc-rich wheat.

- To sustain long-term food security and achieve higher growth in its yield and sustainably, it is important to invest in productivity-enhancing agricultural practices that use inputs such as fertilizer, high yielding seeds and irrigation but have minimum impact on the natural resources. Adapting sustainable agricultural practices is one way to promote agricultural inputs which have the ability to produce more output from less input while focussing on improving grain quality and soil health, thereby ensuring sustainable growth in agriculture.

- The findings suggest that the commodities like pulses and fruits are expected to experience a deficit in supply in the coming years. Therefore, the production and productivity of the protein source and high valued commodities, particularly, pulses, fruits and vegetables should be incentivised through carbon credits on per hectare basis. Also, more investment is needed in their research and development aimed at the introduction of cost-reducing technology focusing on productivity enhancement. Diversification towards high-value commodities, especially perishables, requires major investments in market infrastructure, processing and storage facilities such as warehouses, cold storage, cold chains, etc. to build an efficient and reliable value chain.

- Another important finding of the study is that the country will have a surplus of cereals in 2030-31 ranging between 85-69.6 mt depending upon the different elasticities used. Therefore, India needs to change its policies towards pro-diversification to become competitive globally.

- Climate change is affecting the four pillars of food security: availability, access, utilisation and stability, thus, threatening the livelihood of the farmers. Climate-smart practices need to be promoted to build resilience and adaptive capacity in food systems based on soil and water management and pest control for improving food security and agricultural production for the future generation.

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Reimagining Pristine Ganga through Natural Farming Corridors

Bharat R. Sharma

The future of Ganga depends on our actions to rejuvenate the river and its landscape. Despite being the most revered and of high economic importance, the river remains severely polluted with an endangered flow and ecology. National Mission for Clean Ganga (NMCG) estimated that by the year 2021, the sewage generation along the Ganga main stem will be 3,148 million liter per day (MLD). A capacity of 2,374 MLD (75.4 per cent) is already in place to treat this 'point source of pollution' and efforts are in progress to expand this capacity (Mishra and Upadhyay, 2022). Equally or rather more important is the 'non-point source of pollution' which flows into the 2,525 kilometre (km) long main stem and tributaries spread over 86.15 million hectares (Mha) of the river basin. Runoff from agriculture fields is considered one of the biggest non-point sources of pollution. Currently, there are no precise estimates available on the quantum of pollutants from the runoff but with an average annual rainfall of 110 centimetres (cm) and overdose of residues from pesticides, livestock, and fertilizer application of about 200 kilogram per hectare the volume is likely to be very high. Only innovative, effective, widespread, and sustainable agricultural practices can rejuvenate the river and the dependent livelihoods.

Prime Minister Modi said that the underlying philosophy of the Budget 2022 was “Moving ahead while going back to the roots”. The countrywide launch of chemical-free natural farming with a special focus on creating 5-km wide corridors along the river Ganga in the first stage, envisions going back to the roots of Indian agriculture. The estimated area for this green corridor shall be around 1.5 Mha. The National Ganga Council first mooted the idea of an organic corridor on December 15, 2019, to check the heavy non-point source of pollution from agricultural fields. The government of Uttar Pradesh and Bihar took the lead and promoted organic farming along the banks of Ganga to increase the production of organic crops in the state and cleaning of the river Ganga. The programs planned to create organic farms clusters of about 20.2 hectare (ha).

The transitioning farmers in Uttar Pradesh shall receive a grant of Rs. 14,500 per acre for purchase of organic inputs besides training in natural farming, support in certification, linking the ‘gaushalas’ in the district for the supply of organic manure and wastes, and creation of dedicated organic produce markets (TOI, 2020). Additionally, according to the Economic Survey 2021-22 under Bharatiya Prakritik Krishi Padhiti (BPKP), financial assistance of Rs. 12,200/ha for 3 years is provided for cluster formation, capacity building and continuous handholding by trained personnel, certification and analysis. The program has not yet attracted many farmers as the area coverage of 0.5 Mha under the BPKP is mainly in the non-Ganga River corridor states (Economic Survey, 2021-22). Though the intent and the initial plans are good, they have not yet considered the ever-dynamic river hydrology, ecology and economics, and the vulnerability of the small and marginal farmers occupying the banks of the Ganga.

Ganga is a unique river in several aspects. First, it is a gaining river as the flow increases more than a hundredfold from the source at Gangotri to the delta in the Bay of Bengal. Second, the seasonal variability of the river flow is huge as it floods during the monsoons and shrinks and sometimes has discontinuities during the summer season. Third, is the high extraction of the river flows diminishing, with highly polluted flows, especially in the Uttar Pradesh stretch (Sharma et al., 2010). It is crucial to keep spatial and seasonal variability of the river into consideration for sustenance of natural farming in clusters. The corridors need to be creatively different in the mountainous Uttarakhand stretch, from the fertile plains of Uttar Pradesh, to the flood-prone diaras in Bihar, and the fragile delta in the West Bengal. Conceptually, the natural farming corridor may have some essential components (Figure 1).

FROM THE INNOVATIONS KIOSK
A sunken trench of about 500 meters width shall help trap the entire upstream pollutant load from entering the river. To reduce the flow velocity this land may be planted with important horticultural plants/ agroforestry trees (mango, guava, litchi, poplar, lemongrass etc.) suitable for the region. The next stretch of ~ 3.5 km will be the main natural farming cover planted with crops of high economic value. It should be ensured that the stretch maintains live crop cover throughout the year, and grow 15-20 diverse crops with layered cropping. The main aim is to adhere to the principles of natural farming with no chemical inputs to generate only contaminant-free runoff. This is the zone of high economic growth and relatively assured returns. The last strip is the zone of riverbed agriculture of variable width as per the river flow which is available during the summer and winter months, and suitable for the cultivation of vegetables, melons, flowers, fodder crops, and other short-duration crops (Vijaykumar, 2021).

To ensure that this vision comes to life and the pilot project can be implemented at a large scale, a comprehensive package for participation on the pattern of infrastructure projects needs to be developed with the difference that ownership will remain with the farmers but the land-use practices will see a transition to natural farming. There should be a subsidy for setting up small-scale agro-industries for better grading, sorting, packaging, certification, and marketing of natural products in domestic and international markets, through the creation of a premium Ganga brand. During the transition from inorganic to organic farming systems (~3 years), farmers may be compensated for low yields and crop losses and insured through well-designed instruments. It is a good policy move, but its effective implementation shall require consideration of the relevant river and landscape parameters, adequate resources, and new-age skills, and proper analysis and monitoring. Declaration of the natural farming corridors is just the beginning.

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India is one of the fastest-growing economy in the world today and projected to remain so during 2021-24 as estimated by World Bank and IMF’s World Economic Outlook. On its journey as an independent nation, the country has experienced a spectacular transformation of its food system, from a severe deficit one during the mid-1960s to a self-sufficient and marginally surplus nation (Gulati et al., 2021). This breakthrough transformation has been a result of the 4 Is- Innovation, Investment, Infrastructure, and Institutions which have taken place over the last few decades. As we embark on the journey towards ‘Amrit Kaal’, a major challenge that India is going to face is how to feed a rapidly growing population with rising incomes amidst limited availability of land and water resources. India needs to develop innovations which have a wider, futuristic, and global perspective and can help in overcoming the short comings of India’s agrarian setup. Precision Agriculture is one such innovation which involves use of remote sensing, geographical positioning and information system (GPS & GIS), internet of things (IoT), satellite imagery, sensors, robotics, drones, etc. It has played a major role in transforming the way farming is done and equipped farmers to make smart decisions based on real-time information (Sharma, 2014; Gulati et al., 2021). In February 2022, PM Modi launched the ‘Kisan Drone Yatra’ across India, which has the potential to give major stimulus to the agricultural sector (PTI, 2022) ushering in a new revolution!

In the budget speech, 2021-22 delivered by the honourable finance minister, she emphasized that government will promote use of drones, chemical-free natural farming, and public-private partnerships for the delivery of digital and high-tech services to farmers (PTI, 2022). Drones will particularly be used for crop assessment, digitization of land records, and spraying of insecticides and nutrients on farmers’ fields (PMO, 2022). Department of Agriculture & Farmers Welfare has also released the standard operating procedures (SOPs) for an effective and safe operations of drones in agriculture. The cost of a drone is estimated to be in the range of Rs. 5-10 lakhs (Haq, 2022). To make it more affordable, the central government has provisioned financial assistance at 100 per cent cost of agriculture drone or Rs. 10 lakhs, whichever is less, as grant for purchase of drones by Indian Council for Agriculture Research and state agriculture governments under the sub- mission on agricultural mechanization (SMAM) for taking up large scale demonstrations of this technology on the farmers’ fields (Ministry of Agriculture & Farmers Welfare, 2022). Farmers’ producer organizations or large collectives are also eligible to receive grants up to 75 per cent of the cost for demonstrations under this provision. Furthermore, special funding has been extended to drone hiring centres at 40 per cent of the basic cost of drones or Rs. 4 lakhs (whichever is lower) to provide agricultural services through drones (Ministry of Agriculture & Farmers Welfare, 2022). A contingency expenditure of Rs. 6,000 per hectare has been made available for implementing agencies that do not want to purchase drones but are willing to hire them for demonstrations (Ministry of Agriculture & Farmers Welfare, 2022). A Chennai-based start-up - Garuda Aerospace has stepped forward and committed to manufacturing of 1,00,000 drones in the next 2 years (Haq, 2022). Even Anand Mahindra has intended to scale up farm drones. It is believed that drones or unmanned aerial vehicles (UAVs) can revolutionize the way farmers undertake farming operations.

At this stage of policy planning for the actual rolling out of agricultural drone scheme, we need to move the game ‘one notch up’ and utilize the drones as "Smart Drones” for smart agriculture. Apart from using them as machines to apply pesticides and nutrients on the farm to save labour and time, they can be an important component of the farming process (Figure 1). The design may include crop surveillance through sensors, real-time and field-specific problem or action diagnosis, design of precise action or advice through expert knowledge / artificial intelligence, and finally the implementation of the specific farm operation through agricultural drones.

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1According to the International Society of Precision Agriculture (ISPA), "Precision Agriculture is a management strategy that gathers, processes and analyses temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production." (Source: https://www.ispag.org/about/definition)

2ICRIER and this Bulletin do not endorse explicitly and implicitly, any commercial enterprise.
The government has already implemented the soil health card scheme, which advises the farmers on crop and farm-specific nutrient application. Through crop surveillance sensors, it would be possible to assess the crop condition and understand need for the specific nutrition (leaf colour signatures), the possible appearance of a disease or pest attack, and drought or waterlogged condition (thermal signatures) for the field crops, vegetable farms and the orchards. Based on the problem assessment or action diagnostics, smart and precise farm operations can be designed using expert knowledge and artificial intelligence. For instance, information regarding nutrient (including micro-nutrients) requirement, including the type, and dosage of the agro-chemicals for disease, insect and weed control, advisory for irrigation application or the drainage, and other such operations, which shall be shared with the concerned farmer in-person or through smart-phone based advisory. The agricultural drones shall then be pressed into service to carry out the farm-specific precise operations. Extension officials should educate the farmers about the benefits of the innovation from ‘space to land’, wherein enabling policies, institutions, and partnerships, especially the private sector should be encouraged for making the innovations work and catalysing agriculture growth and economic development.

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