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AGRI-FOOD TRENDS AND ANALYTICS BULLETIN

Re-aligning Agri-food Policies for Protecting Soil, Water, Air & Biodiversity (SWAB)

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Inside the Issue

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From the Director's Desk

In the face of growing pressures on environmental resources exacerbated by climate change, it is crucial to acknowledge the intricate relationship between food production, natural resource management and environmental sustainability. Our agri-food policies wield immense influence in sculpting the vitality of our soil, the purity of our water and air, and the diversity of our ecosystems.

Soil degradation, often caused by erosion, nutrient depletion, and chemical contamination, reduces the fertility and resilience of farms, hampering crop yields. Depletion of groundwater resulting from excessive irrigation and inefficient water management practices, threatens the sustainability of agriculture by diminishing water availability for irrigation. Moreover, the GHGs emissions from agricultural activities, such as methane from livestock and nitrous oxide from fertilizers, exacerbate climate change, leading to unpredictable weather patterns and extreme events that disrupt agricultural productivity. Additionally, the loss of agro-biodiversity undermines the genetic diversity of crops and reduces the resilience of agricultural ecosystems, making them more vulnerable to pests, diseases, and adverse weather conditions. Addressing these interconnected challenges is essential for fostering sustainable and resilient food production systems capable of meeting the needs of a growing global population while safeguarding environmental health.

Against this backdrop, this edition of ICRIER – Agriculture Policy Sustainability and Innovation (APSI) quarterly bulletin, Agri - Food Trends and Analytics Bulletin (AF-TAB), serves as an impassioned call to policymakers, to re-assess and re-align the agri-food policies to protect the Soil, Water, Air, and Biodiversity (SWAB). With well informed and well communicated policy decisions, coupled with collaborative endeavors, India has the power to structure the agricultural food system in a manner that it not only produces enough food, feed, fibre, and fuel (bio-fuel) for the nutritional requirements of present and future generations, but also serves as a custodian of our planet's well-being.

Deepak Mishra
Director & Chief Executive
ICRIER

From the Chief Editor's Desk

The foundational elements of sustainable food systems lie in the synergy of four critical natural resources: soil, water, air, and biodiversity (SWAB). Preserving these resources necessitates the implementation of sustainable agricultural policies and practices.

With India's population projected to reach 1.67 billion by 2050, the strain on the environment is expected to intensify. The excessive exploitation of the limited SWAB resource base to meet growing demands for food, feed, fiber, and fuels (bio-fuels) is likely to worsen soil health, deplete groundwater levels, escalate greenhouse gas (GHG) emissions, and lead to the degradation of ecosystems and loss of biodiversity. The repercussions of this degradation are profound and wide-ranging, necessitating urgent action to preserve the planet and its resources while producing more.

In response to these challenges, this issue of AF-TAB "***Re-aligning Agri-Food Policies for Protecting Soil, Water, Air, and Biodiversity (SWAB)***," sheds light on the influence of agri-food policies on India's agricultural production, use of agricultural inputs, and environmental sustainability. Additionally, this issue proposes strategies for re-aligning these policies towards ensuring people and planet-positive agriculture.

The opening article of this issue, *Smart Subsidies for Sustainable Soils*, underscores the significance of soil organic carbon (SOC) for soil health, structure, and fertility. It discussed the adverse effects of imbalanced use of fertilizers—Nitrogen (N), Phosphate (P), and Potassium (K)—which stems from the disproportionate subsidization of granular urea (N) in relation to P and K. The second article, *India's Food-Water-Energy Conundrum*, delves into the repercussions of falling groundwater levels and the declining quality thereof. The piece elucidates the driving factors behind this challenge, including heavy subsidization of electricity, Minimum Support Price (MSP) backed procurement policy, especially for paddy and wheat, which distorts the cropping pattern in favour of rice, leading to depletion of groundwater levels. Further, highly subsidized fertilizers induce its excessive application, which on leaching into groundwater leads to contamination of groundwater.

In the third article, *Agriculture, Policies and Climate Change*, the focus is on the repercussions of rising temperatures and decreasing summer monsoon precipitation on agriculture, particularly affecting crops like wheat, maize, oilseeds, and sugarcane. It also explores the factors driving greenhouse gas emissions in agriculture propelled by the policies of food, fertilizers, and power subsidies. The fourth piece, *Agricultural*

Subsidies and Agro-biodiversity examines the influence of agri-food policies on the pillars of agro-biodiversity -- production, consumption, markets, and conservation of genetic resources.

The issue aims to establish a policy framework for reorienting distorted agricultural support policies. Proposed measures include rationalizing subsidies on food, fertilizers, and power, transitioning to Direct Benefit Transfer (DBT) per hectare, deregulating input prices, and investing in precision agricultural technologies, agri R&D, and extension that promote not only climate resilience but also mitigation in food system. These steps not only save resources, both natural and financial, but also aid in mitigating environmental impacts.

Ashok Gulati
Distinguished Professor
ICRIER

1 Smart Subsidies for Sustainable Soils

Ritika Juneja and Ashok Gulati

Soil, the loose surface material covering most land, is composed of both inorganic particles and organic matter. It serves as the structural support for crops and acts as their primary source of water and nutrients. There exists an intricate relationship between humans, the Earth, and food sources, which underscores the vital importance of soil as the foundation of agriculture. Unfortunately, soil health has become increasingly fragile over time. As per the latest estimates, about 1/3rd of the total land area and about 1/5th of the global forest cover is severely degraded (UNCCD, 2019). And if this trend continues, 95 percent of the Earth's land areas could become degraded by 2050 (Leahy, 2018).

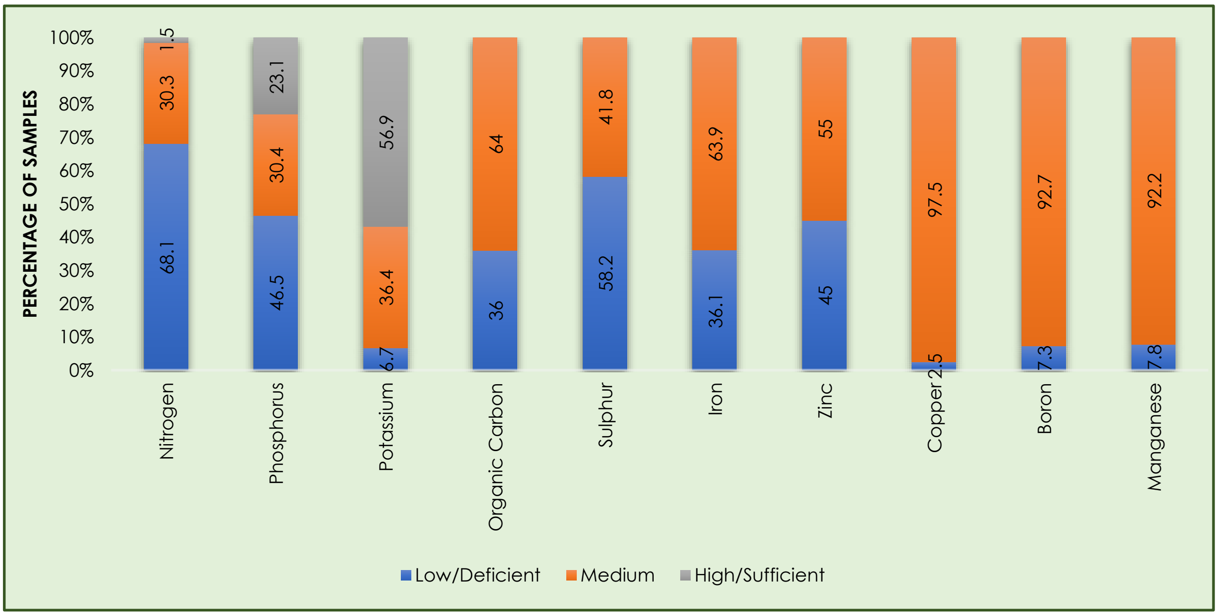
Soil Organic Carbon (SOC) is a crucial indicator of soil health, which provides soil with its water-retention capacity, structure, and fertility. According to Rattan Lal, Soil Scientist, and the winner of the 2020 World Food Prize, "soil contains 1,550 gigatons of organic carbon in soil organic matter, as well as 750 gigatons of inorganic carbon, which adds up to three times the amount of atmospheric carbon." His research on soil degradation revealed that majority of soils worldwide have experienced a loss of 25-75 percent of their original soil carbon content. He maintains that the ideal proportion of soil organic matter should be approximately 2.5-3.5 percent by weight in the root zone and that of soil organic carbon about 1.5-2 percent. However, many tropical soils currently contain less than 0.1 percent SOC. And yet, soil is too often undervalued as a necessity for food production (World Food Prize Foundation, 2020).

Analysis of factors driving soil degradation indicates that intensification of human activities and unsustainable management practices such as imbalance of nutrient extraction on harvested products and the native and applied nutrients, leads to nutrient mining, i.e., depletion of the organic matter in soils. Other factors include crop residue burning directly in the agricultural fields, destroying the available soil organic matter and soil organisms; increasing acidification of croplands driven by excessive nitrogen fertilization and unsustainable water management practices causing soil salinization. Further, the imbalanced use of fertilizers, weedicides, pesticides, etc., makes the soil biologically sterile, combined with the ongoing effects of climate change, have led to significant degradation of soils. This trend is pushing soil towards critical thresholds in its capacity to provide food, feed, and fibre for all.

Status of Organic Carbon in Indian Soils

Falling SOC in Indian soils is a cause of major concern for the agriculture sector challenging food security in India. Deficiency of SOC affects the productivity of soil as micro-organisms do not survive, a key factor to provide nutrients for crops. Data from soil health cards, based on 50 million soil samples tested during 2015-16 to 2018-19 in government - approved laboratories, highlight deficiencies of several nutrients as well as micro-nutrients in Indian soils. Indian Council for Agricultural Research (ICAR) defines the criteria for SOC as: <0.5 (Low); 0.5-0.75 (Medium); and >0.76 (High). These threshold limits, however, are more generous and vary significantly from Rattan Lal's SOC levels. This prompts us to question: what should be the actual secure thresholds of SOC? Nevertheless, the results of SHC scheme underscores that approximately 36 percent of soil samples in India exhibit organic carbon deficiency, while 68.1 percent display nitrogen deficiency, 46.5 percent show phosphorus deficiency, and 58.2 percent indicate sulphur deficiency. Additionally, among micronutrients, zinc deficiency is prevalent in 45 percent of samples, while iron deficiency is found in 36.1 percent (**Figure 1.1**).

Figure 1.1: Status of Indian Soils



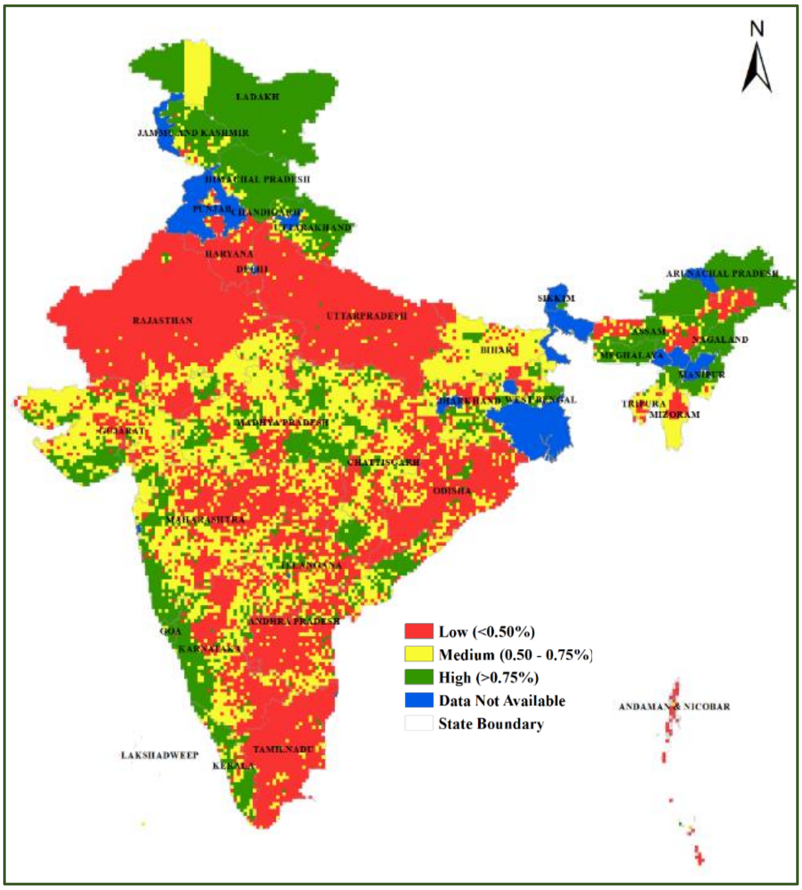
Source: Soil Health Card (SHC) Scheme, Ministry of Agriculture and Farmers' Welfare, Government of India

State-wise status of present SOC highlights that Uttar Pradesh's soils are the most deficient in organic carbon with 98 percent of the total area (24 million hectares (mha)) having less than 0.5 percent of organic carbon followed by Haryana with 95 percent of area, Tamil Nadu with 92.8 percent, Rajasthan (89.3 percent), Odisha (80.9 percent), etc. under low organic carbon category (<0.5 percent). It is noteworthy that data for Punjab is yet not available for the entire state (**Figure 1.2**).

Policy of Fertilizer Subsidy and its Impact on Soil

Fertilizers play a crucial role in agriculture by ensuring high yields and promoting food security through increased food availability. The policy of subsidizing key fertilizers, particularly nitrogenous (N), phosphatic (P), and potassic (K) fertilizers, was initiated in the 1970s when India's green revolution was still unfolding. At that time, India was striving to boost the production of essential staples like rice and wheat. This policy was implemented against the backdrop of rising gas prices, which served as the primary feedstock for nitrogenous fertilizers. Given the high levels of poverty in the country, policymakers aimed to keep output prices low. Achieving this required keeping input prices, such as those for fertilizers, low as well. Also, the response of grains to NPK was more than 10:1. Hence, the decision to subsidize fertilizers was made to support agricultural productivity and ensure affordability for farmers. The fertilizer subsidy in the revised budget of FY24 was INR 1.88 trillion, and it will keep fluctuating depending primarily upon the price of gas.

Figure 1.2: Status of Organic Carbon (SHC Cycle II) in Indian Soils



Source: Soil and Land Use Survey of India

Following the implementation of the nutrient-based subsidy (NBS) regime for P, and K fertilizers in 2010, the prices of these nutrients experienced rapid increases, while urea prices remained controlled and significantly low. Approximately 70 percent of the fertilizer subsidy was allocated for urea, which has resulted in its higher application, leading to issues of soil pollution, toxicity, and degradation. Moreover, synthetic fertilizer inputs contribute to the decline of beneficial soil micro-organisms, thereby impairing soil functionality for ecosystem functioning. This imbalance is reflected in the All-India NPK ratio, which is biased towards nitrogen, standing at 7.7:3.1:1 as of 2021-22 as against a generally considered ideal ratio of 4:2:1 at all India level, though it would vary from state to state.

Furthermore, it is important to acknowledge that granular urea, often broadcasted in fields, is not fully utilized by crops. Estimates of Nutrient Use Efficiency (NUE) indicate that only around 34 percent of nitrogenous urea is absorbed by crops. As the temperature is high, most of the urea will volatilise as ammonia (NH_3), nitrogen gas (N_2), and nitrous oxide (N_2O) gases. Ammonia, upon oxidation, transforms into nitrate (NO_3), which is 273 times the carbon equivalence causing global warming. While a portion of the applied fertilizer nitrogen is leached into groundwater, renders it non-potable due to high nitrate content and contributes to soil acidity. Given the significant negative externalities associated with excessive urea usage, one may question why urea is heavily subsidized while soluble fertilizers, used in drip irrigation, are not. The answer presumably lies in the old technology of fertilizer plants that produce granular urea, which is easy to spread. But for soluble fertilizers, farmers need an additional investment in drip irrigation. They may be reluctant to make this additional investment as the price of water and power remains free or highly subsidized in most states. Despite subsidies on drip and sprinklers, the area under micro-irrigation has not scaled up dramatically. This needs further study that can help tweak the policies that would encourage farmers to use water and fertilizers more frugally, and reduce their carbon footprint. This requires education of farmers too on these lines.

CONCLUSIONS AND WAY FORWARD

Adressing soil degradation requires an integrated approach that combines re-purposing of fertilizer subsidy, sustainable agriculture practices, biodiversity conservation efforts, climate change adaptation strategies, as discussed below:

1. Given the negative externalities caused by the urea subsidy on the environment, a few alternatives to rationalise it could be:
   - Switch to direct cash transfer into the accounts of farmers on the basis of per hectare of gross cropped area, and free up the prices of these fertilisers. This would bring down the wide imbalance between prices of N (urea), P and K fertilisers and would incentivise farmers to use more balanced doses of N, P and K. Also, with the prices of these being market determined, the diversion of urea (N) into non-agricultural uses and even across borders would dramatically reduce, giving high savings to the government, which can be used to promote better farm practices like fertigation through drips. This would significantly improve the carbon footprint of chemical fertilisers.
   - Other alternative could be to bring urea under Nutrient Based Subsidy scheme (NBS), with a flat rate subsidy on N, P and K. This would raise the urea prices significantly. However, to compensate farmers, Diammonium Phosphate (DAP) and Muriate of Potash (MOP) prices can be adjusted downwards in a way that relative prices of these three fertilisers are at par with what they currently are. This would promote more

balanced use of N, P and K and would result in efficiency gains.

- Another alternative would be to bring at par the soluble fertilisers, nano fertilisers, as also bio-fertilisers, after finding their equivalent strength in relation to chemical fertilisers. This would imply a fertiliser-neutral subsidy policy. This would give a big impetus to non-chemical fertilisers, thus having a positive impact on environment. One cannot talk of promoting sustainable agriculture, or chemical free agriculture, when chemical fertilisers are heavily subsidised in relation to non-chemical fertilisers.

2. Rattan Lal's research on soils advocated that soil can sequester carbon at rates as high as 2.6 gigatons per year. He even emphasized that shifting the focus of policymakers and agriculturists from NPK to CNPK (carbon, nitrogen, phosphorus, potassium) is most pressing. Precision agriculture techniques such as no-tillage, cover cropping, mulching and drip irrigation can protect the soil elements, conserve water, and return nutrients, carbon, and organic matter to the soil. Further agroforestry, or incorporating trees on farms and pastures, can help regenerate degraded land and boost yields.

3. Residue burning should be immediately stopped, particularly in states like Punjab, Uttar Pradesh and Haryana and should be left on fields to improve SOC. At the state level, governments are taking several initiatives to discourage stubble burning. However, effectiveness of these initiatives is a matter of further research. It requires massive educational campaign with some incentives for farmers not to burn crop residues on their fields.

4. Also, Rattan Lal advocated that government should prohibit use of top soil for brick making. The top layer of soil has been built by nature after millions of years. Instead, specific mining sites can be carved out, keeping the rest of the land safe. Brick making should switch from using top soils to fly-ash of thermal plants. Each thermal plant in the country should have a brick making facility attached to it.

5. The deficiencies of micro-nutrients in soils not only impacts soil productivity and life but also leads to decline in the nutritional quality of our food. When soils lack certain nutrients, the food crops cultivated in them also suffer from the same deficiency. Zinc deficiency, e.g, in rice and wheat leads to stunting amongst children, which in turn affects their life long earning capacity. Fortification and bio-fortification of basic cereals (wheat and rice) provides a path forward.

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2 India's Food-Water-Energy Conundrum

Purvi Thangaraj and Ashok Gulati

The Earth's surface is predominantly (71 percent) covered by water, with only around 2 percent being freshwater, essential for sustaining life (Durack, 2015; Abbott et al., 2019). Though freshwater is theoretically renewable, its consumption exceeds natural replenishment rates. The escalating demand for water is driven by factors such as rapid population growth, urbanization, and heightened needs from agriculture, industry, and energy sectors. This growing demand exacerbates the imbalance between supply and demand, worsened further by the impacts of climate change. Ultimately these challenges impede advancements towards achieving sustainable use of this natural resource.

India is categorized as a water-stressed[1] nation due to its declining per capita water availability, with estimates decreasing from 1545 m^3 in 2011 to 1486 m^3 in 2021 and projections for 2031 and 2050 even lower at 1367 m^3 and 1219 m^3 respectively (CWC, 2021). Globally, in 2020, freshwater withdrawals amounted to 3895.5 BCM, with agriculture accounting for 71.3 percent, industry 15.4 percent, and domestic use 13.1 percent. Correspondingly, India's freshwater withdrawals totaled 647.5 BCM, with agriculture comprising 90.4 percent, domestic use 7.4 percent, and industry 2.2 percent (World Development Indicators, 2020). However, India's Central Water Commission estimates that 78 percent of water withdrawals in the country are for agricultural purposes. In 2023, India extracted 241.34 BCM of groundwater, of which agriculture consumed 87 percent (209.74 BCM), domestic use 11 percent (27.57 BCM), and industry 2 percent (4.01 BCM) (CGWB, 2023). These varying numbers of 78 percent or 90 percent or 87 percent of fresh water resource being used by agriculture, as given by different sources, need to be synchronized. But that is matter of another research.

Green Revolution and Groundwater

In addressing India's urgent need for food self-sufficiency after independence, the Green Revolution package played a pivotal role in enhancing wheat and rice productivity through the adoption of high-yielding variety (HYV) seeds, increased use of chemical fertilizers, expanded irrigation, and improved farm mechanization. This proved fundamental to India's food security, as evidenced by the rise in per capita food grain availability from 144kg/year in 1951 to 188kg/year in 2022. However, this intensive input-use practice has led to an increase in cropping intensity[2], which has risen from 111.1 percent in 1950-51 to 155.4 percent in 2021-22 (DES, 2022).

Concurrently, the irrigation ratio[3] also significantly improved nationwide, from

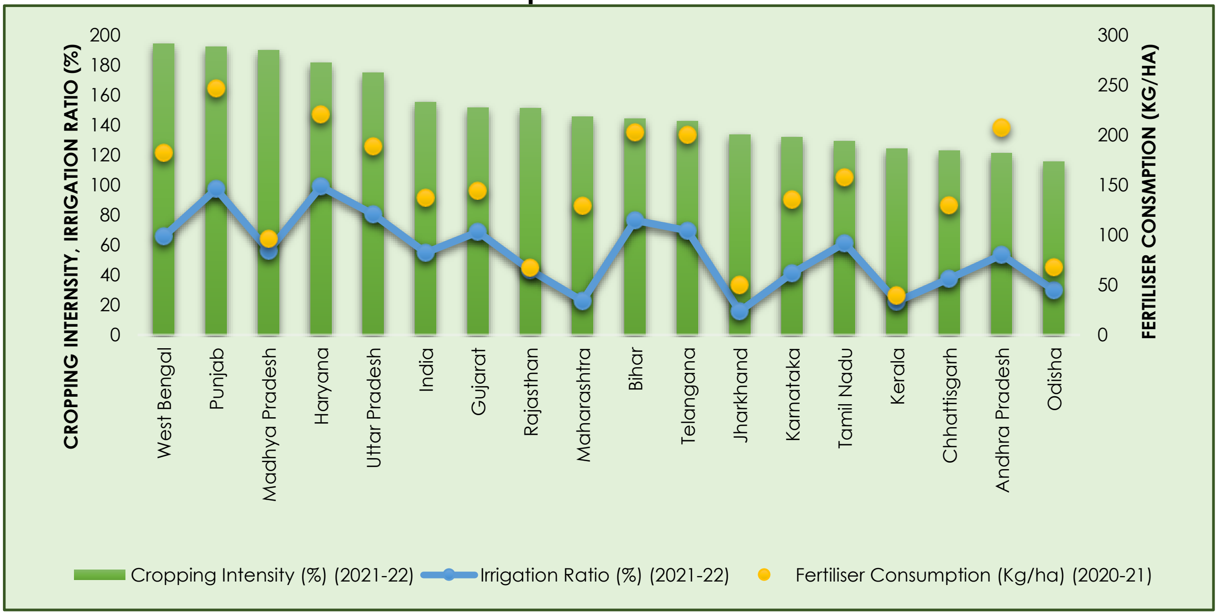
[1] When annual per capita water availability falls below 1700 cubic meters, it is classified as a water-stressed condition, while a level below 1000 cubic meters is regarded as water scarcity.

[2] Cropping intensity represents the number of crops grown on the same field in different seasons during an agricultural year.

[3] Irrigation ratio is measured as a percentage of Gross Irrigated Area over Gross Cropped Area

17.1 percent to 54.9 percent over the same period. Nonetheless, there are notable spatial disparities across states, with West Bengal (194 percent), Punjab (192 percent), Madhya Pradesh (190 percent), Haryana (182 percent), and Uttar Pradesh (175 percent) exhibiting high cropping intensity in 2021-22; Haryana (99 percent), Punjab (97 percent) and Uttar Pradesh (81 percent) exhibiting higher irrigation ratios in 2021-22, and lastly, Punjab (247 kg/ha), Haryana (221 kg/ha), Andhra Pradesh (208 kg/ha), Bihar (203 kg/ha) and Telangana (201 kg/ha) exhibited the highest fertilizer consumption per hectare in 2020-21 (DES, 2022) (**Figure 2.1**).

Figure 2.1: Statewise Cropping Intensity, Irrigation Ratio and Fertilizer Consumption per hectare



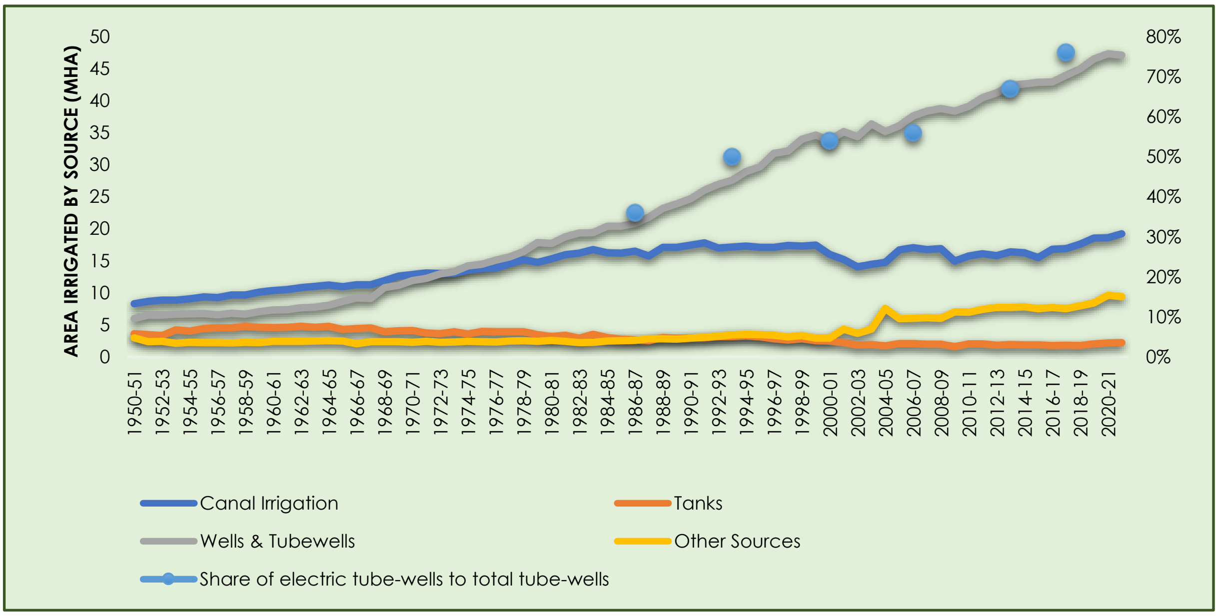
Source: DES 2022

However, these advancements have facilitated a remarkable evolution in the country's irrigation practices, transitioning from predominantly canal irrigation, which covered 8.3 million hectares (mha) in 1950-51, to groundwater irrigation through tube-wells and dug-wells (
Figure 2.2). The latter has seen a substantial expansion, rising from a mere 6 mha to 47 mha between 1950-51 and 2021-22. This has changed the share of groundwater irrigation from 29 percent to 60 percent, while that of canal irrigation has reduced from 40 percent to 25 percent during the same period (DES, 2022).

The widespread adoption of tube-well irrigation, primarily fueled by increased electricity availability for agriculture, has been the driving force behind this transition. Since the 1980s, the rapid expansion of groundwater-irrigated areas has resulted in a notable surge in electricity consumption within the agricultural sector, increasing from 18,234 GWh in 1983-84 to 228,451 GWh in 2021-22 (DES, 2022). Tube-wells currently play a significant role in India's electricity consumption, constituting about one-third of the total usage, with varying state-wise contributions, ranging from 27 to 45 percent (Singh, Kasana, &

Bhardwaj, 2022). Currently, there are approximately 23 million operational groundwater irrigation schemes in India, with around 76 percent of them depending on electricity, marking a substantial rise from 36 percent recorded in 1986-87 (MoJS, 2023).

Figure 2.2: Sources of Irrigation and electric-operated tube-wells



Source: Land Use Statistics and Minor Irrigation Census (various years)

PERILS OF POWER SUBSIDY

The extraction of groundwater for irrigation is closely linked to the availability of subsidized or free electricity across the country. In the late 1970s, many state governments significantly altered the relationship between farmers and energy boards. By supplying farmers with power at flat prices rather than metered rates, and eventually, for free, successive state governments across India set off a chain reaction with major long-term ramifications for the agricultural sector. Some argue that this change was a populist political move to develop and grab an important and powerful vote bank, while others regard it as an unavoidable consequence of the logistical challenges of metering, the prevalence of meter reader harassment, and the high transaction costs of a meter-based power system. Whatever the dominant motivation, and it is certainly possible that both were at work, the result was a gradual de-metering, the introduction of water use patterns and cropping decisions that did not reflect the scarcity value of water or the cost of electricity, and a culture of agrarian entitlement to free electricity (Dubash, 2007).

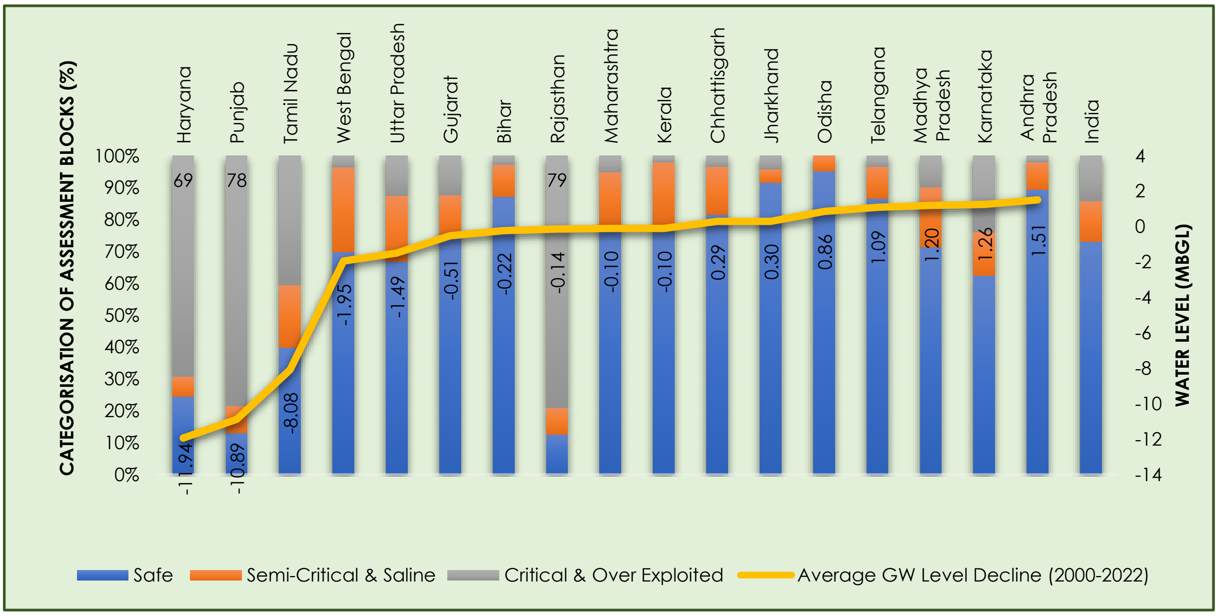
The issues of depleting and deteriorating groundwater and its quality observed in the agricultural sector can be largely attributed to longstanding policies of subsidies for agricultural inputs, such as power and fertilizers, as well as price support mechanisms like Minimum Support Price (MSP) for crops like paddy and wheat, and Fair and Remunerative Price (FRP) for sugarcane. These policies have had several consequences, including a bias towards water-intensive crops and distorted production choices (Gulati & Juneja, 2022). The structure of incentives led through faulty policy frameworks, plays a significant role in farmers' decisions to grow these crops, even in areas with limited water resources (Shah & Vijayshankar, 2022). Three "water guzzler" crops—rice, wheat, and sugarcane— occupying about 41 percent of the gross cropped area, consume more than 80 percent of irrigation water (Sharma, et al., 2018). Sugarcane, occupying only 4 percent of the cropped area in Maharashtra consumes 65 percent of the irrigation water (Shah, 2019), while in Karnataka, rice and sugarcane covering 20 percent of the cropped area, uses 70 percent of the irrigation water (Karnataka Knowledge Commission, 2019).

At the epicenter of Green Revolution, Punjab, and Haryana, comprising only 10 percent of India's rice-growing area, collectively produced 18 percent of the nation's rice output, and around 80 percent of the rice produced in these states is procured by the Government of India at MSP in 2021-22. In Punjab, with free power, a significant portion of the power subsidy, amounting to 67 percent of the total subsidy of INR 6745 crores in 2021-22, was allocated to rice cultivation. Specifically, the power subsidy per hectare stands at INR 8628, while rice cultivation received a per-hectare power subsidy of INR 14,599 (Singh & Gulati, 2023). While in Haryana, the agriculture tariff was reduced from 25 to 10 Paise/KWH, resulting in almost free power and a spend of INR 5027 crores in 2021-22.

The provision of this often and almost free and unmetered electricity has created a problematic nexus between groundwater and energy consumption in the country, particularly in Haryana and Punjab, where the states have witnessed an average decline in water levels of -11.94 and -10.89 meters below ground level (mbgl), respectively between 2000 and 2022 (**Figure 2.3**). In India, of the 6553 assessment units, 73 percent were categorized as safe, and the remaining were semi-critical (11 percent), critical (3 percent), over-exploited (11 percent) and saline (2 percent) (CGWB, 2023). Correspondingly, the stage of groundwater development in 2023 reveals that 79 percent of the assessment blocks are classified as critical and over-exploited in Rajasthan, 78 percent in Punjab, and 69 percent in Haryana, highlighting increased pressures in these states.

Depleting water tables from excessive extraction can degrade groundwater quality by concentrating contaminants, allowing intrusion of saline water, and lowering water levels in wells, potentially drawing from deeper aquifers with naturally occurring pollutants. Therefore, groundwater suffers not just in terms of the sheer depletion of the quantity used but also a grave impact on groundwater quality. Groundwater quality issues also exhibit strong linkages to over-exploitation- most of the assessment units that are 'critical' or 'over-exploited' also suffer from salinity, fluoride, and arsenic contamination. Groundwater in many districts contains toxic levels of fluoride, iron, nitrate, arsenic, and uranium due to both geogenic and anthropogenic factors. Even low levels of arsenic and uranium (10 and 30 parts per billion, respectively) pose significant health risks, including cancer and kidney failure. Areas with arsenic contamination produce a substantial proportion of India's rice (22.6 percent), wheat (42.6 percent), and maize (11.1 percent) (Alam, Villholth, & Podgorski, 2021). Uranium concentration in groundwater is exacerbated by declining water tables and high nitrogen levels in soils, contributing to cancer concerns in Punjab's Malwa region. The Central Ground Water Board (CGWB) reported that 6 percent of wells in Punjab and 4.4 percent of wells in Haryana had uranium concentrations above 60 µg/l, in 2020. Similarly, in 2021, nitrate levels exceeded permissible limits in Punjab and Haryana due to excessive fertilizer use, with 16-29 percent of samples testing above the permissible limit (45 mg/l).

Figure 2.3: Average Groundwater Level Decline, 2000-2022 and Groundwater Development 2023



Source: India Water Resources Information System, CGWB, 2023

Conclusions and Way Forward

The challenges of declining groundwater levels and deteriorating quality in agriculture stem largely from longstanding policies providing subsidies for inputs like power and fertilizers, along with price support mechanisms of MSP for crops like paddy and FRP for sugarcane, leading to a preference for water-intensive crops and distorted production decisions. There is a need for transforming the agriculture sector policies in line with SDG 6.4, to "Increase Water-Use Efficiency and Ensure Freshwater Supplies: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity." This would require a paradigm shift by changing the distorted structure of incentives.

1. Implementing Direct Income Support on a per-hectare basis offers a promising solution to address the

policies of free power supply, coupled with deregulating power tariffs to reflect market dynamics and implementing universal metering. This strategy could effectively tackle the problem of water depletion and reduce the power subsidy bill of states. However, given the political dynamics of state governments between state electricity boards and farmer vote banks, navigating any region's political landscape may pose a significant challenge.

2. Gulati and Juneja (2022), recommended that reducing the area under rice cultivation by at least one million hectares in states like Punjab and Haryana, where 99 percent of rice fields rely on flood irrigation methods and redirect rice cultivation to eastern India. This measure would contribute to addressing groundwater depletion caused by excessive water extraction in these states. To further this objective, largely stemming from the policies of free power and open-ended and assured procurement, it is imperative for the government to carefully diversify its crop procurement operations, tailored to distinct locations and aligned with local agro-ecologies.

3. Water-saving irrigation technologies like micro-irrigation (such as drip and sprinkler systems) promoted under the Government of India's *Pradhan Mantri Krishi Sinchayee Yojna* are imperative as a precursor to sustainable agricultural intensification. Furthermore, altering rice cultivation and irrigation practices, including the adoption of alternate wetting drying (AWD) and Direct-seeded rice (DSR) presents a more efficient alternative to conventional puddle rice cultivation. Further, recently introduced water saving initiatives in Punjab and Haryana like, *'paani bachao, paise kamao,' 'Mera Pani-Meri Virasat,' and 'Kheti Khaali, Fir Bhi Khushali,'* are in the right direction. However, their impact evaluation is a matter of further research.

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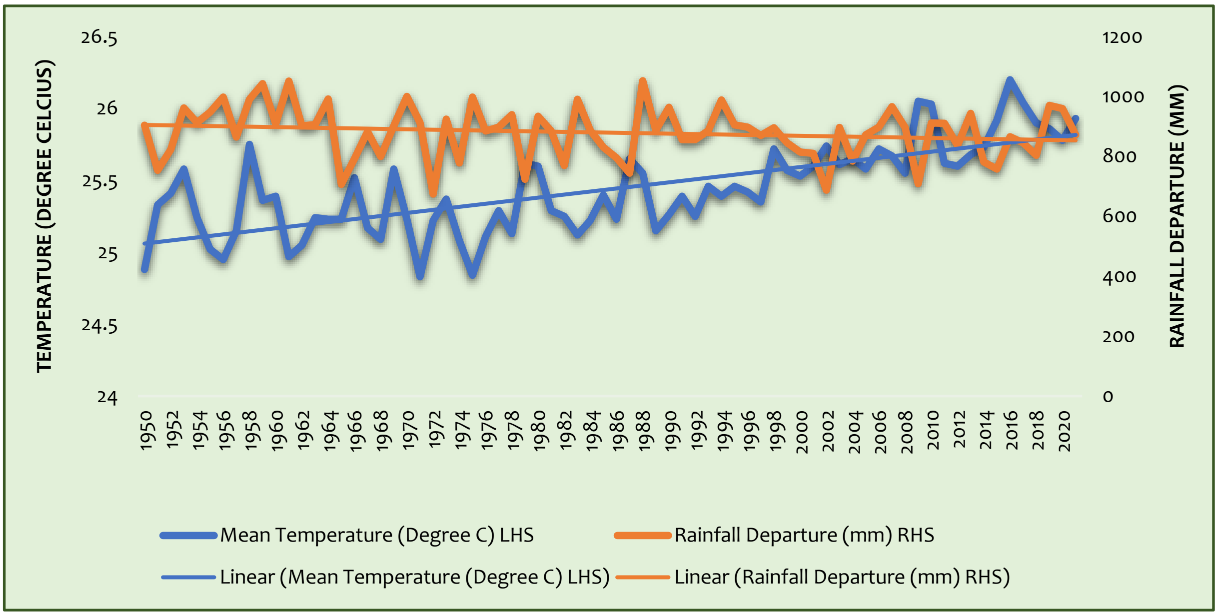
3 Agriculture, Policies and Climate Change

Reena Singh and Ashok Gulati

Over the period 1950-2018, average temperatures in the country has increased by 0.7⁰ C while the summer monsoon precipitation (June to September) over India has declined by around 6 percent from 1951 to 2015, with notable decreases over the Indo-Gangetic Plains and the Western Ghats (**Figure 3.1**, IMD). Increase in weather variability also increased in the country, with temperatures recorded above 50⁰C in certain regions and the increased variability in monsoon season (in timing and quantity of rainfall). By the end of the 21st century, average temperature in the country is projected to rise by approximately 2.4°C and 4.4°C relative to the recent past (1976–2005 average), under intermediate and high emission scenarios respectively.

Figure 3.1: Climate Change in India (1950-2021)



Source: India Meteorological Department (IMD)

Climate change is harming those sectors of the economy which are dependent on the weather such as agriculture. Even with the achievement of more ambitious nationally determined contribution (NDC) targets proposed by countries under intermediate emission scenario, the total economic value of crop loss (including both food and non-food crops) in India are projected to be USD 28.6 to 54.8 billion during 2030–2050, and USD 612 to 1,014 billion[4] during 2050–2100 (MoEFCC, 2023).

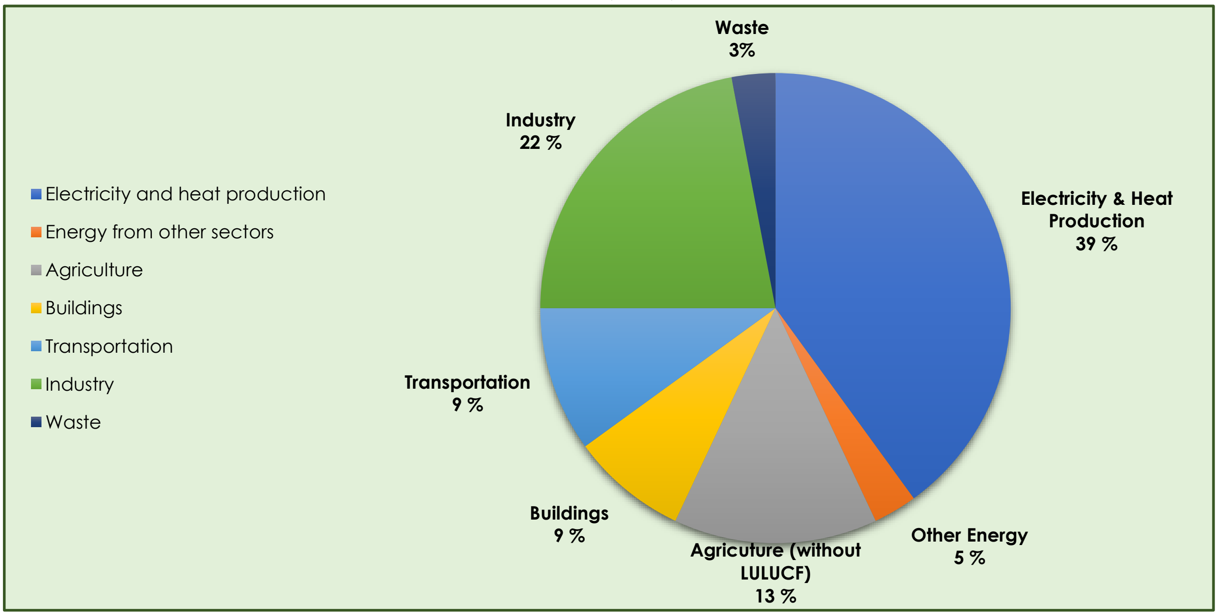
INDIA'S AGRICULTURE EMISSIONS ARE ON AN UPWARD TRAJECTORY DUE TO INCREASING INPUTS IN AGRICULTURE

Agriculture sector is affected most adversely by climate change impact but

[4] All figures are in 2015 prices, an undiscounted sum of yearly losses

at the same time it also adds to the climate crisis. The sector has contributed about 13.44 percent of the total Greenhouse Gas (GHG) emissions in India in 2019, MoEFCC, 2023 (**Figure 3.2**).

Figure 3.2: India's Greenhouse Gas (GHG) Emissions by Economic Sector



Source: MoEFCC, 2023

Note: Land-Use, Land-Use Change and Forestry (LULUCF) emissions are not included

The emissions from the agriculture sector are non-CO_2 emissions, in particular methane (CH_4) emitted by livestock and rice cultivation, and nitrous oxide (N_2O) caused using synthetic fertilizers and the application of manure on soils. CH_4 and N_2O have 27.2 times and 273 times stronger impact on the climate than CO_2 respectively. Emissions from agriculture have been rising since 1994 (base year for calculating emissions) from 344 million tonnes carbon-dioxide equivalent (Mt CO_2 eq) to 421 Mt CO_2 eq in 2019 (MoEFCC, 2023). The national GHG inventory reports direct emissions (excluding electricity) under agriculture sector, however, in this article we have calculated direct and indirect[5] emissions related to agriculture sector under crops and livestock. Crop production includes direct emissions from rice cultivation, agriculture soils and residue burning (obtained from national GHG inventory). Since crop production require inputs such as fertilizers, pesticides, and electricity for cultivation, emissions from the production of these inputs were included as upstream emissions under indirect category. Emissions related to fertilizer and pesticide consumption was estimated using emission factors as given by Pathak & Wassman 2007[6]. Emissions from electricity consumption in agriculture was calculated using emission factor from Central Electricity Authority (2021)[7].

[5] Down-stream emissions (transportation processing and packaging) are not calculated.

[6] Emission factor of 1.3 kg CO_2 per kg of N input, 0.2 kg CO_2 per kg of P and K input was used (Pathak & Wassman 2007)

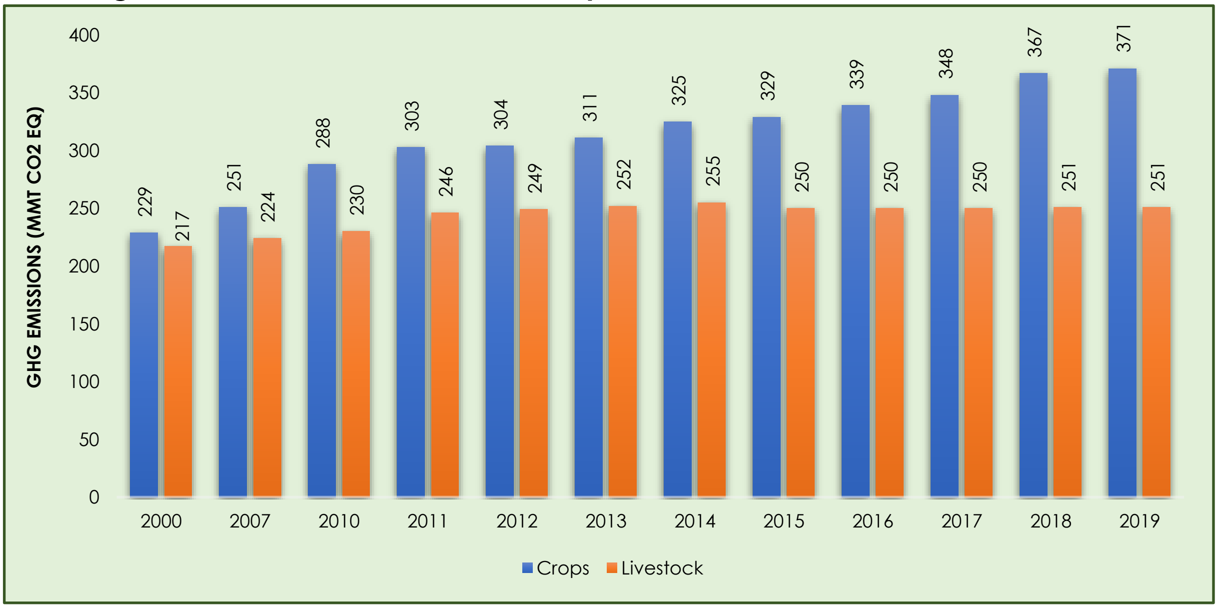
[7] Emission factor of 0.82 Kg CO_2 per KWH (CEA 2021)

In 2000, direct emissions from crops were 139 Mt CO_2 eq which increased to 160 Mt CO_2 eq in 2010 and were around 170 Mt CO_2 eq in 2019 (MoEFCC, 2023). However, if we include the indirect emissions (from fertilizer, pesticides, and electricity consumption in crop sector) then the total emissions from crops would be 229 Mt CO_2 eq in 2000, which increased to 371 Mt CO_2 eq in 2019 (**Figure 3.3**). The emissions from livestock include enteric fermentation and manure management emissions, which were 217 Mt CO_2 eq in 2000, became more or less stabilized in 2012 and is at 251 Mt CO_2 eq in 2019 (MoEFCC, 2023). This means, though direct emissions from livestock are higher than crops but if we include emissions from inputs then emissions from crops are far higher than livestock.

UNDER CURRENT POLICIES, EMISSION INTENSITY (EI)[8] OF CROPS IS ON UPWARD TRAJECTORY WHEREAS IT IS DECLINING FOR LIVESTOCK

India's NDC target is to reduce EI of its GDP by 45 percent by 2030 from 2005 level. India has already achieved the reduction in EI of its GDP by 33 percent in 2019 from 2005 (MoEFCC, 2023). So far, agricultural emissions have not been addressed by India, due to perceived fear of negative impact on food production, regulatory difficulty to measure emissions at individual farm level and partly due to the lack of political will. EI from the crop sector showed upward trend. In 2007, each billion INR from crop sector emitted 28,814 tCO_2 eq, which has increased to 33,466 tCO_2 eq in 2019 (**Figure 3.4**), a 16 percent increase from 2007. In contrast, EI from livestock declined from 89,974 tCO_2 eq in 2007, which has reduced to 43,148 tCO_2 eq in 2019, a 52 percent decrease from 2007.

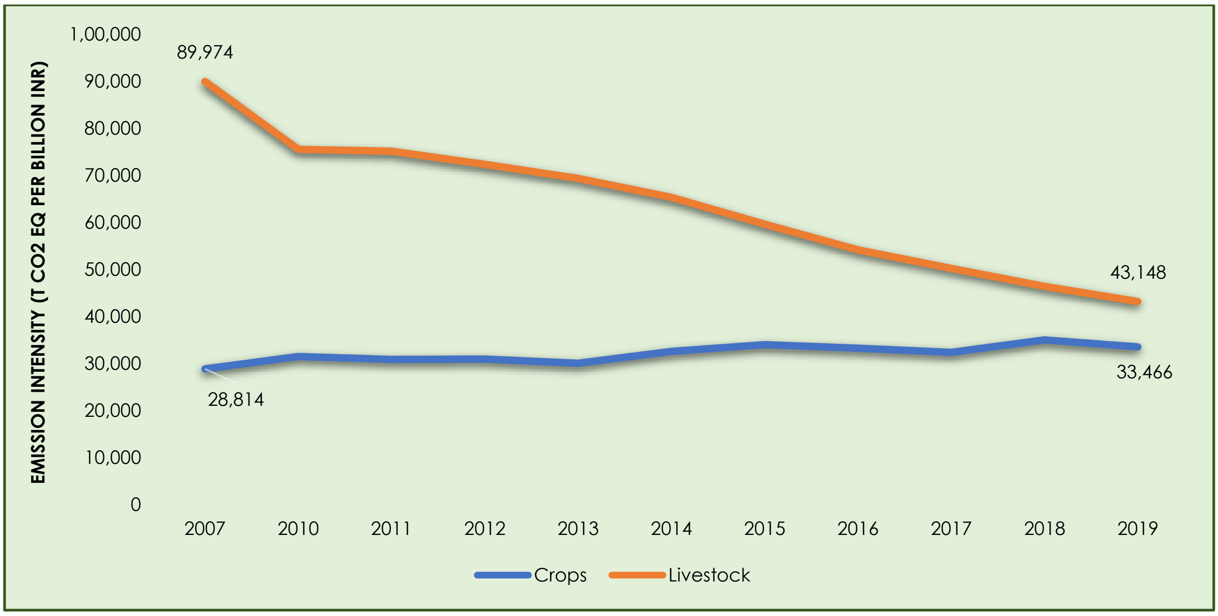
Figure 3.3: Emissions Related to Crop and Livestock Production, 2000-2019



Source: Authors Calculations using MoEF 2004 & 2012; MoEFCC, 2015, 2018 & 2021; MoEFCC 2023; DES 2022; Pathak & Wassmann 2007; CEA, 2021

[8] Emission intensity (EI) of the economy is the total amount of greenhouse gas emissions emitted for every unit increase of GDP. GDP of Crop and livestock sub-sectors were taken from MoSPI to calculate emission intensity.

Figure 3.4: Emission Intensities from Crop and Livestock Production, 2000-2019



Source: Authors Calculations using MoEF 2004 & 2012; MoEFCC 2015, 2018 & 2021; MoEFCC 2023; DES 2022; Pathak & Wassmann 2007; CEA, 2021; MoSPI

AGRICULTURAL POLICIES HAVE TRADE-OFFS WITH RESPECT TO CLIMATE CHANGE

Fertilizer subsidy has played an important role in Indian agriculture as it has boosted the consumption of fertilizer which positively impacted yield and output of major and minor crops. In absolute terms, consumption of total nutrients has increased from 16.7 Million Metric Tonnes (MMT) in 2000-01 to 32.5 MMT in 2020-21. In terms of per hectare of gross cropped area (GCA) has increased from 90 kg/ha in 2000-01 to 154 kg/ha in 2020-21. However, the rapid increase in the consumption of synthetic N fertilizers which is encouraged by subsidized fertilizers, and low N use efficiency in Indian croplands have also led to an increase in nitrous oxide (N_2O) emissions[9] from 0.56 MMT CO_2 eq (in 1960-61) to 58 MMT CO_2 eq in 2020-21 in Indian agriculture (Singh & Gulati, forthcoming).

Energy is also one of key input for crop production primarily for irrigation and land preparation. The sector's energy consumption for India in 2000–2001 was 84,729 GWh, which is about 26.78 percent of the country's total electricity consumption. The series has followed an increasing trend, between 2000–2001 and 2020–2021, reaching 229,000 GWh in 2021-22, though the share has declined to 17.66 percent (DES 2022). Unmetered and subsidized electricity, even though is credited to play a key role in agriculture production, has not only imposed a financial burden on the government but has also encouraged high electricity consumption for the sector. Free or subsidized electricity for farmers by states has made groundwater the major source of irrigation, which has led to over-exploitation of ground-water and increase in CO_2 emissions.

[9] Calculated using IPCC Tier 2 methodology with Country Specific Emission Factors. GWP 273 (as per IPCC Sixth Assessment Report 2022) has been used for converting nitrous oxide emissions into carbon dioxide equivalence

Conclusions and Way Forward

The long-term impacts of climate change—are not inevitable. India ranks third in GHG emissions, after China and USA at global level. India is the lead contributor of GHG emissions from agriculture sector (excluding LULUCF) amongst G20 as well as globally (Climate Watch 2021). There is no doubt that there will be significant impact to agriculture, in the short term as well as long term. But if India moves quickly to low-carbon agriculture, the country can at least partially mitigate the damage.

1. Shift from price input to direct cash transfer on per hectare basis and free up input prices. Presently GHG intensive inputs e.g. urea, and power are highly subsidized. These incentives need to be "crop neutral" and "input neutral". By shifting from price subsidy to income subsidy for direct cash transfer to farmers on per hectare basis, farmers can purchase the fertilizers as per their requirement (including micronutrient fertilizers) and choice (that include bio-inputs, vermicompost etc.). Also, paddy consumes high amount of water (20-25 irrigations vs 4-5 irrigations in other crops), electricity (for pumping water for irrigation purposes), fertilizers and is GHG intensive. And by freeing up input prices, farmers will have to pay high input cost for paddy cultivation as compared to other crops thus crop diversification from paddy will be encouraged.

2. Premium minimum support price (MSP) for low-carbon crops. At present, the Central Government procures food-grains (wheat and rice) at MSP for buffer stock requirements for Targeted Public Distribution System (TPDS) and other welfare schemes. Every year Commission for Agricultural Costs and Price (CACP) provides recommendations for MSP of various crops to the central government. However, CACP does not account for carbon cost while recommending MSP for various commodities. In rice, cultivation practices like Direct Seeded Rice (DSR), Alternate Wetting and Drying (AWD), System of Rice Intensification (SRI) are reported to save upto 2-2.5 t CO2 eq/ha (Sapkota el al. 2019). To encourage farmers to shift to low-carbon cultivation practices, premium support price (which can be linked to the carbon price and can be recommended by CACP) should be offered to the farmers. Since farmers respond to price signals through MSP, this measure will not only address food security objective but will encourage farmers to grow low-carbon crops.

3. Agriculture sector offers India the opportunity to lead carbon market for carbon farming credits. The country's agriculture contributes to 13 percent of the world's agriculture emissions (Climate Watch 2021) and thus have significant scope for trading carbon under carbon trading system, where one carbon credit unit is equivalent to one tonne of carbon dioxide emissions. Carbon credits can thus allow farmers to earn an income for every unit of GHG reduction or sequester from the atmosphere. Farmers can earn 3-5 credits per hectare. The value of one carbon credit depends upon the carbon market price. Farmers are generally

paid USD 15 to USD 20 per ton of carbon saved/sequestered under agriculture companies' programs. Companies such as fertilizer producers, mining, oil companies etc. who have higher carbon footprints and have opted for carbon neutrality goals, can offset their emissions by purchasing carbon credits from farmers. National as well as international companies can pitch in to offset their emissions from Indian croplands and livestock sector and can contribute to the global mission of net zero.

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4 Agriculture Subsidies and Agro-biodiversity

Reena Singh and Ashok Gulati

Food production is delicately dependent on biodiversity, and similarly, biodiversity is the outcome of food production processes that include deliberate crop selection, planned/unplanned exposure to a range of natural conditions, field-level cross-breeding, inputs and other agriculture practices. Biodiversity generates critical ecosystem services necessary for human well-being that include support to food and feed production, energy, medicines, materials, pollination, pest control, heat regulation, carbon sinks, and soil moisture feedback for rainfall amongst others. The biodiversity and its richness is thus vital for the productivity and resilience of food production systems. The Convention on Biological Diversity (CBD) provides a global framework for conservation and sustainable use of biodiversity. India is amongst 196 countries that has ratified CBD. Alarmed by the continued loss of biodiversity and the threat this poses to nature and human wellbeing, the Kunming-Montreal Global Biodiversity Framework (GBF) was adopted during the 15th meeting of the Conference of the Parties (COP 15) held in December 2022. Framework's key elements are 4 goals for 2050 and 23 targets for 2030. Target 18 of the framework proposes *"to redirect, repurpose, reform, or eliminate incentives harmful for biodiversity by 2030, reducing them by at least USD 500 billion per year, including all the most harmful subsidies, and ensure that incentives, including public and private economic and regulatory incentives, are either positive or neutral for biodiversity"*.

Agriculture sector in India is largely driven by policy signals and subsidies/incentives. Subsidies are useful and powerful tools, and are provided to promote crop production for ensuring food security as well as increasing income in a particular sector. Additionally, budgetary support is provided by governments to overcome market and climate risks (e.g crop insurance), aid vulnerable regions and population (e.g PM-KISAN, food subsidy, MGNREGA) and promote resource saving technologies (e.g. drip and sprinkler irrigation) that might not yet be competitive on the market. Against this backdrop, the present study assessed the impact of subsidies/incentives on three pillars of food systems where agro-biodiversity contributes: (i) production systems, contributing to agriculture sustainability (pillar 1); (ii) consumption and markets, contributing to healthy diets (pillar 1); and (iii) genetic resource conservation, contributing to safeguarding future option (pillar 3).

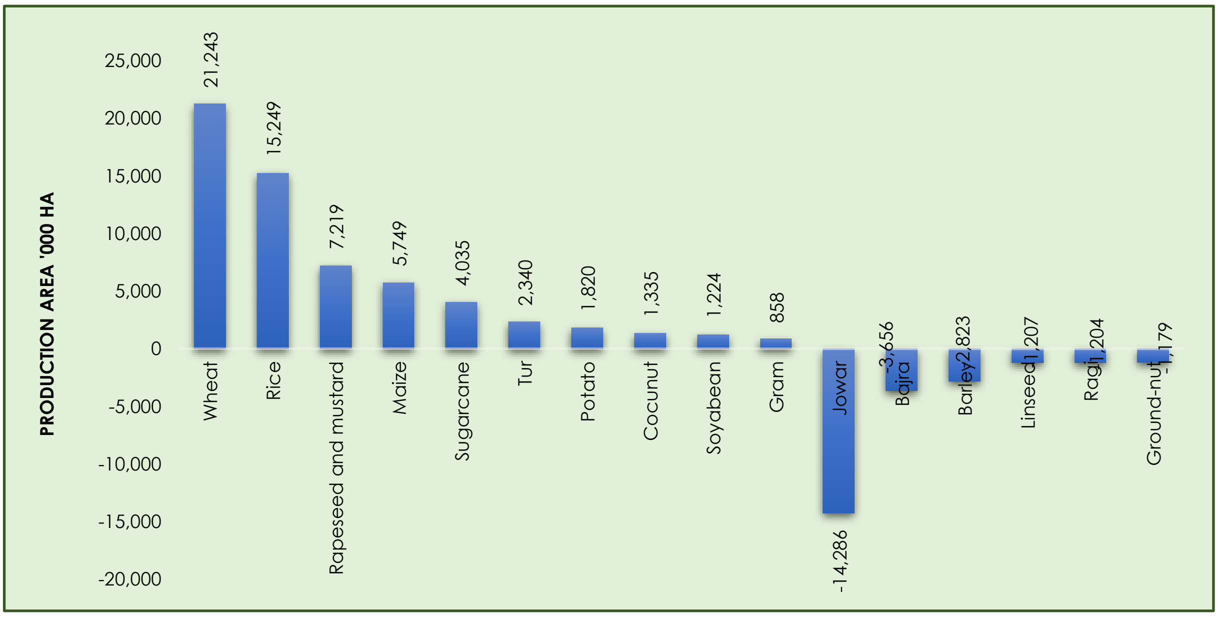
Production system diversity (Pillar 1)

Crop area in India increased by 43 percent, from 153 million ha (mha) in 1961-62 to 219 mha in 2021-22 (LUS 2021-22). Amongst food crops, rice was the dominant crop throughout this period; its area increased from 34.6 mha in 1961-62 to 49.9 mha in 2021-22[10] (LUS 2021-22).

[10] However, according to Agriculture Statistics at a Glance in 2021-22, area under Rice is 46.38 mha (advance estimates)

Wheat area nearly tripled during the same period from about 13.5 to 34.8 mha and is now the second most planted crop in India. The difference in rice production area increase was 15,245 ha between 1961-62 and that of wheat was much higher (21,243 ha) (**Figure 4.1**). Rice and wheat, together, covers 39 percent of the gross cropped area and 52 percent of the food crop area. Rapeseed and soybean expanded strongly after 1981. On contrary, the cultivation area under other coarse cereals and millets reduced significantly during the same time – area under jowar reduced from 18.2 to 3.9 mha; under bajra reduced from 11.2 to 7.6 mha; under ragi reduced from 2.4 to 1.25 mha and under barley reduced from 3.3 to 0.48 mha. The native pulses, such as moong, gram, etc., and some other oilseed crops, such as mustard, sesame, etc., were not cultivated further on a larger scale than it was before. As per NSS 77th Round 2019, 162 crop types are cultivated for food in India. However, of these seven crops (rice, wheat, maize, gram, tur, sugarcane, and potato) constitute 73 percent of total food crop production area of India (LUS 2021-22).

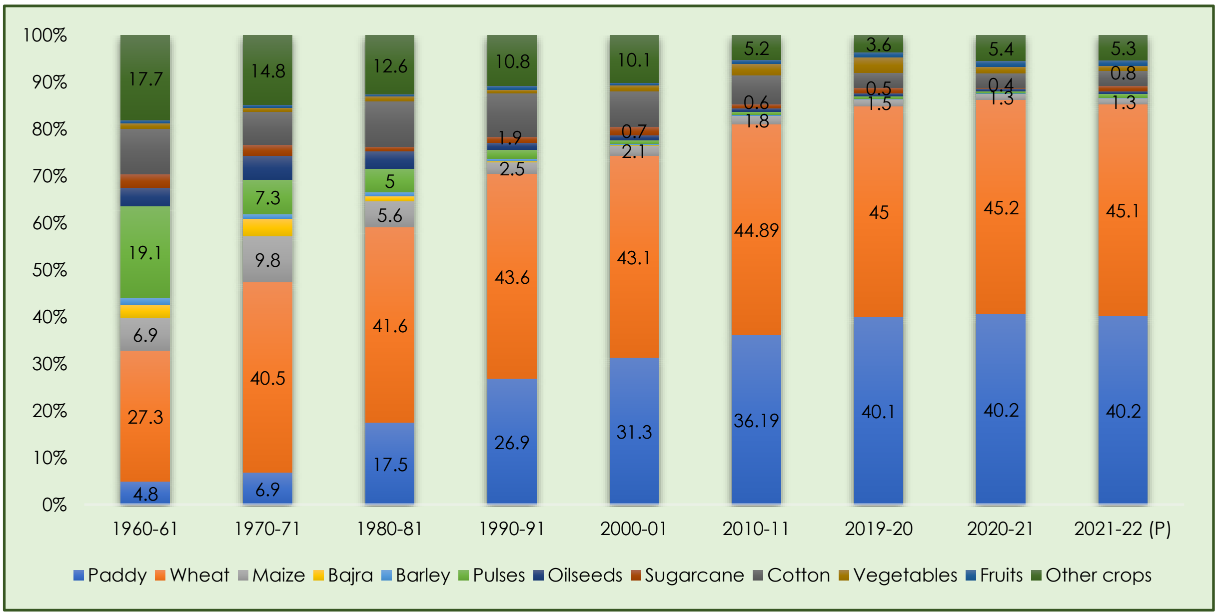
Figure 4.1: Difference in crop production area in India (1961-62 to 2021-22)



Source: Land Use Statistics (Various Years) compiled by Purvi Thangaraj

As a result of the Minimum Support Price (MSP) backed procurement policy of the centre, in Punjab, in terms of percentage of production, around 75 percent of wheat and more than 100 percent of rice produced in Punjab were procured by government agencies during TE 2021-22. This has led to wheat-rice mono-cropping in the state. In 1960-61, the area under paddy cultivation was only 0.22 mha which has increased to 3.14 mha in 2021-22, thereby increase in cropped area share from 4.8 percent to 40.2 percent (**Figure 4.2**). Similarly, the wheat cultivation area increased from 1.4 mha to 3.53 mha with increase in cropped area share from 27.3 percent to 45.1 percent. Though the central government announce MSPs for 23 commodities, but only wheat and rice are procured by the FCI on a continuous basis. Due to the assured income from the procurement of wheat and rice, the preference of farmers also changed in terms of the cultivation of these two crops leading to increase in their share in the total cropped area.

Figure 4.2: Crop-wise percentage of Punjab's cropped area



Source: Authors 'compilation from Punjab Economic Survey 2021-22, LUS (various years)

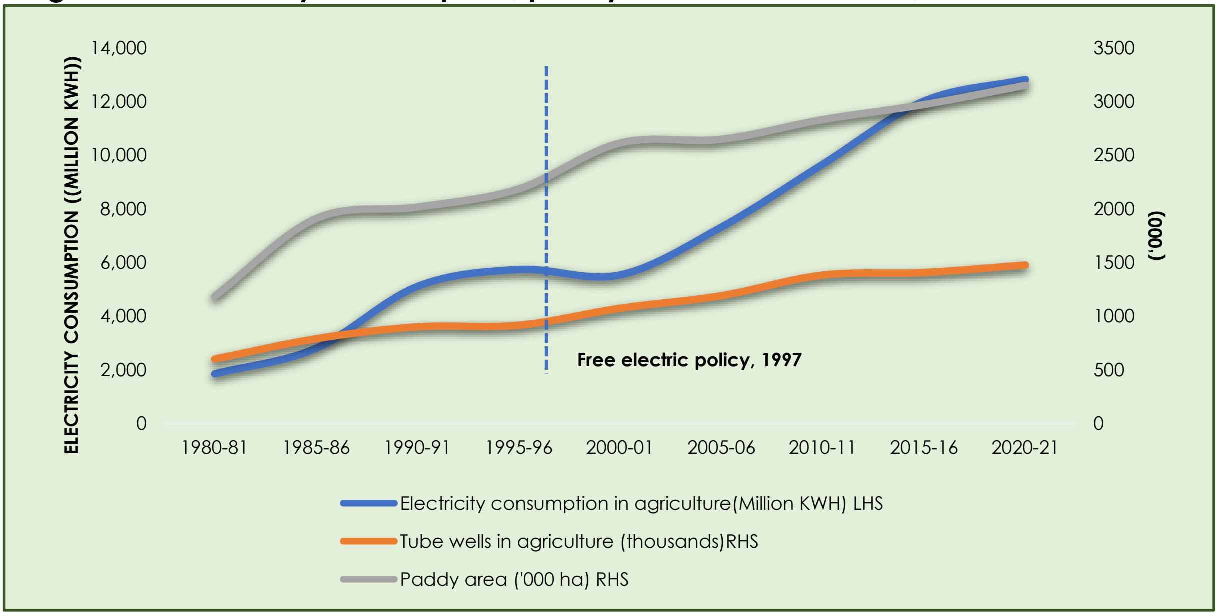
Paddy cultivation is also aided through subsidized electricity operated tube-well irrigation. State Electricity Regulatory Commissions decide the electricity tariffs of their respective States and many of the state subsidize power for agriculture use. Punjab agriculture is one glaring example where approximately two-third of the state's agriculture and allied sector budget expenditure gets diverted to power subsidy to farmers. In TE 24, power subsidy to farmers was INR 83.8 billion (Punjab State Budget). Free power has led to an increase in tube-well irrigation, which also shows proportionate increase in rice cultivation area, and increased electricity consumption in Punjab agriculture (**Figure 4.3**). Out of the total power subsidy, two-third of the power subsidy goes for paddy cultivation (Singh and Gulati 2023) as paddy requires 20-25 irrigations as compared to 4-5 irrigations in other crops.

CONSUMPTION AND MARKET DIVERSITY (PILLAR 2)

The Central Government, under the *Pradhan Mantri Garib Kalyan Anna Yojana* (PMGKAY) is implementing the largest food programme in the world and free food grains are being distributed to about 81.35 crore beneficiaries (i.e. *Antyodaya Anna Yojana* (AAY) households and Priority Households (PHH) beneficiaries) as per their entitlement. Thus, food subsidy is the largest component of government's subsidy bill in India and amounted to INR 2,530 billion in TE 24 (Union Budget Documents). Since the government distributes wheat and rice food grains, *prima facie* it appears that this subsidy encourages the consumption of only carbohydrates and discourages healthy balanced diet. However, NSSO Consumer Expenditure Survey data indicates that the expenditure on vegetable and fruits, milk, meat, and eggs are increasing even in rural population, whereas on wheat and rice, the expenditure is declining. This may mean that due to free availability of wheat and rice, the beneficiaries are able to consume other food-crops, and thus the consumption basket is increasing indirectly through food subsidy.

However, there is reduced cultivation of indigenous varieties of wheat, rice, millets, lentils, etc. and increased cultivation of fertilizer intensive high yielding varieties (HYVs) and hybrid crops since green revolution (Taylor, 2019). During 2013-14, area under local variety of wheat was 2.8 percent in Rajasthan, one percent each in Uttar-Pradesh and Bihar, and nil in Punjab and Haryana (Pavithra et al. 2017). It is also noteworthy that around 80 percent of the wheat area is covered by top 5 hybrid varieties of wheat in Punjab, Haryana, and Bihar. In Western Uttar-Pradesh, mere one sugar-cane variety (Co 0238) covers 90-95 percent of the sugarcane production area particularly for high yield and high sugar recovery of 8-10 percent (Indian Council for Agriculture Research - Indian Institute of Farming Systems Research (ICAR-IIFSR), Modipuram and Daurala sugar mills, Meerut). These trends indicate over-dependence on hand-full of fertilizer intensive hybrid varieties and loss of indigenous and local varieties for market consumption.

Figure 4.3: Electricity Consumption, paddy area and tube wells, 1980-81 to 2020-21



Source: Authors compilation from Punjab Statistics 2021-22

While chemical fertilisers are the main cause of adequate crop production for the country's population, their excessive, imbalanced, and unscientific application of nitrogenous fertilizers, which is often available to farmers at subsidized rates, has encouraged handful of fertilizer intensive HYVs and presents serious challenges to agro-biodiversity. In TE 2024, fertilizer subsidy amounted to INR 1980 billion, out of which urea was INR 1316 billion (66 percent of the total fertilizer subsidy) and this encourages imbalanced use of N (through urea). Un-utilized N is lost from the soil-water system through leaching (predominantly as NO_3

ions), volatilization (as NH_3 gas), denitrification (as N_2O and N_2 gas) and surface run off and erosion. Elevated nitrate concentrations are observed in groundwater regions This leads to water pollution and eutrophication affecting aquatic ecosystem and aquatic biodiversity. Use of fertilizers can suppress production of certain soil enzymes involved in nutrient cycles. Excessive fertilizer applications can also cause soil and land degradation (NEP 2006). The rapid increase in the consumption of synthetic N fertilizers, and low N use efficiency in Indian croplands have also led to an increase in nitrous oxide (N_2O) emissions. N_2O is a Green House Gas (GHG), which is 273 times more impactful than carbon-dioxide (CO_2) for temperature rise. Climate change has been recognized as a driver for biodiversity loss (IPBES 2019).

Punjab: Narrowing diversification base

Prior to green revolution, 41 varieties of wheat, 37 varieties of rice, 4 varieties of maize, 3 varieties of bajra, 16 varieties of sugarcane, 19 species/varieties of pulses, 9 species/varieties of oil seeds and 10 varieties of cotton were in use in Punjab. Punjab Agriculture University (PAU) released 49 post green revolution varieties of wheat, only 3 are widely used. Out of 27 varieties of rice released, only 9 are currently in use. Pusa 44, PR 121, and PR 114 cover more than 50 percent area of the entire paddy cultivation area in Punjab. Amongst basmati variety, basmati 1121 is the preferred choice for farmers.

67 percent of domesticated cattle in Punjab are crossbred Holstein, 8 percent are non-descript and 2 percent are Sahiwal. 93 percent of the buffalo in Punjab are Murrah and 3.6 percent are non-descript buffalo. Only 3 local breeds of sheep, 2 of goat, one of horse and 2 of poultry are reared.

Source: Punjab Biodiversity Board, PQARS 2021, MAHSD 2023.

GENETIC RESOURCE CONSERVATION FOR SAFEGUARDING FUTURE OPTIONS (PILLAR 3)

The systematic collection and conservation of germplasm is being carried out by country's National Bureaus supported by National Agricultural Research System (NARS) - one of the largest agriculture research systems in the world. In TE 24, the support for agriculture research amounted to INR 89 billion. As on 31st March, 2023, National Bureau of Plant Genetic Resources (NBPGR) holds a total of 4,67,315 accessions (seed genebank, -18^0C) of major crops/crop groups. This includes 5,034 released varieties and 1,762 conserved crop species. In addition, it maintains in vitro genebank ($25\ ^0$ C) of different fruits, tuber crops, and other crop groups totaling 1,985 numbers and cryogenebank (-196^0C) holding 14,984 collection s. National Bureau of Animal Genetic Resources (NBAGR) has registered 212 indigenous breeds and maintains semen of 64 animal breeds. The National Bureau of Agricultural Insect Resources (NBAIR) is one of the largest live insect repositories in Asia and maintains (ex-situ) 136 live insects, entomopathogenic organisms such as *Bacillus thuringiensis* and in situ conservation of 33 different species of bees. National Bureau of Agriculturally Important Micro-organisms (NBAIM) maintains *(in situ*) 7,866 micro-organisms that includes cyanobacteria, bacteria, and fungi. With changing climate, increasing weather uncertainties, more pest attacks, stagnant crop yields etc. these germplasms can offer possible solutions for future unseen problems.

CONCLUSIONS AND WAY FORWARD

Agriculture subsidies can impact negatively on biodiversity, directly (e.g. when diverse cropping pattern is converted to mono-cropping) and indirectly (e.g. climate change, which then impact biodiversity). Impacts can be immediate (e.g. land change, crop change, biomass burning), arise over time (e.g. pollution, eutrophication, leaching etc.) and sometimes can be felt acutely by future generations (e.g. climate change). Overall net impacts may be less clearly negative where the incentive creates both positive and negative impacts (e.g. food subsidy achieving food security objectives but encouraging mono-cropping of wheat-rice cultivation through assured procurement of MSP).

Instead of further incentivizing biodiversity harmful subsidies, India should assess options to repurpose subsidy policies to neutralize their effects on biodiversity which is also critical to the resource mobilization needed to implement the GBF.

- These incentives are currently "inequitable." Rice receives the highest share per hectare amongst crops due to high electricity, water, and fertilizer use. Amongst fertilizer products, urea receives the highest subsidy. These incentives need to be "crop-neutral" and "input neutral".
- Centre government subsidizes price input for fertilizer and State government subsidizes price input for power and canal water. Shift from price input to direct cash transfer on per hectare basis should be jointly implemented by Centre and State government. This will not only encourage crop diversification but will also empower farmers.
- Under PMGKY, the procured food grains are distributed through fair price shops (FPS) in India, which are 5.38 lakh in number (NFSA Portal). These are operated by 2.95 lakh individuals, 83K co-operatives, 9.7K Panchayat, 26K Self-Help Groups and 92K other FPS. To increase the consumption diversity from wheat-rice to other nutritious crops – biofortified rice and wheat, millets, pulses, edible oils, soybean products, fortified milk, eggs etc – these FPS needs to be upgraded. At least 10 percent of these fair price shops may be declared as nutrition food hubs containing diversified food basket, from which the consumers can chose using electronic vouchers, similar to e-food coupons in a food court (Gulati 2023).
- Agro-biodiversity services need to be valued and mechanisms for green-credits or biodiversity credits need to be developed so that producers can get incentives for opting for crops and practices that favour agro-biodiversity.

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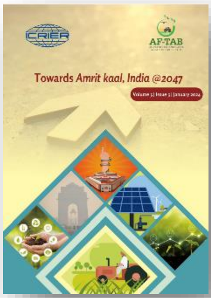

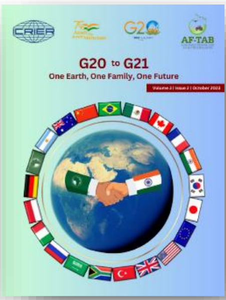

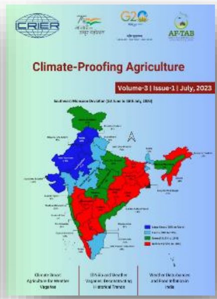

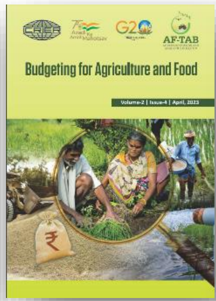

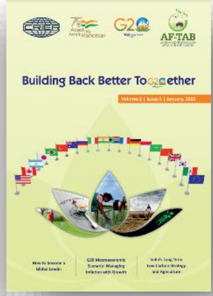

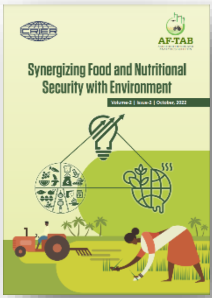

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