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Review of Rural Affairs

Five papers historically, conceptually, and empirically analyse the role of science and technology in increasing food production in India and positioning Indian agriculture in the era of climate change, and respond to some of the critical questions raised in the contentious literature on agricultural technology, productivity and environment. pages 30–79

M S Swaminathan (1925–2023)

Swaminathan brought the focus on nutrition security by consistently calling to move from food security to "food and nutrition security" for a productive and healthy life. page 21

Nutrition Security and G21

Access to nutritious food alone cannot address the multidimensional problem of undernutrition in these regions but requires a multisectoral solution. page 10

IT Rules and Censorship

The Information Technology Amendment Rules of 2023 violate the guarantee of freedom of speech by granting the union government complete authority over the truth "in respect of any business" related to itself. page 19

Economic&PoliticalWEEKLY

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Cinema of Uttarakhand

While Uttarakhand was originally founded with ecological considerations in mind, progress in this regard has been lacking. The recent floods serve as a stark reminder of the urgent need for sustainable development in the region. It is reported that in Joshimath, a town in Uttarakhand, residents have raised concerns about the sound of powerful water currents beneath their homes, shedding light on the potential consequences of large-scale projects that often disregard ecological issues. One significant cause of this situation is unsustainable tourism, which has resulted in environmental degradation, resource depletion, the commercialisation of hill areas, and community displacement in Uttarakhand. These factors have collectively put immense strain on the delicate ecological balance of the region.

Uttarakhand, a cherished tourist hotspot, has consistently been favoured as a cinematic backdrop, highlighting the role of film-induced tourism in the state's tourism sector. The connection between cinema and Uttarakhand dates back to the 1950s. Uttarakhand has been a favourite film location for many acclaimed film-makers, gracing the silver screen in at least over 50 films, including several blockbusters, owing to its breathtaking scenery. Key filming sites in Uttarakhand include the Forest Research Institute and the Military Academy in Dehradun, along with sites in Mussoorie and Nainital. Uttarakhand received recognition as the best film-friendly state at the National Awards in 2019, and it garnered a special mention for its film-friendly environment from the Government of India in 2017. Film tourism thrives in Uttarakhand, and the state government actively supports it as a significant revenue source. There are plans underway to establish a film city in Uttarakhand, further underscoring the government's commitment to this sector.

However, these cinematic representations frequently perpetuate stereotypical portrayals of the region's picturesque landscapes, mountain lifestyle, and Himalayan culture, often relegated to mere scenic backdrops. This can potentially lead to a growing influx of tourists primarily attracted to the area for its visual allure, lacking a profound appreciation for its ecological or cultural concerns.

However, serving as a film location provides limited tangible contributions to the overall development of Uttarakhand. Frequently, these locales assume a nondescript role in films, particularly during song sequences, where they serve primarily as aesthetic spectacles or artistic backgrounds. Furthermore, the concept of "sight" in cinema offers a malleable canvas for arbitrary interpretations and meanings, susceptible to manipulation or augmentation by both creators and viewers. For example, the movie *Kashmir Files* was predominantly filmed in Mussoorie and Dehradun, yet the narrative unfolds in Kashmir. It is important to recognise that the cultural essence and fundamental character of Uttarakhand transcend its geographical attributes.

Despite its scenic beauty and popularity as a film location, it is unfortunate that Uttarakhand has not established its own film industry. This is where the requirement of a regional industry is significant. The potential advantages of nurturing regional film-making are numerous, as it can give rise to a cinema of Uttarakhand that authentically addresses the state's unique cultural and ecological concerns. This approach transcends the mere portrayal of the landscape as a spectacle and enables the state to amplify its genuine identity. To realise this vision, the state should not only promote film tourism but also actively encourage regional film-making that authentically represents the people and culture of Uttarakhand.

Rahul Rawat, the director of the short film *Sunpat* (2021), emphasises the importance of cultivating a vibrant cinema culture within the state. He argues that cinema can contribute to cultural preservation, boost tourism, raise social awareness, foster community engagement, and promote overall economic development in Uttarakhand. Rawat calls upon the people of Uttarakhand and cinema enthusiasts to actively support and encourage the creative talents emerging from the state.

Thus, establishing an independent film industry that reflects Uttarakhand's culture, heritage, and values is advisable to genuinely support the state's sustainable growth. This initiative has the potential to not only foster sustainable development but also enrich the state's cultural and economic well-being, transcending its scenic beauty.

Vidya Sasikumar
BENGALURU

An Incomplete Account of Russia's War on Ukraine

Anuradha M Chenoy's account of Russia's war on Ukraine (*EPW*, 9 September 2023) is a strikingly incomplete jumble of tendentious pro-Russian talking points masquerading as a representative overview of the position.

The central error Chenoy makes is to deny Russia and Ukraine political and ethical agency. Chenoy never asks what the Ukrainian people want. The author could claim that her wishes are irrelevant—to Chenoy, after Euromaidan, Ukraine became "a bastion of permanent hostility towards Moscow" (p 24). That elision is only tenable by ignoring the subsequent victory of Volodymyr Zelenskyy, a Russian-speaking moderate who advocated negotiations with Moscow, over the far more Europhile Petro Poroshenko—a proof of survival of competitive electoral democracy in Ukraine, in contrast to Russia. Similarly, Chenoy ignores earlier Russian freedom of action. Once, most Ukrainians probably were happy to live in a strategically neutral state, economically integrated both with Russia and the European Union (EU). The first polls indicating a wish to join the North Atlantic Treaty Organization occur only after the Russian military intervention in February 2014. That intervention and earlier pressure on Viktor Yanukovych to halt economic integration with the EU were mistakes that the Kremlin need not have made.

That denial of Russian and Ukrainian agency also leads Chenoy to write of a "proxy war" (p 24) waged by "global elites" with "little concern" (p 25) for the Ukrainian people. Of course, Western assistance makes a difference. But Western powers in early 2022 were offering evacuations and debating how to assist a government in exile. They were quite prepared to see Ukraine collapse, and would not sacrifice their own citizens in a war against Russia. The explanatory lacuna is filled by what Chenoy steadfastly refuses to acknowledge—the resolve of the Ukrainian people to defend their national sovereignty.

Chenoy's approach is also methodologically deficient; she baldly makes a number of misleading assertions without evidence or analysis. First, Vladimir Putin cannot seriously regard the use of depleted uranium shells as "bordering on using fissile material" (p 24) when Russia produces such munitions itself. Second, the direct attack on Kyiv in the early weeks of the war suggests that Russia did not merely seek to "enforce" a neutral status on an unwilling Ukraine but to subordinate it as a colony—as we see in Russian-controlled Ukraine. Chenoy also never asks herself whether a nuclear-armed power really needs colonial "buffer states" for its own security, or what Western excesses such a principle would legitimise. Third, and perhaps the most bizarre, is the direct appeal to Putin's word, after studious attempts to appear neutral—the West, of course, was to blame for sabotaging peace negotiations, "as stated by Putin" (p 25). Well, as Putin also wrote (in 2021), when "some part of a people … become[s] aware of itself as a separate nation," others should respond "only … with respect!"

J P Loo
OXON

Corrigendum

In the article "Meitei Majoritarian Politics of the BJP in Manipur" by Amom Malemnganba Singh (*EPW*, 7 January 2023), "in coalition with" on p 10 should have read as "is supported by."

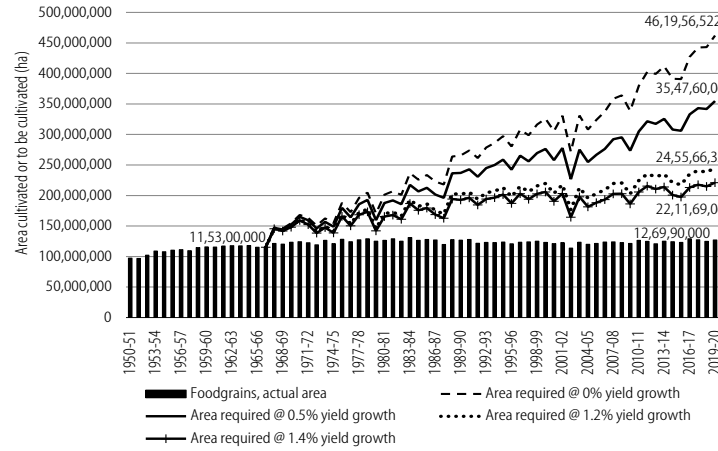
The error has been corrected on the *EPW* website.

Errata

In the paper "Decelerating Farmers' Incomes: New Evidence from SAS Data and Ways Forward" by A Narayanamoorthy and Chandra S Nuthalapati (*EPW*, 21 October 2023), the following reference should have been removed: "Nuthalapati, Chandra S, A Narayanan, A Mulla, and R Sharma (2022): "Direct Procurement and Vegetable Growers Wellbeing in the Pandemic: Panel Data Evidence from India," Mimeo, Institute of Economic Growth, New Delhi."

In the current paper "Public Agricultural Science and Yield Barriers in Foodgrains: A Long View on the Indian Experience" by R Ramakumar (*EPW*, 28 October 2023), Figure 2 should have been as follows:

Figure 2: Projections of Cultivated Area Required to Maintain Actual Levels of Foodgrain Production at Varying Growth Rates of Yield after 1965–66, India, 1950–51 to 2019–20



The errors have been corrected on the *EPW* website.

The errors are regretted—Ed.

Note: Clearer and coloured figures in the paper "Public Agricultural Science and Yield Barriers in Foodgrains: A Long View on the Indian Experience" by R Ramakumar (*EPW*, 28 October 2023), are available in the online version.

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Need for an Immediate Ceasefire in Gaza

An unconditional establishment of peace must proceed further towards ensuring justice.

The intransigence by the political leadership in Israel has seemingly plunged the Gaza Strip into a humanitarian catastrophe. Although the oppression faced by the Palestinian people is by no means new, civil society in several countries across Europe, South Asia, North America, and West Asia rose in protest in one of the largest anti-war mobilisations witnessed in recent times following the bombing of the Al-Ahli Arab Hospital in Gaza City on 17 October.

A lot of misinformation was spread in the wake of this hospital bombing, where scores of healthcare professionals and patients, including many children, lost their lives. The Israeli leadership claimed this bombing to be the doing of Hamas, despite media reports stating that several hospitals in Gaza had received warnings of evacuation from the Israeli military. On 19 October, the ancient Greek Orthodox Church, which is the oldest functioning church in Gaza, was also reportedly bombed by Israel, citing pretexts that it had become a Hamas control centre. This church in Gaza City was sheltering hundreds of displaced Palestinians, including many Palestinian Christians, who sought temporary refuge there after several residential blocks in Gaza City had already been flattened by Israeli air strikes. Palestinian authorities claim that more than 5,000 people have been killed in the Gaza Strip, including more than 2,000 children, and another 14,000 injured in this new round of hostilities.

It is difficult to imagine the humanitarian costs already incurred by this ongoing offensive. Despite the calls for immediate ceasefire raised by international organisations, several nation states and multiple protest demonstrations around the world, particularly in West Asia and North Africa, Israel's military actions in the Gaza Strip and the West Bank have been nothing short of relentless. On top of that, Israel has drastically curtailed the provision of basic amenities like fuel, electricity, water, food, and other forms of aid in the Palestinian territories.

Israel has termed this retaliatory action as a response to the horrific 7 October attacks reportedly carried out by Hamas. The borders dividing Israel and Gaza were breached by highly armed Hamas militants early on 7 October, which marked a major Jewish holiday, allowing them to infiltrate southern Israel. Israeli officials claim that at least 1,400 persons were killed, the majority of whom were civilians, including children.

Notably, targeting civilians is forbidden by international humanitarian law, and it is a war crime to deliberately target and kill civilians. In an armed conflict, abuses and violations by one side do not excuse abuses and violations by another, notably when it comes to targeting civilians. Both Hamas, which also constitutes the elected government in Gaza since 2007, and the Israeli government are guilty of war crimes.

In this regard, the statement of António Guterres, the United Nations (UN) Secretary General, is noteworthy. Guterres was caught in considerable controversy over his statement that "it is important to also recognize [that] the attacks by Hamas did not happen in a vacuum." While the Israeli envoy to the UN has termed these remarks as "shocking" and as justificatory of Hamas's terrorism, Guterres also pointed out that "the grievances of the Palestinian people cannot justify the appalling attacks by Hamas."

Much of the opposition to what Guterres termed the "collective punishment of the Palestinian people" is emerging from Israel itself, where the government led by Benjamin Netanyahu has become even more unpopular following the 7 October attacks, with many Israeli citizens blaming Netanyahu for the uptick in Hamas's militancy and the consequent loss of Israeli and Palestinian lives this month. Demonstrations against the Netanyahu government and calls for the immediate release of all hostages held captive by Hamas only show the domestic instability of Israeli politics as being at least partially responsible for the catastrophic situation in the last few weeks.

Such domestic instability in Israel has also impacted the politics of neighbouring countries in West Asia. Countries in the region, which are habitual trade partners of Israel, are also facing the heat of local popular pressure as calls to stop trade with Israel gain momentum. Countries like Saudi Arabia, Qatar, and Turkey, which were normalising ties with Israel or were on the brink of normalisation, have been forced to revisit their priorities. Meanwhile, the United States, United Kingdom, and France have expressed their unconditional support to Israel in its fight against Hamas. However, these countries too are facing intensifying demands for an immediate ceasefire, which is evident in the massive demonstrations held across these countries, and in some instances, even defying official prohibitions.

Another noteworthy aspect is the significant participation of the Jewish community in these protests as they are categorically distancing themselves from the Zionist political project and asserting its marked distinction from Judaism as a religion. The cavalier and convenient tactic to term any criticism of the Israeli state's actions as "antisemitic" appears vacuous in the face of these conscientious acts by the Jewish community worldwide.

India too pledged its support to Israel in its fight against terrorism. However, the Ministry of External Affairs released a statement clarifying that "India has always advocated the resumption of direct negotiations towards establishing a sovereign, independent, and viable State of Palestine living within secure and recognized borders, side by side at peace with Israel." It is also remarkable that India sent humanitarian aid of medical supplies and disaster relief material for the beleaguered residents of Gaza via Egypt on 22 October, after the Prime Minister spoke with the Palestinian president to express condolences over the deaths of civilians at the Al-Ahli Arab Hospital in Gaza City.

There are reports now that Israel is preparing for a ground invasion of Gaza. It is imperative to recognise that an immediate ceasefire by Israel and an earnest declaration of negotiations with Palestinian authorities, along with fresh elections in Gaza, would likely be the first step towards ensuring peace and justice in the region. The dehumanising rhetoric employed by the Israeli political leadership, even to the extent of terming their enemies as "human animals," along with threats of a ground invasion, does not bode well for any possibility of peaceful and just relations with the Palestinian people.

The Supreme Court's Marriage Equality Verdict

The Court has now placed the responsibility of enacting marriage equality on the legislature.

Saptarshi Mandal writes:

The high courts and the Supreme Court of India have historically refused to exercise their constitutional authority to intervene in family law. The verdict of the Supreme Court in the case, *Supriyo Chakraborty v Union of India*, delivered on 17 October 2023, where it rejected the petitioner's case for legal recognition of same-sex marriage, is consistent with that history. The courts have, in the past, repeatedly declined to scrutinise sex- and religion-based distinctions within personal law by the argument that these laws derived their authority from religion rather than the state and, hence, were outside the scope of judicial scrutiny. Even a basic account of the evolution of personal laws in India does not bear out such a claim. Every aspect of the personal law system bears the imprimatur of the state.

Nonetheless, by following this refrain right from the 1950s, the courts made sure that the power to change the laws governing the family remained the exclusive prerogative of the state. The state alone could decide when to change the laws, for what reason, and to what effect. An aggrieved citizen could not trigger the process by taking the state to Court.

In *Supriyo Chakraborty v Union of India*, the Court has stuck to that position. The five-judge bench has been unanimous in concluding that there is no constitutional right to marry for which queer citizens could approach the courts. It is for the state to decide whether marriage and the associated benefits should be made available to those in non-heterosexual relationships. Thus, citizens have the right to exercise freedom within the framework currently provided by the state, that is, freedom to access heterosexual marriage under different laws, but they do not have the right to demand that the state expand the range of available options by recognising same-sex marriage or civil unions as well. And what if the currently available options are discriminatory?

In 2017, in the triple talaq verdict, the Court had signalled a new direction in its attitude towards constitutional scrutiny of family laws. The majority in that case had held that while an uncodified law such as the Muslim personal law was immune from constitutional challenge, laws enacted by Parliament could be scrutinised for violation of fundamental rights. In this case, however, the judges rejected the petitioners' argument that the Special Marriage Act (SMA), 1954 was discriminatory for excluding non-heterosexual relationships, with a cursory (and incorrect) analysis, thereby making it clear that it was not willing to upset the status quo.

To repeat a point that was made above, the attitude of the Court towards constitutional rights arguments in this case is not a departure from some earlier period of radically progressive jurisprudence. The Court has always been deferential to the state in this area of law and has refrained from striking down discriminatory laws even when it has had much stronger justifications to do so than in this case. And if it did not do so earlier, there was no reason to expect the Court to adopt a different position in this case where the scale of the likely disruption was much bigger. Admittedly, in some instances (such as the ones noted below), judicial restraint has been justified and necessary. But in others, it has been self-imposed.

The general attitude of passivity notwithstanding, there is one aspect of the verdict that must be highlighted. It is that although the Court rejected a set of key equality rights, its verdict is not motivated by prejudice towards queer people. Thus, the judges turned down the petitioner's plea to interpret the SMA in a gender-neutral manner, not because they thought that marriage was only acceptable between a man and a woman, but because doing so would have amounted to judicial legislation and would have clashed with other laws to which the SMA is linked. Similarly, the majority refused to grant the right to adopt, not because they thought that the LGBTQ+ people were unfit to be parents, but because such a right could not be secured only by tweaking the Juvenile Justice (Care and Protection of Children) Act, 2015 when adoption had consequences in maintenance and succession laws as well.

In fact, the text of the judgment bears ample evidence of the judges' empathy for the petitioners, their feelings of being excluded and discriminated against, as well as the practical difficulties that queer couples face in the absence of legal status. It is this

empathy that leads the judges to urge the state to remedy the unjustified exclusion of queer people from marriage, parenthood, and other associated benefits. The observation that the state cannot reframe the adoption regulations to directly or indirectly discriminate on the basis of sexual orientation is particularly relevant given that the National Commission for Protection of Child Rights had opposed the plea for marriage equality on the ground that it was going to be detrimental to children's welfare and the argument is likely to be made in the future as well. In sum, although the verdict was along expected lines given the Court's history, these observations by the judges are a gain and a resource for future advocacy to draw on and, hence, must not be dismissed as "mere platitudes."

Saptarshi Mandal (*saptarshi@jgu.edu.in*) teaches at the Jindal Global Law School, O P Jindal Global University, Sonipat.

FROM 25 YEARS AGO

ECONOMIC AND POLITICAL WEEKLY

VOL XXXIII, NO 45 NOVEMBER 7, 1998

Reflections on Amartya Sen's Prize

Pranab Bardhan

Sen has challenged the basic utilitarian approach of mainstream economics, and in going beyond, he has also found the alternative approaches of Nozickian entitlement theory, Rawlsian focus on primary goods, or the Dworkian approach of equality of resources, deficient, and instead he focuses on freedom and capabilities. To him poverty is capability deprivation (in terms of some of the basic functionings in life), and development is expansion of freedom (which, of course, includes the removal of poverty as well as tyranny). He has developed measures of poverty and inequality that are sensitive to these broader issues. In a major forthcoming book, entitled *Development as Freedom*, collecting some of his earlier results and drawing upon new work, he contrasts the focus on human freedoms with the narrower concentration of the development literature on economic growth, or marketisation, or industrialisation, or technological advance. […]

Kenneth Arrow and Amartya Sen are the two giants of modern welfare economics. Arrow showed the impossibility of getting an aggregation of individual preferences into social choice based on a particular informational structure and a particular set of regularity and reasonableness requirements. Sen provided a positive way out of the impasse by breaking through the informational restrictions that traditional welfare economics had imposed on itself, by using richer utility and non-utility information, allowing for interpersonal comparison of well-being, partial ordering of social states, and considerations like rights and liberty. One of his classic papers, 'The Impossibility of a Paretian Liberal', departed from traditional formulations of welfare economics in making room for rights and identified a conflict even with the mildest of the welfare-economic principles, viz, the weak Pareto principle. Predictably this gave rise to a very large literature in the theory of social choice and political philosophy.

Sen has also questioned the basic postulates of rational choice in economics, based as they are on an oversimple view of human motivation and conduct, and focused on values that influence people's attitude to action rather than on its final outcome *per se*. In the context of poverty and deprivation he emphasises the ambiguity of interest perception (by the oppressed woman or the helpless sharecropper): the most blatant forms of inequalities and exploitation, as he has repeatedly pointed out (and formalised in his concept of well-being and capabilities), survive in the world through making allies out of the deprived and the exploited. Thus in his work on intra-family allocations and distributions, he not merely introduces a mixed game of conflict and congruence of interests (as in his early work on labour allocation in a production co-operative), but cautions about the rigid format of the 'bargaining problem' mis-specifying the nature of perception of those interests. Similarly, in discussing the problem of population control he goes against the grain of the neo-Malthusians in emphasising women's agency, literacy, and economic opportunity.

FROM 50 YEARS AGO

ECONOMIC AND POLITICAL WEEKLY

VOL VIII, NO 44 NOVEMBER 3, 1973

The Satyashodhak Samaj and Peasant Agitation

Gail Omvedt

There is no denying that, given the substantial amounts of inequality in landholding throughout the colonial period, a stratum of 'rich peasants' among non-Brahmans did exist. It is also true that this stratum, along with the educated class of non-Brahmans and some merchants, provided the basis of support for the non-Brahman political party (which must be distinguished from the movement as a whole) — something that was inevitable given the narrow electorate and conditions of parliamentary democracy. It is similarly true that important tensions existed between caste Hindu non-Brahmans and untouchables, particularly in the villages; although, for a time, the non-Brahman movement did "make common cause with untouchables". (The truth was not so much that the movements drew apart as that the non-Brahman movement *per se* — particularly the Satyashodhak Samaj — died away after 1930 as its leaders joined the Congress, while the untouchable drive gathered momentum and retained its radical, separatist impulse. Part of the reason for this was that the wealthier among non-Brahmans lost their need to retain significant social radicalism as they managed to consolidate their power within the framework of the Congress party.) Finally, the Maharashtrian class structure today appears to present a clear case of dominance of a consolidated rich peasant class in fairly comfortable coexistence with the intelligentsia and urban capitalists.

But it would be a mistake to analyse this historical process in oversimplified terms. It is erroneous to read back the present structures of class dominance into the early twentieth century. In the nineteenth and early twentieth centuries, the 'rich peasants' did not represent a consolidated class with interests in conflict with those of agricultural tenants and poor peasants. […] Again, while the non-Brahman Party did represent rural elite interests in the Legislative Council and the Local Boards, it also provided a basically democratic thrust that was in the interest of all non-Brahmans and maintained a fair degree of alliance with untouchables in the 1920s. To assert that the present class-elite structures were the determining features of the earlier movement is to take a technological view of history. The position taken here is to the contrary: that the non-Brahman movement as a whole was a mass movement, that it failed in terms of its full goals, and that the consolidation of a rural elite which tended to monopolise the gains of the movement occurred primarily after its failure and as a result of the inability of the movement to overcome the basic structures of the colonial situation itself.

India–Africa in G21
The Challenge of Nutrition Security

ASHOK GULATI, SHYMA JOSE

The inclusion of the African Union under India's G20 presidency has brought the challenges of the global South to the forefront. India and Africa confront quite similar challenges, including persistent poverty, high population growth and widespread undernourishment. The article explores India's experience in achieving zero hunger and ending all forms of malnutrition by 2030 to facilitate south-south learning on this complex issue. It finds that access to nutritious food alone cannot address the multidimensional problem of undernutrition in these regions but this requires a multisectoral solution. Investing in women's higher education and nutritional status can contribute substantially to bringing down malnutrition among children.

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One of the hallmarks of India's Group of Twenty (G20) presidency is the inclusion of the African Union as a permanent member of the G20. The group may now be called G21. By bringing in the African Union in G21, India has ensured that the voice of global South is put firmly upfront. The African Union comprises 55 countries and 1.4 billion people on this planet. Now the new G21 will represent 84% of the global population, bringing it closer to the motto of "One Earth, One Family, One Future."

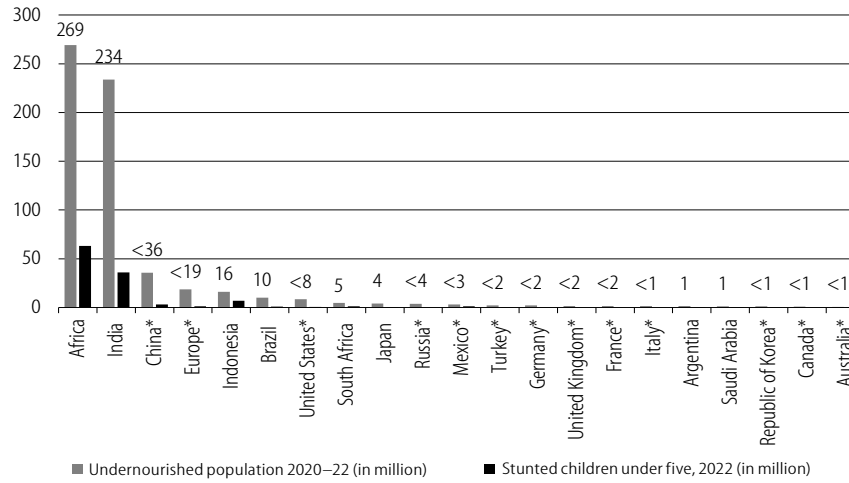
India and Africa within the G21 face similar challenges. They both have low per capita income, persistent poverty, and widespread undernourishment, which gets acute with relatively high rates of population growth. Moreover, their economic structure, sectoral composition, and internal heterogeneity, etc, can make the comparison between India and Africa an interesting study for mutual south-south learning.

India and Africa together constitute around 36% of the global population. By 2050, the population of Africa will account for more than one-fourth of the world population (UN 2022). Just as in India, so in sub-Saharan Africa comprising 48 countries, a large segment of the population (around 424 million) lived in extreme poverty in 2019. That is, about three-quarters of the world's poor live in Africa and India together (Aguilar et al 2022).

Achieving the Sustainable Development Goal (SDG) 2 of zero hunger and SDG 3 of ensuring healthy lives and promoting the well-being of all by 2030 are big challenges for both India and Africa. As per the latest report on *The State of Food Security and Nutrition in the World* (2023), about 69.4% (503 million out of 725.1 million) of the world's undernourished people were in India and Africa in 2020–22 (FAO et al 2023) (Figure 1).

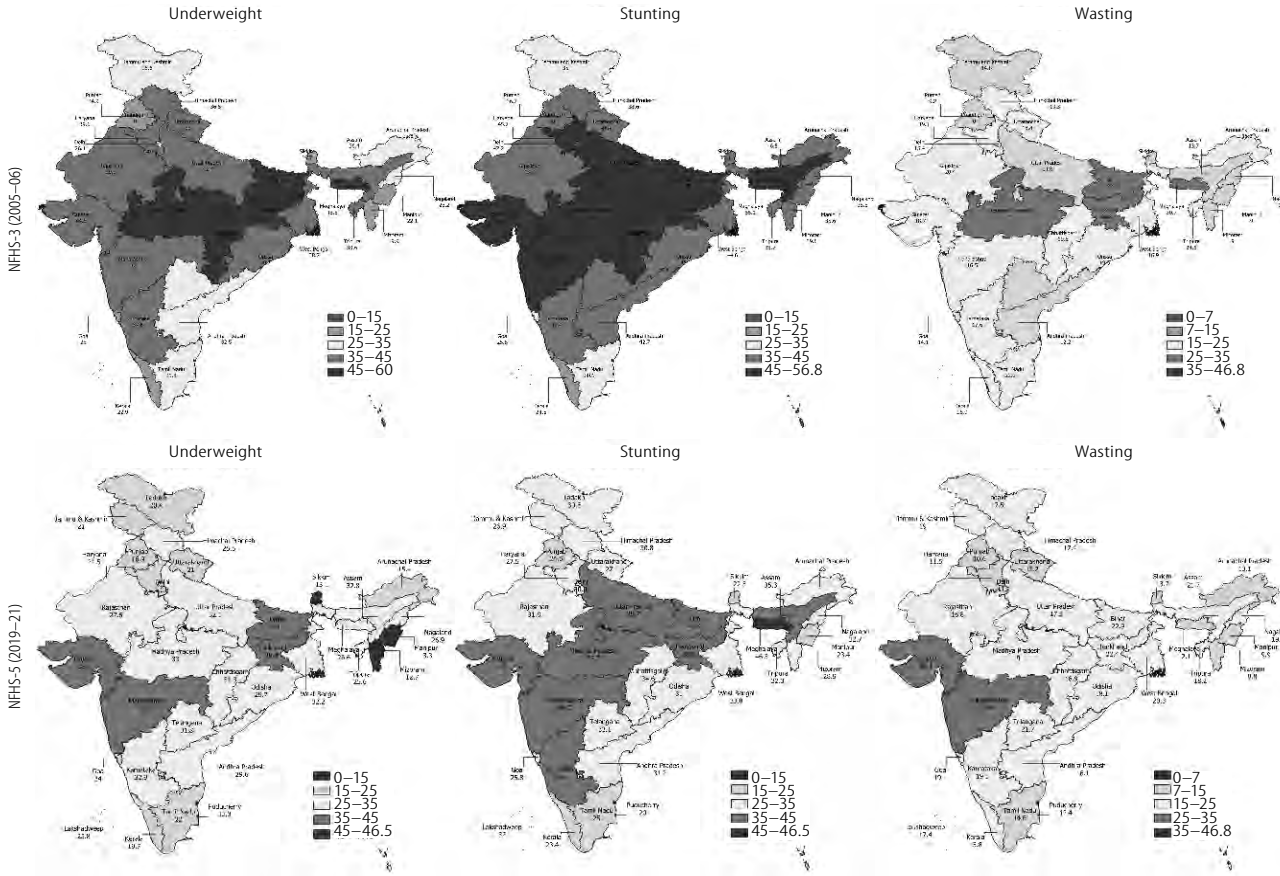
As a proportion of their own populations, the prevalence of undernourishment was about 16.6% and 19.3% in India and Africa, respectively during 2020–22. However, within Africa, sub-Saharan Africa reported a higher prevalence of 22.1% of its total population being undernourished. In comparison, other emerging economies of G21 had a much lower percentage of their respective populations as malnourished. For example, China had 2.5%, Brazil 4.7%, Indonesia 5.9%, and South Africa 7.9% (FAO et al 2023). Unfortunately, India and

Figure 1: Number of Undernourished Population and Stunted Children under Five among G21 Members



* Estimated using UN (2022). Countries have <2.5% of their population as undernourished. Data for stunted children not reported for France, UK, Canada, Russia, and Italy.
Source: FAO et al (2023).

Figure 2: Statewise Comparison of Nutritional Status of Children, 2005–06 to 2019–21



Maps illustration by Rahul Arora using QGIS. The map is only for representational purposes and does not, in any way, indicate the national boundaries.
Source: NFHS-3 and 5.

Africa are also home to 67.0% of the world's stunted (low height-for-age) and 75.8% of the world's wasted children (low weight-for-height) under five years of age in 2022. However, as a percentage of their own population of children below the age of five, the African continent had 30.0% and India 31.7% as stunted in 2022 according to FAO et al (2023).

In terms of under-five deaths, India and sub-Saharan Africa account for 71.8% (3.6 million) of the world's under-five deaths in 2022. Incidentally, India had the largest number of under-five deaths before Nigeria reported a larger number of deaths in that age group in 2019 (UNICEF 2022).

Africa's and India's commitment to bringing down undernourishment and malnutrition among children has global significance as the two account for the largest chunk of the global numbers. Moreover, the global crises of the COVID-19 pandemic, climate change, and geopolitical conflicts have jeopardised progress made towards achieving the SDGs.

Indicators of Child Nutrition and Mortality

Assessing India's progress in improving nutrition security and mortality rates can help in identifying the factors that need focused interventions. Such analysis may also help in south-south learning on this issue, though more in-depth research needs to be conducted between different countries of the African Union and Indian states, as many countries in the African Union are of the size of one or the other state in India. For example, the most populous state in India, namely Uttar Pradesh, has a population of 236 million (Census projections for 2023) which is higher than the most populous country in sub-Saharan Africa, namely Nigeria with 224 million.

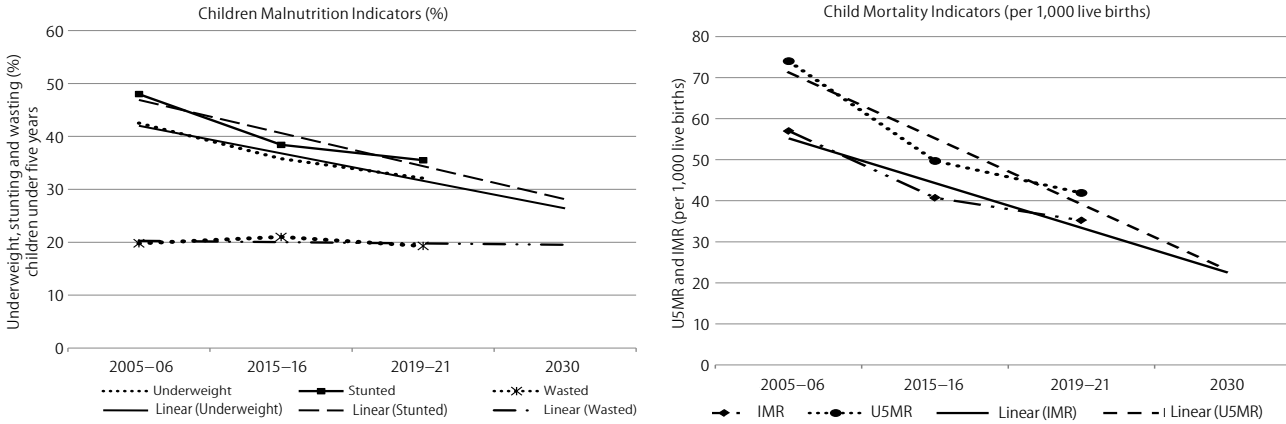
As per the latest National Family Health Survey (NFHS) 2019–21, the nutrition indicators for children under five years of age have improved over the last 15 years. Stunting has reduced from 48.0% to 35.5%, wasting from 19.8% to 19.3% and underweight prevalence from 42.5% to 32.1% during 2005–06 and 2019–21 (Table 1). Several research studies have highlighted a strong correlation between malnutrition and childhood

Table 1: Trends in the Nutrition and Mortality Indicators among Indian Children

Indicators	NFHS-3	NFHS-4	NFHS-5	Per Year Decline (%)		
Children <5yrs	2005–06	2015–16	2019–21	NFHS-3 to 4	NFHS-4 to 5	NFHS-3 to 5
Underweight (%) (Low weight-for-age)	42.5	35.8	32.1	0.61	0.74	0.69
Stunted (%) (Low height-for-age)	48.0	38.4	35.5	0.87	0.58	0.83
Wasted (%) (Low weight-for-height)	19.8	21.0	19.3	-0.11	0.34	0.03
Anaemic (age 6–59 months)	69.4	58.6	67.1	0.98	-1.70	0.15
IMR (deaths per 1,000 live births)	57.0	40.7	35.2	1.48	1.10	1.45

Nutrition indicators for children under five years of age are based on the new WHO reference population.
Source: NFHS-3, 4 and 5.

Figure 3: Projection of SDG Targets Based on Current Trends



Source: Authors' calculation based on NFHS-3, 4 and 5.

mortality indicators. India has made remarkable progress in reducing its infant mortality rate (IMR) from 57 to 35.2 deaths per 1,000 live births during the period from 2005–06 to 2019–21. Yet, despite the progress made in reducing the child mortality rate, malnutrition indicators have not improved as substantially. This distressing situation creates a vicious cycle in which children surviving childhood mortality add to the pool of malnourished children. It is, thus, imperative to lower the level of child mortality even more to effectively combat malnutrition.

Despite reasonable progress in nutritional outcomes at the all-India level, there exists a wide interstate variation across the malnutrition indicators. In many states, more than one-third of children under the age of five are undernourished even today. As per the NFHS-5, more than 35% of children in Assam, Chhattisgarh, Karnataka, Bihar, Jharkhand, Gujarat, Madhya Pradesh, Uttar Pradesh, and Meghalaya were stunted in 2019–21 (Figure 2, p 11).

Over-temporal comparison over the last 15 years shows that states such as Madhya Pradesh, Chhattisgarh, Arunachal Pradesh, Haryana, Meghalaya, and Uttarakhand have performed commendably in reducing stunting and the number of underweight children.

Factors that Impact Malnutrition

The UNICEF's conceptual framework classifies the key determinants of malnutrition as basic, underlying, and immediate factors. A number of studies also lay emphasis on the inclusion of nutritional interventions for addressing immediate and underlying determinants (Black et al 2013; Menon et al 2018). Household food security and access to a nutritious diet capture only one aspect of malnutrition. Adequate care, a healthy household environment, access to healthcare services and socio-economic factors should be given equal priority in combating malnutrition. Therefore, India needs a set of multipronged strategies to tackle the multidimensional problem of undernutrition.

To empirically determine factors impacting malnutrition in India, we use logit regression on the unit-level data for children under the age of five years from NFHS-3 (2005–06), NFHS-4 (2015–16), and NFHS-5 (2019–21). Annexure Table 2 (p 14) presents the logit estimates for all three rounds; however, we will discuss only the NFHS-5 results in this section for brevity.

The dependent variable assumes 0 if the child's anthropometric indicator is more than median -2 SD (no malnutrition) and 1 if the child's anthropometric indicator is less than -2 SD which is measured by underweight (low weight-for-age), stunting (low height-for-age) and wasting (low weight-for-height).

The independent variables used in the logit regression include immediate determinates such as the mother's body mass index (BMI), duration of breastfeeding, and consumption of nutritious food (including green leafy vegetables, fruits, milk, and milk products). The second set of factors is nutrition and healthcare interventions such as the number of antenatal visits during pregnancy, iron folic acid (IFA) supplements taken during pregnancy, and place of delivery, and the underlying factors include mother's education and access to improved sanitation and drinking water sources.

Among all the dependent variables, the association between the mother's education level and the probability of the child being underweight and stunted under five years of age is the strongest and statistically significant. Higher education among women strongly correlates with women's autonomy in decision-making, sanitation and hygiene, and child-caring practice (Jose et al 2020). Children under five years, whose mothers have higher education levels (12 years or more), have lower log odds of being underweight (-0.63), stunted (-0.77) and wasted (-0.27), as compared to those of mothers with education up to the secondary and primary level.

The second most important variable that had a significant impact on child malnutrition indicators is the mother's nutritional status measured by the BMI. The estimates indicate that children whose mothers have a BMI>18.5kg/$m2$ have lower log odds of being underweight (-0.49), stunted (-0.31), and wasted (-0.32).

The third most significant determinant of child malnutrition is the household's access to improved sanitation facilities. We find that the magnitude of the coefficient of different malnutrition indicators decreases with improved sanitation facilities. For every one-unit increase in the improved quality of sanitation (flushed), the log odds of being underweight (stunted) declined by -0.32 (-0.30), whereas the log odds of being wasted declined by -0.17.

The other cause of child malnutrition is the duration of breastfeeding and the

reference category is children who have never been breastfed. The logit regression estimates show a strong negative association between children who are breastfed for the first six months and malnutrition indicators, that is, underweight rates (-0.15) and stunting (-0.34). Children who are exclusively breastfed for the first six months have a lower probability of being malnourished. However, if the child is breastfed for more than 13 months, the coefficients of stunting turn positive, showing that there is a higher probability of being stunted. This is because after six months, when the weaning period starts, the child's diet needs to be supplemented with nutritious and solid food.

The estimates also indicate that the consumption of nutritious food (including green leafy vegetables, fruits, milk, and milk products) has a significant impact on reducing the probability of being wasted (-0.10). Across nutritional and healthcare interventions, higher coverage of antenatal care (ANC), measured by the number of ANC visits, has a negative and statistically significant relationship with stunting and underweight rates. The higher the number of ANC visits, the higher the decline in child undernutrition rates. Women with more than 10 ANC visits have the lowest chances of giving birth to underweight children (-0.21).

The regression estimates show that IFA supplements taken during pregnancy by the mothers reduce the probability of stunting (-0.04) among children. Another variable which impacts child undernutrition is the place of delivery. We find that delivery at a healthcare facility (government or private), as compared to delivery at home lowers the log odds of being underweight (-0.16), stunted (-0.21) and wasted (-0.12). The improved source of drinking water, such as piped connection within the premises has a significant impact on reducing the probability of being underweight (-0.06).

Will India be Able to Achieve Nutrition Security by 2030?

With only seven years remaining to the SDG Agenda, business-as-usual projection of the current trends till 2030 helps us identify the areas that require serious intervention. The estimated linear projection of malnutrition indicators for children under five years of age (underweight, stunting and wasting) are expected to lag far behind the SDG targets of 2030 (Figure 3, p 12).

These projections highlight the need for urgent action in order to achieve the SDG targets of reducing stunting and wasting by 2030. Without such measures, these targets are unlikely to be met. Our projections for malnutrition indicators align with the findings of Kharas et al (2018), who predicted that by 2030, India will account for 33% of the world's stunted children and 21% of the world's wasted children.

When considering the linear projection of IMR and under-five mortality rates (per 1,000 live births), it is encouraging to see that a substantial decline can be expected by 2030. Under current trends

What Can the Global South, Especially Africa, Learn from These Results of India's Largest Database and Analysis?

Addressing the challenges of malnutrition in India and Africa necessitates the adoption of a comprehensive approach that integrates multipronged short- and long-term strategies, if SDGs have to be achieved by 2030.

First, our analysis for India highlights that mothers' education, particularly higher education, and her nutrition status are strongly associated with the nutrition parameters of children. Investing in women's higher education can contribute substantially to increase the female labour force participation in the long-term, thereby fostering higher economic growth. Hence, the state governments in India need to promote higher education among women through better targeted scholarship programme. Introducing a scholarship of say ₹500 per month from Class 9 and gradually increase to ₹1,000 until graduation, and then further increasing it to ₹2,000 per month for post-graduation can significantly reduce the dropout rates among female students in secondary and higher education.

Second, the implementation of WASH (water, sanitation, and hygiene) initiative has a substantial impact on nutritional outcomes. The Swachh Bharat Abhiyan, aimed at eliminating open defecation and eradicating manual scavenging, has witnessed remarkable progress. The number of households with access to improved sanitation facility increased from 48.5% to 70% between 2015–16 and 2019–21. Similarly, under the central government's Jal Jeevan Mission (Har Ghar Jal), the coverage of household with drinking water tap connection has significantly expanded to 65.5% of the total rural households as of 4 August 2023 (PIB 2023). However, during NFHS-3 to NFHS-5, the household reporting tapped connection increased meagrely from 24.5% to 32.9%, emphasising still ample work is left. The success of WASH initiatives depends on spreading awareness through comprehensive awareness programmes, empowering Anganwadi workers and community participation to bring about significant behavioural change.

Third, the piecemeal approach of the government's food safety nets, including the mid-day meal scheme, the Anganwadi system under the Integrated Child Development Scheme (ICDS), and subsidised foodgrains through the public distribution system (PDS), seems to have failed in improving the nutritional status of the population. About 800 million Indians still rely on the PDS. In the Union Budget for 2023–24, an allocation of ₹1.97 lakh crore was for food subsidy under the Pradhan Mantri Garib Kalyan Anna Yojana (PMGKAY). The food safety nets, biased in favour of staples, need to shift towards providing a nutritious diet. In this regard, the in-built provision under the National Food Security Act (2013) could be utilised to provide households a choice-based system to opt between subsidised foodgrain or conditional cash transfers. Alternatively, a centralised system could be devised to issue vouchers, which would be inflation-indexed cash entitlements. These vouchers would be distributed through the existing network of PDS outlets, granting beneficiaries autonomy to make choices as per their diet preferences and requirements.

Fourth, scaling up biofortification in staple crops, an innovative and cost-effective technique, can ensure availability of nutritious diets in areas affected by chronic malnutrition in India and Africa. Initiatives like the ArvestPlus programme by the Consultative Group on International Agricultural Research (CGIAR) have made significant strides in developing new varieties of nutrient-rich staple foods in many African countries and India. Such innovations can be implemented on a large-scale in Indian states and African countries to reduce malnutrition on a war footing.

Fifth, the introduction of complementary feeding and a diverse diet has not improved significantly over the last two decades. Saksham Anganwadi and Mission POSHAN 2.0 requires large-scale comprehensive awareness programme and infant and young child feeding guidelines to improve breastfeeding practices and the introduction of nutritious diets during the weaning period. Anganwadi workers and community participation can contribute in ensuring significant improvements in childcare practices and antenatal care for mothers and children through good governance.

These findings need to be shared widely with African nations for cross-learning in global South collaboration. The mutual exchange of best practices can help in designing action-oriented and targeted strategies aimed at eradicating hunger and malnutrition in both India and Africa by 2030.

(business-as-usual), India appears to be on track to achieve the goal of reducing under-five mortality rates by 25 per 1,000 live births by 2030.

NOTES

1 NFHS-5 has a sample of 2,05,641 for underweight, 2,01,276 for stunted and 1,97,314 for wasted children under five years.

2 Improved sanitation facility includes: Flush to piped sewer system, flush to septic tank, flush to pit latrine, flush to do not know where, ventilated improved pit (VIP)/biogas latrine, pit latrine with slab, twin pit/composting toilet, which is not shared with any other household (NFHS-5).

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Annexure

Table 2: Logit Estimates for Children Below Five Years of Age using Unit-level Data of NFHS 2019–21, 2015–16 and 2005–06

Variables	NFHS-5			NFHS-4			NFHS-3			Remarks
	Underweight	Stunting	Wasting	Underweight	Stunting	Wasting	Underweight	Stunting	Wasting	
Mothers' education status (Ref: no education)										
Primary	-0.09 ***	-0.11 ***	-0.15 ***	-0.16 ***	-0.15 ***	-0.03 *	-0.14 ***	-0.11 ***	-0.03	Most impactful variable for all three rounds
Secondary	-0.32 ***	-0.36 ***	-0.16 ***	-0.31 ***	-0.37 ***	0.01	-0.26 ***	-0.28 ***	-0.10 ***	
Higher	-0.63 ***	-0.77 ***	-0.27 ***	-0.64 ***	-0.67 ***	-0.04 *	-0.64 ***	-0.68 ***	-0.07	
Mother's BMI (Reference: BMI lower than 18.5)										
BMI >18.5	-0.49 ***	-0.31 ***	-0.32 ***	-0.51 ***	-0.22 ***	-0.39 ***	-0.45 ***	-0.17 ***	-0.44 ***	
Sanitation (Ref: no toilet)										Subsumed in wealth index in NFHS 3 and 4
Improved toilets	-0.32 **	-0.30 ***	-0.17 ***							
Not improved source (pit latrine)	-0.19 **	-0.19 ***	-0.07 ***							
Wealth index (Ref: poorest) #				-0.18 ***	-0.10 ***	-0.10 ***	-0.19 ***	-0.13 ***	-0.12 ***	Proxy for household assets including sanitation and drinking water
Poorer				-0.36 ***	-0.23 ***	-0.18 ***	-0.40 ***	-0.21 ***	-0.24 ***	
Middle				-0.50 ***	-0.39 ***	-0.19 ***	-0.53 ***	-0.33 ***	-0.32 ***	
Richer				-0.73 ***	-0.59 ***	-0.25 ***	-0.92 ***	-0.70 ***	-0.47 ***	
Richest				-0.18 ***	-0.10 ***	-0.10 ***				
Duration of breastfeeding (Ref: never breastfed)										
0–6 months	-0.15 ***	-0.34 ***	0.01	-0.28 ***	-0.54 ***	-0.28 ***	-0.40 ***	-1.09 ***		
7–12 months	-0.18 ***	-0.22 ***	-0.12 **	-0.15 ***	-0.35 ***	-0.15 ***	-0.07	-0.49 ***		
13 and above months	0.06	0.17 ***	-0.25 ***	0.14 ***	0.24 ***	0.14 ***	0.29 ***	0.24 **		
Consumption of nutritious food * by child (Ref: did not consume)										
Consumed	-0.02		-0.10 ***	-0.16***						
Antenatal visits (Ref: no visits)										
1–4 visits	-0.08 ***		-0.18 ***	-0.04 ***	-0.10 ***		-0.28 ***	-0.15 ***	-0.13 ***	
5–10	-0.13 ***		-0.19 ***	-0.13 ***	-0.27 ***		-0.44 ***	-0.36 ***	-0.25 ***	
10 above	-0.21 ***		-0.38 ***	-0.24 ***	-0.25 ***		-0.73 ***	-0.58 ***	-0.40 ***	
Taken iron folic supplements during pregnancy (Ref: not taken)										
Taken supplements	0.00	-0.04 *	-0.01	-0.03 ***	-0.09 ***					
Place of delivery (Ref: at home)										
Institution (private or govt healthcare facility)	-0.16 ***	-0.21 ***	-0.12 ***	-0.07 ***	-0.04 ***		-0.11 ***	-0.11 ***		
Water facility (Ref: source outside HHD)										Subsumed in wealth index in NFHS-3 and 4
Improved source: piped inside household	-0.06 ***	-0.007	-0.01							
Caste (Ref: scheduled population)										
OBC or others				-0.13 ***	-0.09 ***	-0.11 ***	-0.38 ***	-0.20***	-0.34 ***	
Basic vaccinations **(Ref: not received)										
Received									-0.24 ***	
Constant	0.34 ***	0.37 ***	-0.30	0.58 ***	0.45 ***	-0.82 ***	0.62 ***	0.65 ***	-0.59 ***	
Number of observations	80,183	158,106	76,515	1,60,493	1,60,493	2,16,027	30,249	30,249	27,461	
Pseudo R square	0.02	0.03	0.01	0.06	0.06	0.01	0.09	0.09	0.03	

* Nutritious food includes green leafy vegetables, fruits, milk and milk products, **Basic vaccination includes BCG, measles, and three doses each of DPT and polio vaccine (excluding polio vaccine given at birth). # Wealth Index construction subsumes sanitation and drinking water facility, and hence not taken in NFHS-5 regression analysis due to collinearity. NFHS gives information on the wealth index which is based on assets and housing characteristics.

Source: Authors' calculation based on WHO standards.

Use of Technology in Addressing Disruptions in Education

TANUKA ENDOW, BALWANT S MEHTA

Technology changed the dispensation of education during the COVID-19 pandemic and contributed to maintaining some continuity in learning even for children from marginalised groups such as the Scheduled Caste/Scheduled Tribe communities. Drawing insights from India's experience during the pandemic in Haryana and Jharkhand, the study reveals how technology facilitated educational continuity for such children. It also uncovers associated challenges such as learning loss, digital divides, and infrastructural gaps.

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The COVID-19 pandemic presented unprecedented challenges to education, leading institutions to transition from physical to remote learning. Technology played a pivotal role in countering learning loss and enhancing global and Indian learning outcomes. Various technological tools ensured continual educational access, engagement, and quality. Approximately 320 million Indian students were affected, spurring the shift to online classes with platforms like Zoom, Microsoft Teams, television, and WhatsApp. Initiatives like Swayam Prabha TV, e-Pathshala, and Diksha portal reshaped education (UNESCO 2021). The National Education Policy 2020 emphasised "Equitable and Inclusive Education," addressing disparities, especially for disadvantaged students and females. Studies revealed the pandemic's unequal impact, notably on marginalised groups, and the Indian digital divide was evident with rural–urban and gender disparities (IHD and UNICEF 2021; Roy 2021; Pokhrel and Chhetri 2021; Dash et al 2022). As per the National Family Health Survey (NFHS-5) (2019–21) data, access to the internet in India is notably skewed across gender, rural–urban and social groups. Only one-third of women (33%) have ever accessed the internet, in contrast to over half of men (57%). The digital divide is even more pronounced in rural India, where men are almost twice as likely as women to have utilised the internet (49% versus 25%). Additionally, across social groups, those belonging to Scheduled Castes (SCs) (48%) and Scheduled Tribes (STs) (39%) exhibit considerably lower internet accessibility in comparison to Other Backward Classes (OBCs) (54%) and General Caste (64%). Despite these challenges, the pandemic illuminated transformative learning opportunities for marginalised groups through technology (Behal and Kalia 2023; Dayal S 2023). This article delves into the contribution of technology, citing India-specific examples for vulnerable groups. Lessons learned can inform future efforts to utilise digital technology for widespread education during similar crises like natural disasters and conflicts.

Data and Methodology

This study is based on a primary survey in two states, Haryana and Jharkhand, which were chosen based on development levels—one developed (Haryana) and one relatively backward (Jharkhand). Mixed methods were adopted, that is, both quantitative and qualitative surveys were undertaken among students, parents, teachers, and other stakeholders. Six districts were selected considering concentrations of SC populations in Haryana and ST populations in Jharkhand, also ensuring reasonable SC presence. The chosen districts were Ambala, Rohtak, Palwal in Haryana, and Simdega, Latehar, Godda districts in Jharkhand. The study involved 1,293 households across 36 villages in both states. In Haryana, 645 households were surveyed, comprising 54% SCs and 36% "Others" (including OBCs at 18% and General at 28%). In Jharkhand, 648 households were surveyed, with 55% STs, 11% SCs, and 34% "Others" (including OBCs at 32% and General at 2%). In Haryana, the majority of surveyed schools remained closed due to COVID-19 disruption during April–December 2020 for 11 months, while in Jharkhand, schools experienced closures between 10 and 12 months.

Findings and Discussions

Instruction mode: When asked about the instructional format most teachers utilised during the lockdown, those from Haryana reported that all of them conducted online classes or shared educational videos. In Jharkhand, half of the teachers employed this method, a quarter opted for offline teaching, and the remainder distributed assignments to students via WhatsApp. Thus, online classes emerged as the principal channel for facilitating education during the lockdown.

Dropping out of school: Due to limitations in mobile phone accessibility and internet connectivity, both states witnessed an increase in the proportion of students dropping out of school following the COVID-19 outbreak, as compared to the pre-COVID-19 scenario. This dropout trend was more pronounced among students belonging to STs and SCs compared to "Others," and among girls compared to boys. Particularly for older adolescents (15–16 years), dropout rates were very high at 7%–9% in Haryana and 10%–18% in Jharkhand.

Coping with studies after lockdown: In Haryana, 6.7% students (6–16 years) did not engage in any form of study during the period of school closures. The majority of students (74% of those aged 6–16 years) continued their studies by interacting with teachers or peers through lessons disseminated via WhatsApp. Other study methods included independent learning, studying with assistance from family members, utilising worksheets provided by teachers, self-guided learning through YouTube videos, and engaging with teachers/peers via mobile communication. This underscores the substantial reliance on mobile technology for education continuation.

In Jharkhand, 7.5% of surveyed students did not study during school closures. But here, the role of technology as a coping mechanism was considerably more limited. The practice of "self-study" constituted nearly half (49%) of the responses (Table 1). Other approaches included self-studying with help from parents or other family members, self-guided learning via YouTube videos, interaction with teachers or peers through WhatsApp (where lessons were shared), private tuition, utilising worksheets provided by teachers, and engaging with educators or peers via mobile communication. While some schools organised classes through platforms like Zoom or Google Meet after the lockdown, the primary source of educational content and assignments continued to be WhatsApp. Examinations were administered using Google Sheets.

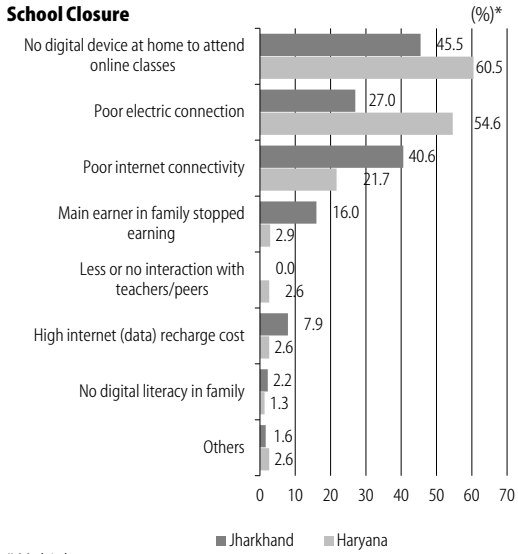
Table 1: Attendance of Online Classes of Children (6–16 Years) by Social Groups in Haryana and Jharkhand

(% of total)

State		Regularly All Classes	Not So Regularly	Not Attended	Total
Haryana	SC	37.5	45.1	17.4	100.0
	Total	41.1	44.6	14.3	100.0
Jharkhand	ST	7.5	18.2	74.3	100.0
	Total	8.1	17.7	74.2	100.0

Source: IHD Primary Survey, 2022.

Figure 1: Reasons for Not Attending as Reported by Students Who Did Not Attend Online Classes after School Closure



* Multiple responses.
Source: Primary Survey.

Reasons for not attending online classes: In Jharkhand, three-fourths of the surveyed children (ages 6–16 years) indicated that they did not participate in online classes. The absence of digital devices was the primary reason behind the majority of responses explaining the students' inability to join online classes. Conversely, in Haryana, the percentage of students unable to attend online classes was notably lower, at around 14%. The reasons for non-participation were mainly limited access to mobile devices, inadequate internet connectivity, absence of electricity, and high mobile recharge costs (Figure 1).

Learning loss amid adversity—A tale of struggle and educational setbacks: The qualitative survey revealed that a significant number of children struggled to recall previous lessons accurately from earlier classes. This struggle encompassed forgetting fundamental mathematical formulas and making errors in writing. All respondents conveyed a noticeable decline in their writing speed following the lockdown, in contrast to their pre-COVID-19 capabilities. Furthermore, a consensus among teachers emerged that the current abilities of students in reading, writing, and mathematics have regressed in comparison to the levels exhibited prior to the COVID-19 outbreak.

While instances of learning loss were observed in both states, the impact appeared particularly severe in Jharkhand. A vivid illustration emerges from Jaldega village in Simdega district, where Pooja, a Class 7 student belonging to the SC, faces significant adversity. Her father's passing when she was just five months old left her mother to single-handedly raise her. The family's status as social outcasts, stemming from an inter-caste marriage, coupled with their lack of land and dependency on Antyodaya Anna Yojana ration card further compounds their challenges. Her mother narrated how her daughter's study halted in the absence of a smartphone:

> I am grappling with the responsibility of ensuring the family's financial stability, engaging in masonry to make ends meet. Pooja's educational journey took a downturn as her school failed to provide online classes, forcing her to rely on her limited collection of books at home for studying. Even during the intermittent periods when her school did reopen while she was in the sixth grade, her attendance remained irregular due to our family's circumstances. Despite the extension of online classes to students in grades 6 to 12, the unaffordability of a smartphone left Pooja unable to participate in this mode of learning. As a result, Pooja found herself in a situation where she effectively stopped studying throughout the entire lockdown period.

Another case study highlights the hunger, financial crisis, and dropping out of school through the experience of an ST girl named Ankita in Jharkhand. She was from Konmerla in Simdega, and a Class 10 student before lockdown. Her father's death in 2011 led her sister to work in Delhi. Lockdown brought her sister home, but her employer withheld wages, causing a financial crisis. As her mother remarried and left, an uncle provided food and cash. Attending a school 4 km away, Ankita and siblings could

not join WhatsApp classes due to lack of smartphones, and stopped school. Turning to agriculture for income, they later sold snacks earning ₹400–₹500 daily. They gathered forest produce on other days. Improved finances allowed them to enrol their younger brother in school again.

In Haryana, there were reported cases of learning loss among children. A Class 8 student from Ambala, belonging to the SC, highlighted the absence of a smartphone within her family during the lockdown. Compounded by the fact that all her siblings attended the same school, the lack of devices resulted in a backlog of assignments. She resorted to using their neighbours' phones for online classes. A poignant example emerges from Rohtak district as Kavita, a Class 8 SC student in a family of eight, had to share a single mobile device with her father and siblings. This dearth of resources caused Kavita to miss out on several classes.

While learning loss was evident in both states, the significantly higher proportion of students attending classes in Haryana, in contrast to Jharkhand, accentuates the significance of technology during disruptive periods like the pandemic. A key factor behind this discrepancy is the more extensive ownership of digital devices in the former state. Nearly 8 out of 10 households owned smartphones in Haryana, compared to 5 out of 10 in Jharkhand. Furthermore, nearly twice the number of households surveyed in Haryana (47%) acquired a digital device compared to Jharkhand (26%) during the pandemic. In addition to device ownership, access to essential public infrastructure, such as stable internet services and uninterrupted electricity supply, emerged as critical prerequisites for sustained online access.

Challenges related to internet connectivity ranked as the most significant hindrance to attending online classes, particularly pronounced in the sampled villages of Jharkhand. Insufficient electricity supply also hindered the charging of mobile phones, thereby obstructing children's participation in online learning. In a village in Simdega district, respondents reported power outages lasting three to four days, disrupting the learning process. Pritam, an SC student in Class 12 from Konmerla village, highlighted the network problems, which required them to climb to higher locations for connectivity. A similar scenario unfolded for a Class 8 student from an ST family in Targa village, Simdega district, where only 7–8 hours of power supply were available each day. Any electrical fault could take up to two weeks to rectify, leading to prolonged disruptions. This issue of delayed power restoration was reported in Godda district as well. Migrant workers' children encountered a unique challenge. Siblings from a Muslim family in Godda district explained that their father's return home during the COVID-19 period allowed them to join the school's WhatsApp group for online learning. However, when their father returned to the city for work, he took away the smartphone, adversely affecting their education.

The problems related to technology-dependent dispensation of education were reflected in the rise in the education-related expenses for most social groups, as parents were compelled to purchase smartphones during school closures. This was exacerbated by schools charging fees during the lockdown, with few exceptions. Those able to acquire devices financed the expenses through personal savings, borrowing, or seeking support from relatives and friends. Instances of rising indebtedness and asset sales (like cattle) due to smartphone purchases during the lockdown were particularly prevalent in Jharkhand.

Another challenge as stated by children was the absence of interaction with teachers and peers. Younger students (6–10 years) were particularly affected by the lack of connection with teachers and peers.

Government's initiatives: The insights gleaned from students in Haryana highlighted the significance of WhatsApp groups established by schools, wherein educators circulated educational videos and assignments. Upon completing these assignments, students captured photos and shared them within the group. A notable aspect of the educational landscape was the administration of weekly tests through the AVSAR app, an application developed by the State Council of Educational Research and Training (SCERT) in Haryana. The state government also distributed tablets to board examination-bound Class 10 and 12 students.

Upon the resumption of in-person classes in Haryana, several schools incorporated smartboards as a means of dispensing education, a strategy that resonated well with the student body. The provision of YouTube videos via WhatsApp groups was also well-received by students, as these videos could be revisited multiple times, thereby facilitating the learning process. One student noted that, previously, taking leave from school would result in a loss of learning, but the flexibility of online classes alleviated this concern, since the videos could be played at their convenience. They also remarked upon the use of vibrant graphs, diagrams, and three-dimensional presentations to elucidate intricate concepts.

In Jharkhand, the situation was less favourable, as three-quarters of the surveyed students were unable to participate in online classes. Consequently, minimal studying occurred during the lockdown period due to the closure of schools and the lack of access to devices. Some students resorted to private tuition, incurring additional expenses, while others attended *mohalla* classes. Teachers provided their own video content to students from April to September 2020. Post that, DigiSATH app was used to distribute content.

Lessons Learned and the Way Forward

The preceding discussion highlights that during the COVID-19 disruption, it is technology in the form of smartphone-enabled Zoom, WhatsApp, YouTube, etc, services that allowed some continuity in education for SC/ST children in the two states surveyed. It highlighted the learning loss during the pandemic. It also unpacked the divide created among students through the possession of smartphones or lack of it; and it underscored the indebtedness and other distresses brought about as poor parents struggled to acquire smartphones for their children's education. The crucial need for internet and electricity was highlighted. The discussion also indicated that students missed face-to-face interaction with teachers and peers during

school closures, and it especially affected younger children in the age group 6–10 years.

In the coming years, it is likely that the world will continue to face disruption whether in the form of viruses such as COVID-19 or conflicts or natural disasters such as floods and earthquakes, along with climate change. Technology for education will continue to be important in such cases. Even in normal times, technology would have an importance in the dispensation of education as was seen with children's preference for lessons on YouTube videos since these can be replayed and revisited, unlike offline lessons.

Therefore, ideally, the combination of offline teaching in schools supplemented by technical tools needs to be the way forward. While remote learning should not replace the human connection in the form of direct interaction with teachers at schools, technology should be harnessed in the best possible way.

As the GEM report 2023 puts it: "Technology's capabilities offer education systems tools to overcome long-standing inequalities along two key dimensions: reaching disadvantaged populations and ensuring content reaches all learners in more engaging and cheaper form," and those advantages should be harnessed.

Several recommendations to enhance support for school education, particularly for marginalised rural children, are outlined below:

(i) Bridge the digital gap for students, especially those from marginalised backgrounds and remote regions. Improving internet connectivity in rural areas is crucial.

(ii) Develop a hybrid learning approach. Disseminating educational materials (videos and assignments) through WhatsApp proved effective. Students also valued the ability to rewatch YouTube videos, aiding their learning. A hybrid model appears to be the future of education delivery.

(iii) Equip educators with new skill sets to adeptly manage digital education and students' emotional well-being.

(iv) Innovate teaching and learning methodologies, especially for students with limited access to technology. An exemplar is Karnataka government's "Vidyagama" (doorstep classes) for government school students.

(v) Effectively utilise allocated funds for the welfare of SCs and STs. There is a notable underutilisation of funds earmarked for SC/ST welfare schemes. In 2021–22, approximately 43% of the allocated funds for SC welfare and 35% for ST welfare remained unspent. Redirecting these unused funds towards priority areas, targeted programmes, scholarships, digital devices, skill-building initiatives, and livelihood creation for disadvantaged SC/ST families could significantly enhance education opportunities for their children.

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The IT Amendment Rules, 2023
Censorship in the Guise of Fact-checking

HEMENDRA SINGH

The Information Technology Amendment Rules of 2023 grant the union government the authority to remove any online content pertaining to its business that it deems to be false or misleading. Under these rules, social media platforms and intermediaries will be deprived of the protection of the safe harbour principle if they fail to comply with government orders. The use of vague and broad wording "in respect of any business" raises concerns over its chilling effect on the right to freedom of speech and expression.

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The Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Amendment Rules, 2023 were notified by the Ministry of Electronics and Information Technology on 6 April 2023. Apart from provisions related to online gaming, the rules also grant authority to a "fact check unit of the Central Government" to label internet content concerning "any business of the Central Government" as "fake, false or misleading" and mandate its removal from the internet. This implies that the union government now possesses the authority to remove any information it considers false, and there is more to it. The amendment includes a provision revoking the legal protection granted to social media platforms and intermediaries under Section 79 of the Information Technology (IT) Act, 2000, if they fail to comply with the union government's orders.

According to Section 79 of the IT Act, 2000, intermediaries are exempt from hosting third-party data, information, or communication, as long as they practise "due diligence" while performing their duties under the act as defined by the IT rules. However, if an intermediary fails to do so, they will not receive immunity from liability under Section 79. Essentially, the government has granted itself unrestricted authority to decide what is true or false concerning its own affairs and to demand its removal from the internet accordingly. However, there is no information about the regulatory framework that will guide this fact-checking unit. It seems the real purpose behind this amendment is to remove all types of criticism of the union government (Sibal 2023).

Deprivation of Safe Harbour

Section 79 of the IT Act, 2000 provides a safe harbour defence that shields intermediaries from responsibility for third-party information, data, or communication made available or hosted by them. However, certain conditions must be met for the safe harbour to apply. Section 79(3)(b) specifies that safe harbour protection will not be granted if the intermediary neglects to expeditiously remove a post or content even after the government has flagged it as being used for illegal activities.

The safe harbour provision is a crucial element in the functioning of online platforms, as it ensures that intermediaries are not held accountable for the content that is beyond their control. The primary role of an intermediary is to receive, store, and transmit information without any involvement in creating it. Users are responsible for generating the content or information that is received by the intermediary and transmitted to other users. The intermediary serves as a conduit between content creators and users. Thus, it is unfair to hold an intermediary accountable for any content posted by a third-party user on the platform due to the sheer volume of data exchanged between users that is impossible to monitor continuously. Furthermore, this practice poses a problem as it gives the union government the authority to decide the extent of freedom of speech and expression.

The Supreme Court was presented with a challenge to the constitutional validity of Section 79(3)(b) in the case of *Shreya Singhal v Union of India* (2015). Although the Court ultimately upheld the validity of the section, it did so with the caveat that any Court order or notification issued by the appropriate government or its agency must adhere strictly to the subject

matters outlined in Article 19(2). The new IT rules exceeded the authority of Section 79 of the IT Act as it allowed for the removal of the safe harbour protection for intermediaries on grounds that were not in line with Article 19(2), as established by the Shreya Singhal case ruling.

Vague and Unconstitutional Restrictions

The new IT rules, by instructing social media intermediaries to censor or alter content, violate Article 19(1)(a) of the Constitution and are not protected by Article 19(2). As established in the Shreya Singhal case, restrictions on the right to freedom of speech and expression are deemed unconstitutional if they are too broad or vague. The phrase "in respect of any business of the Central Government" is excessively broad and unclear. Even if we were to assume, for argument's sake, that the government has some right to respond to certain types of speech in respect of its business, it is a limitless and easily manipulated term that could include nearly any aspect of modern life.

As it was held in the Shreya Singhal case, laws that are excessively broad and ambiguously worded can have a chilling effect on the freedom of speech and expression. The "chilling effect" arises when imprecise laws that restrict speech create a large grey area in which citizens must guess where the line between legal and illegal speech lies. To avoid any potential legal repercussions, citizens may choose to self-censor even lawful speech, resulting in over-regulation and the stifling of free expression. It is clear that the lack of clarity in the phrase "in respect of any business" will inevitably create a chilling effect, leading intermediaries to remove any content flagged by the union government's fact-checking unit to avoid losing the safe harbour protection.

The new IT rules violate the guarantee of freedom of speech by granting the union government complete authority over the truth "in respect of any business" related to itself, and mandating private parties (social media intermediaries) to enforce that version of the truth on all users of the intermediary. Additionally, the new IT rules leave the matter to the union government's subjective satisfaction, rendering it unaccountable to anyone other than itself. The problem with government-mandated censorship arises primarily because the government holds a unique position of power, with access to an extensive range of communication channels that have the widest reach possible in society. If the government thinks fake or misleading news is being spread about its own activities, it can use its resources and reach to correct it. This means that the solution to fake and misleading news is speaking up and sharing the truth.

Moreover, the new IT rules fail to fall under any of the eight categories specifically enumerated under Article 19(2) of the Constitution, rendering them void from the beginning and unconstitutional. As per the judicial ruling in *Sakal Papers Pvt Ltd and Ors v Union of India* (1962), the grounds for restricting speech are restricted to those mentioned in Article 19(2), and no additional grounds can be introduced into its provisions. Even if the new IT rules are found to fall under Article 19(2), it still fails the third and the fourth prong of the proportionality test. According to the third prong of this test, the "least restrictive alternative" must be selected (Reddy 2018). Other less restrictive options were available to the government. For example, the government can provide clarifications to incorrect information related to its business. It would be less restrictive than requiring social media intermediaries to remove content posted by their users.

The fourth prong of the test requires striking a balance between the importance of the intended goal and the extent of the restriction imposed on fundamental rights (Chandra 2020). The new IT rules place an undue burden on intermediaries to monitor user-generated content proactively and take down any objectionable content. This requirement could negatively impact the intermediaries' ability to provide a platform for free speech and expression. The rules impose heavy penalties on intermediaries for non-compliance with the provisions, which could further discourage them. Thus, it is crucial to strike a balance between regulation and the protection of fundamental rights to ensure a free and democratic society.

Violation of the Equality Principle

The new IT rules 2023 violate Article 14 of the Constitution on several grounds. Under the new rules, the government acts as both the judge and the prosecutor when it comes to content related to its own business. It is unfair and violates one of the most fundamental principles of natural justice. It also implies that any content which is critical of the government is likely to be flagged as "misleading" by the government's own fact-checker, creating a high risk of arbitrary and abusive implementation of the rules. Moreover, the new IT rules do not give users a chance to defend themselves before a decision is made about the truthfulness of their content. There is no mechanism for users to dispute the decision or appeal to a court. The rules also lack reasonable safeguards against the union government's subjective discretion.

The new IT rules goes against the principles of the rule of law because it encroaches upon the exclusive role of courts to act as impartial judges in disputes, including those involving the state and its citizens, and to determine the facts of such disputes. Judicial independence is an aspect of the "rule of law" (Srivastava 2020). The new IT rules represent an intrusion by the union government into the role constitutionally assigned only to the courts and thus violates the rule of

law. The Constitution clearly demarcates the roles of the three organs. Nevertheless, there have been efforts by different governments to encroach upon this express separation of powers.

On 17 January 2023, the union government released a draft of the IT rules for public consultation. Despite receiving significant objections from numerous stakeholders, the government made only minor, inconsequential changes and proceeded to notify the IT rules 2023. This shows that the government was acting arbitrarily and without reason, in violation of its obligation to act legally and reasonably under Article 14.

In Conclusion

Recently, there has been a battle between the union government and X (formerly Twitter) over compliance with the IT rules 2021. The government had asked X to take action on various types of content, including accounts that support secession and critical tweets about the government's handling of the COVID-19 pandemic. The IT rules 2023 are straightforward, and non-compliance means that intermediaries cannot claim the safe harbour principle. The penalties for non-compliance are severe. Therefore, intermediaries must comply with the new IT rules 2023 to avoid losing the defence under the safe harbour principle.

However, the future of the IT rules 2023 remains uncertain, and different intermediaries and other stakeholders may challenge its validity to maintain their autonomy and control. It is high time that we must understand that any arbitrary rule or regulation cannot result in censorship in the guise of fact-checking. The right to freely express in a democracy is a fundamental right of every citizen and curtailing this right in the name of fact-checking is arbitrary, unreasonable, and authoritarian.

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Recalling the Contributions of M S Swaminathan (1925–2023)

R V BHAVANI

A leading agriculture scientist, humanist, and institution builder, M S Swaminathan passed away on 28 September 2023. The best way to honour him and his rich legacy is by continuing his unfinished mission of eradicating malnutrition with more determination and vigour.

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A humanist, an institution builder, a visionary, a person with a mission, all these epithets apply to M S Swaminathan, who passed away on 28 September 2023. He would have turned 100 in another two years. The father of India's green revolution, Swaminathan was recognised by *Time* magazine in 1999 as one of Asia's 20 most influential thinkers of the 20th century, M K Gandhi and Rabindranath Tagore being the two other Indians on the list. A recipient of numerous awards, accolades, and honorary doctorates, he strode tall as a committed and relentless crusader for ending hunger and malnutrition across the world.

Sustainable and Nutrition-sensitive Agriculture

A scientist par excellence, his contributions to the field of agricultural research have been documented by his biographers and students. Among his significant institutional initiatives when he was director general of the Indian Council of Agricultural Research (ICAR) were to establish the Indian Agricultural Research Service and lay the foundation for the National Academy of Agricultural Research Management, conceptualised on the lines of the Academy for Indian Administrative Services probationers in Mussoorie (Swaminathan 2014). It was also during his tenure that the plan for krishi vigyan kendras (KVKs) or farm science centres was developed and operationalised to bridge the gap between scientific knowledge and field-level action. These initiatives laid a strong foundation for agricultural research and extension in the country.

The green revolution helped increase food production and ward off doomsday predictions of hunger and famine; its success was, however, not without negative consequences, as we know. As early as the late 1960s, Swaminathan drew our attention to the dangers of over-exploitation of natural resources in the race for higher production and said that the green revolution should not turn into a greed revolution. He coined the term "evergreen revolution" to promote sustainable production without ecological harm. To him must also go the credit for bringing the focus on nutrition security, through his calls at both national and international forums for moving from just

food security to "food and nutrition security" for a productive and healthy life. Swaminathan (2017) defined nutrition security as "physical, economic, and social access to balanced diet, clean drinking water, sanitation, and primary healthcare."

As director general of ICAR, he introduced a course on nutrition in the syllabus of agriculture and veterinary colleges to familiarise students with food-based approaches to address malnutrition. A strong advocate of nutrition-sensitive agriculture, he had produced a plan to combat malnutrition through nutrition gardens way back in 1978 and advocated their promotion through agricultural universities and KVKs. Today, nutrition gardens are an integral part of poshan abhiyaan[1] and there is also a directive from the Ministry of Human Resource Development to promote them in schools![2] Swaminathan went on to coin the term "farming system for nutrition" (FSN), defining it as:

> the introduction of agricultural remedies to the nutritional maladies prevailing in an area through mainstreaming nutritional criteria in the selection of the components of a farming system involving crops, farm animals, and wherever feasible, fish. (Nagarajan et al 2014)

This had to be accompanied by nutrition awareness and he coined the term "community hunger fighters" to recognise rural men and women who underwent training to be the champions of nutrition awareness at the grassroots level.[3] Even as he entered his 10th decade, he provided guidance to the project team at the M S Swaminathan Research Foundation (MSSRF),[4] the institution established by him, to demonstrate the feasibility of the FSN approach under a research programme on the Leveraging Agriculture for Nutrition in South Asia (Pradhan et al 2021).

A Friend of the Farmer

Swaminathan was a true friend of the farmer. The national demonstrations under the green revolution were purposefully done on small farmers' fields, given that they are the large majority in our country. The well-being of the farmer was the focus of the National Commission on Farmers (NCF) that he chaired from 2004–06, often referred to as the Swaminathan Commission. Emphasising on farmers' income, he wrote:

> The Minimum Support Price (MSP) should be at least 50% more than the weighted average cost of production. The "net take home income" of farmers should be comparable to those of civil servants.[5]

I had the opportunity to work in the NCF as an officer on special duty to the chairperson. Swaminathan set a fast pace of work for the team. Engaging in extensive consultations to address the detailed terms of reference, the NCF went on to submit five reports under the generic title—"Serving Farmers and Saving Farming," and a draft National Policy for Farmers (NPF).[6] The commission made far-reaching recommendations addressing aspects relating to crop and animal husbandry, including harnessing information technology and remote-sensing tools to provide block- and district-level planning and advisory services, and market reform, to ensure the livelihood security of farm men and women. It was based on the NCF's recommendation that the union government adopted an NPF in 2007 and the Ministry of Agriculture was renamed as the Ministry of Agriculture and Farmers' Welfare.

The drafts of two landmark national legislations relating to the rights of farmers, the Protection of Plant Varieties and Farmers' Rights Act, 2001 and the Biological Diversity Act, 2002 emerged from consultations under Swaminathan's leadership at the MSSRF. The Indian legislation is unique, in that it recognises both breeders' and farmers' rights, recognising the contributions of the farmers who preserve genetic resources for public good at their personal cost. Likewise, the Biological Diversity Act, 2002 also incorporates the concept of farmers' rights concerning recognition and reward for local conservers. It was also based on Swaminathan's suggestion that the union government introduce the Genome Saviour Award and Breed Saviour Award to recognise rural men and women who have conserved rich genetic diversity of crops and indigenous animal breeds, respectively.

Women and Agriculture

Swaminathan was particularly sensitive to the role of women in the economy and society, and the need to recognise the role of women farmers in agriculture. The Sixth Five Year Plan (1980–85) was formulated when he was in the Planning Commission in 1980–82, and he took the initiative to introduce a chapter on "Women and Development" in the plan for the first time. He recalled this in late 2004 when conceptualising the chapter on a "New Deal for Women in Agriculture" in the first report of the NCF. The draft NPF submitted by the NCF, which was subsequently adopted by the union government, flags paying special attention to the needs of women farmers through measures such as promoting women-friendly implements, issuing of Kisan Credit Cards, and provision of support services for childcare.

In 2001, with support from the Government of Tamil Nadu and the Department of Biotechnology, the union government and the MSSRF under Swaminathan's stewardship established the first women's biotechnology park in the country, to encourage women scientist entrepreneurs.[7] Following a field trip of the NCF to agrarian distress areas in the Vidarbha region of Maharashtra in late 2005, the MSSRF under his guidance commenced a programme for the empowerment of women farmers—Mahila Kisan Sashaktikaran Pariyojana (MKSP)—in Wardha

district to alleviate farmers' distress. In 2010–11, the union government launched MKSP as a national programme, making it a subcomponent of the National Rural Livelihood Mission under the Ministry of Rural Development. When he was a member of the Rajya Sabha, he introduced a Women Farmers' Entitlement Bill in Parliament as a private member's bill in 2012. The bill, unfortunately, lapsed with the end of his term in 2013, but is another example of his commitment to the cause. In his farewell statement to the Rajya Sabha on 22 March 2013, he requested the members to "take up the cause of women farmers or *mahila kisans*, who constitute the majority of women in our country, in the interest of both household livelihood security and national food security" (Rao 2015).

Institutions and Initiatives

The MSSRF was established by Swaminathan in 1988 with the award money from the World Food Prize. The endeavour was to fill critical gaps in ongoing research (strategic, anticipatory, and participatory) in the field of agriculture following a pro-poor, pro-women, and pro-nature approach. He steered the MSSRF as chairperson for a quarter-century till 2012. An external review committee on the completion of 20 years of the organisation observed:

> the MSSRF has no parallels in its entirety. The Review team searched for but was unable to identify a comparable organisation which combines scientific research with action, uses a combination of modern science and traditional knowledge, and develops innovations to address the triple challenges of poverty, gender inequity and environmental sustainability.[8]

Coastal Systems Research involving concurrent attention to inland and coastal fisheries and particular reference to mangroves was one of the first areas of work at the MSSRF. The impact of this work was visible during the tsunami of December 2004, when it was observed that areas with mangrove forest cover were less ravaged. A chapter titled "Beyond Tsunami: Saving Lives and Livelihoods" was included in the first report of the NCF that was submitted in December 2004, recommending short-, medium-, and long-term measures to be taken to address the immediate suffering and build resilience. Subsequently, the Coastal Regulation Zone Notification (CRZN) 2011 issued by the union government drew on the recommendations of the report of a committee chaired by Swaminathan to review the CRZN 1991.[9]

Incorporating the experience gained by the MSSRF in Integrated Coastal Zone Management (ICZM), the report recommended an ICZM approach that involved the local community playing a major role in conserving the marine ecosystems to protect the livelihood security of coastal communities and promote sustainable development. Like the MKSP, this was another example of a demonstration on the ground providing evidence for policy advocacy and upscaling.

"Mission 2007: Every Village a Knowledge Centre" and "Mission 2007: Hunger Free India" were two initiatives launched by Swaminathan as India approached the 60th anniversary of its independence. The first was to harness the power of information and communications technology for rural development, building on the model of village knowledge centres (VKC)

piloted by the MSSRF and bringing together multiple stakeholders—government agencies, research institutes, industry, civil society organisations and networks, and the rural community. Responding to the momentum generated, the union government announced a budget allocation in 2005–06 for setting up VKCs across the country, followed by the common service centre initiative in 2006–07 as part of the National e-Governance Plan.

Under the second initiative, building on the mapping of the food security situation in the country by the MSSRF with support from the United Nations World Food Programme (UNWFP), a series of regional and national consultations were organised across the country jointly by the MSSRF, the UNWFP, and the NCF. The feedback from these consultations provided inputs for the NCF recommendations on a strategy for food and nutrition security. The NCF also recommended a National Food Guarantee Act that became a reality in 2013 with the enactment of the National Food Security Act.

Besides the MSSRF, Swaminathan nurtured and mentored many institutions and initiatives such as the National Foundation of India, the Centre for Science and Environment, and the Third World Academy of Sciences. A direct experience for me was seeing the evolution of the National Coalition for Food and Nutrition Security (NCFNS). In August 2007, under his guidance, I coordinated the organisation of a national nutrition conclave in collaboration with the Vistaar project of the United States Agency for International Development and the Indian Council of Medical Research. The conclave ended with the formation of a Coalition for Sustainable Nutrition Security chaired by Swaminathan. Sustained perseverance through the years eventually led to the network being registered in 2015 as the NCFNS.

The Ramon Magsaysay Award for Community Leadership in 1971, the first World Food Prize in 1987, and being declared a "Living Legend" by the International Union of Nutrition Sciences in 2013, were among the many notable international recognitions bestowed on Swaminathan. As the director general of the International Rice Research Institute from 1982 to 1988, he helped Burma, China, Cambodia, Vietnam, the Philippines, Egypt, and Madagascar to develop strong national rice research institutes. Some of the other significant international positions held by Swaminathan were: Independent Chairman of the Food and Agriculture Organization of the United Nations (UN) Council (1981–85), President of the International Union for the Conservation of Nature and Natural Resources (1984–90), President, Pugwash Conferences on Science and World Affairs (2002–07),[10] the first life scientist to be chosen for the position, co-chair of the UN Millennium Project on Hunger (2002–05), and first chairman of the Steering Committee of the High Level Panel of Experts (HLPE) on Food Security and Nutrition (FSN) of the Committee on Food Security (CFS), a position he held from 2010 to 2013. The HLPE, a UN body constituted to examine the science related to global FSN, produced four reports during his tenure—dealing with food security and price volatility, social protection, climate change, and land tenure and international investments in agriculture. He also chaired a task force set up by the Ministry of External Affairs to oversee projects in Afghanistan and Myanmar—providing leadership towards the establishment of the Afghan National Agriculture Science and Technology University (ANASTU) in Kandahar, Afghanistan, and training of their faculty at the Indian Agricultural Research Institute. In Myanmar, the MSSRF, in partnership with the Department of Agricultural Research, Yenzin, established a rice biopark conceived by Swaminathan, in Naypyitaw. The rice biopark is a solution that Swaminathan had been recommending in recent years to alleviate the recurrent problem of stubble burning and consequent air pollution in North India.

In Conclusion

One may say that Swaminathan was a multifaceted person focused on using science for societal benefit leaving no one behind. I have attempted to highlight a few aspects of his large body of work and its impact. Notwithstanding his stature, Swaminathan was always approachable and accessible to all. Endowed with a prodigious memory and will, he was bold to think forward and put in place teams to work towards what he visualised. His energy level until a few years ago was amazing. His abiding interest in science saw him continue to supervise doctoral students amid his many activities and his last student (the 77th) submitted her thesis in 2017. Calmness and perseverance were his innate characteristics.

Swaminathan leaves behind a rich legacy. His is a life to learn from, celebrate, and strive to emulate. Committing to work to realise his unfinished agenda of ending malnutrition with renewed vigour will be a fitting tribute to him.

NOTES

1 https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1912577.
2 https://samagra.education.gov.in/docs/SNG_Guidelines.pdf.
3 https://www.youtube.com/watch?v=a-Qey3OUC-sY.
4 www.mssrf.org.
5 https://agricoop.gov.in/sites/default/files/NCF5%20Vol.-1%20%281%29.pdf.
6 https://ruralindiaonline.org/en/articles/all-reports-by-the-swaminathan-commission/.
7 https://www.biotechpark.co.in/.
8 http://59.160.153.188/library/sites/default/files/Uma%20lele%20program%20review.pdf.
9 http://iomenvis.in/pdf_documents/MSS_Report.pdf.
10 https://pugwash.org/; an initiative for a world free of nuclear weapons and weapons of mass destruction.

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Reading Press Freedom through Constitutional and Legal History

ARITRA MAJUMDAR

BOOK REVIEWS

Between Freedom and Unfreedom: The Press in Independent India by V Krishna Ananth, *Gurgaon, Haryana, India: The Alcove Publishers, 2020; pp 445, ₹599 (Paperback).*

Historians of the press face a central question—do they focus on the influence of business interests on the press reportage, or should the relations of the state with the Fourth Estate take precedence? Between the histories of censorship (Barrier 1974) on the one hand and favourable biographies of the press barons on the other (Verghese 2005), the interaction of various interests and the ever-extended arm of the state becomes blurred. Hence, when an ex-journalist and current teacher of history attempts to write the history of the press in independent India, he steps into an already crowded field (the latest being Devika Sethi's work on censorship in 2019). He tasks himself with re-examining the decades since India's independence with a Habermasian lens on the influences that may colonise the press and through it, the lifeworld of rational discourse (Habermas 1984).

The author approaches this task through seven chapters, a rather short epilogue and a rich set of appendices. Treading lightly on the theoretical frameworks around freedom of expression and the press, V Krishna Ananth starts the book with the pre-independence beliefs in fundamental rights of free speech and how they initially played a role in shaping the Objectives Resolution of the Constituent Assembly. He cuts a clear path through the verbose debates to show how the fuzzy idealism of the freedom struggle collided and withered in the face of legal experts with an eye on reality. He considers the latter's introduction of terms like public order and sedition as limiters of the fundamental right to freedom of speech, while refusing to give the press a special place in the scheme, an "original sin" from which the postcolonial woes of the press began.

Revisiting Nehruvian India through the Eyes of the Press

The first two chapters are largely constitutional and legal histories. Readers are introduced to the famous *Romesh Thappar v the State of Madras* and *Brij Bhushan and Another v the State of Delhi* cases and their implications, with the author providing helpful commentary on how the Supreme Court upheld the freedom of the press and right to free circulation from the strictures of the state, in the nascent period of independent India. This leads us to the First Amendment and the Press Commission, both of which have been studied recently by Devika Sethi. While Sethi's (2019) work focuses on a range of communications—personal and official—as well as newspaper commentary of the period brings out a rich tapestry of opinions, this book stands on a thinner ground due to its almost exclusive focus on legal and formal proceedings. That said, the analysis of the Press Commission's findings provide vital understanding of how the press was inevitably developing as a business proposition and the possibilities of financial incentives for those who could mould publicity to their own ends. For anyone wishing to understand the role of the First Press Commission (1954) in predicting changes that went beyond the state-media dichotomy, the author's insights are invaluable.

Chapter 4, unlike the well-trodden ground of the First Amendment, provides a timely study of the Working Journalists and Other Newspaper Employees (Conditions of Service) and Miscellaneous Provisions Act, 1955, and the legal challenges brought against it by the legendarily thrifty Ramdas Goenka and his *Express Group of Newspapers*. We find the Express Group complaining that implementing the Wage Board (set up through the act) report did not take into account the newspapers' ability to pay. The recommendations in the report were thus financially untenable and must result in utter collapse. The Wage Board itself had anticipated such a challenge with the minority of proprietors' representatives warning that such a wage increase would force newspapers to borrow and eventually close down. The chairman, Justice Diwatia, however, noted that encouraging the growth of newspapers in numbers should not be at the cost of the payment of reasonable minimum wage. Eventually, the Supreme Court, while refusing to entertain the overall contentions of the Express Group, did dilute the requirement that newspapers must be able to pay the minimum wage by stipulating that such minimum wage must take into consideration the industry's capacity to pay.[1]

As the reader journeys through the lengthy recommendations and judgments, the author makes the complex legalese comprehensible when seen through the eyes of the working journalist, a viewpoint often omitted in the grand story of the press. He makes it amply clear that only by freeing himself from fear of retrenchment and wage loss could the journalist report honestly. Yet again, however, the exhaustive coverage of legal proceedings leaves no room for narrating the real-life experiences of journalists, who fought for—and often failed—to obtain due remuneration. Indeed, proprietors went to the extent of shifting newspaper offices and losing valued editors (Verghese 2005). While not strictly necessary, such anecdotes would have

enlivened what increasingly becomes a slow climb through dry legal history.

While Chapter 4 chronicles the victory of free speech and journalists' rights against big capital, the next draws attention to its serious reversal. The author takes up another rarely studied subject while dissecting the Supreme Court's judgment in the *Sakal* case that led to the Daily Newspapers (Price and Page) Order, 1960, being overturned. As the author shows, the attempt to link prices of newspapers with the number of pages printed was an attempt at preventing monopolies and upholding the diversity of the press. However, the *Sakal* contented that such correlation would deprive it of the freedom to price the paper based on circulation and readers' ability to pay while providing the maximum amount of news to them. Hence, the proprietors' perspective claimed that the order impinged on both their right to freedom of business as well as expression. Drawing upon specific sections of the Press Commission's report, the Supreme Court agreed. The author, however, makes it clear that even the commission's advice was aimed at restricting monopolies and thus colonisation of the press by big business.

Thus, the 1960 Order was an effective bulwark that would promote diversity in the public sphere. The Supreme Court's stance, he argues, ensured the growth of an oligopolistic environment where business could effectively stifle debate on matters that seemed inimical to the oligopolists' interests.

During and after the Emergency

Chapter 6 looks at India's descent into what the author calls "un-democracy" (Ananth 2020: 174) before and during the Emergency. Before approaching the tumultuous 1970s, the author follows the actions of the Nehruvian state on individual newspapers, as well as the press as a whole, and see how the press and the courts responded. The result is a well-knit account of the state's unwillingness to walk the talk on press freedom, laying the grounds for the blatant abuse of power during the Emergency regime. Further, while it is well known that the courts and the major newspapers were never willing to keep up the battle against censorship, the major litigation was, in fact, an attempt at claiming particular exemption rather than fight it as a common enemy. Partly to blame, perhaps, was the atmosphere of fear produced by carefully delaying access to justice for those who fell foul of the arrogant regime.

The last chapter—dealing with the zenith of press activism in the 1980s—is also the most diverse in terms of its sources. Hence, alongside the legal judgments, the reader is introduced to fearless journalists like Olga Tellis, Neerja Choudhury, and others. Their attempts at uncovering the malfeasance of the Congress ministries disguised beneath ideology and the inevitable repercussions from an oversensitive government, are necessary reading for anyone wishing to appreciate the breadth of the freedom of expression exercised by the press in this period. Culminating in the Bofors scam and its coverage, the chapter is careful to show that many of those who bent over—like the *Hindu* and *Times of India*—made amends by fiercely upholding journalism as an agent of social change in this tumultuous period. At a methodological level, the reader receives a much-welcome break from legal history when she learns of the efforts of individual journalists, their stories and the coverage of the events themselves in their own words.

The book ends with an all-too-short epilogue, which demonstrates the final victory of big capital over journalism, even as the social elites within the press used communal agendas to marginalise the growing relevance of the Mandal Commission report and the affirmative action politics it engendered. Cases decided decades ago, such as the *Sakal* judgment, were used by proprietors to transform newspapers into profitable businesses in the 1990s. In the process, they hollowed out the wage protection provisions and the trade unions defending them through direct contracts with journalists. When the boom started slowing down in the 2010s, the barons undertook widespread retrenchment without the need to follow the provisions of the working journalists act meant to protect against this very eventuality.[2]

Final Thoughts

Almost uniquely, among recent histories of the press, the author provides readers a selection from his rich collection of primary sources in the form of over a hundred pages of appendices. Like all works attempting a study of so broad and complex a period, the work has its flaws. The most obvious one is overt reliance on legal history. While the constitutional and legal framework is doubtless of vital importance, extensive quotes of the sometimes complex legal language make for a difficult read if the reader is not well-versed in court documentation. This is brought all the more into focus by the author's shift of focus to include major journalistic works in the last chapter, which enlivens the narrative with vivid examples of press freedom on the ground.

Some complaint may also be made by those seeking interaction with existing scholarship. While the author references Robin Jeffrey extensively, recent works like that of Sethi's are not referred to. Sethi's analysis of the debates on freedom of the press in the Constituent Assembly, which could have provided useful context for the author's own arguments, is regrettably missing (Sethi 2019). Equally absent is commentary on the role of women journalists from the late 1970s onwards (Joseph and Sharma 1994; Mankekar 2014), even though a number of journalists mentioned in the last chapter happened to be women.

These notwithstanding, the book largely achieves the goal the author sets himself in the prologue—studying the relations between the state and the Fourth Estate without losing sight of press as a business proposition and a living profession. The book's forays into lengthy legal proceedings leaves the reader with a clear understanding of how, where and why the freedom of the press was circumscribed and then abridged to suit the needs of the state, even as the agency of individual journalists waned and waxed under the influence of press barons. The book contextualises what freedom of expression meant through concrete examples that are sympathetic to both the lofty ideals of journalism as well as the everyday working conditions of the everyman journalist. Alongside

the biographies of journalists and proprietors and the histories of censorship (and the press in general), this book will surely take its place as a novel attempt at defining freedom (and un-freedom) of the press through multiple constitutional and legal lenses.

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NOTES

1 The author is grateful to the anonymous peer reviewer for pointing out the importance of providing the business perspective when discussing the tortuous interactions between journalists and media barons.

2 The author is indebted to the peer reviewer for suggesting an exploration of the importance of journalistic freedom in the context of job security and the wages paid to working journalists. This aspect takes on greater urgency against the backdrop of the press barons closing down some newspapers, using the justification of financial implicaitons of the COVID-19 pandemic. A case in point is the shutdown of the *Telegraph's* North-East Edition, with most Guwahati journalists being asked to resign at short notice (Guwahati Plus 2020).

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Mirror and the Lamp

AMMEL SHARON

Land, Guns, Caste, Woman: The Memoir of a Lapsed Revolutionary by Gita Ramaswamy, *New Delhi: Navayana Publishing, 2022; pp 432, ₹599.*

In Deepa Dhanraj's film, *We Have Not Come Here to Die* (2018), which follows the events after Rohith Vemula's death on the campus of the University of Hyderabad, there is an unforgettable scene in which Ambedkarite students and Vemula's friends storm the science building demanding accountability from the vice chancellor, who is also a scientist. The camera notes the stand-off as disaffected science students murmur that Vemula was no brother of theirs. Outside, a student expresses annoyance at the interruption of her research. The scene calls to mind the anti-Mandal agitations led by medical students against caste reservations, and both beg the question: Does disciplinary training preclude fraternity and social conscience? It is a question we might associate with the debate between Karl Popper and the Frankfurt School (Adorno et al 1977). The Frankfurt School—known for critical theory—attempted a practical theory of society in the wake of fascism in Europe, while Popper's critical empiricism and his falsification principle turned away from the deterministic outlook of Marxism in his time. This debate demonstrated that for both the sciences and the social sciences, knowledge cannot avoid value judgments, whether in subjecting empirical questions to scientific investigation or by proceeding with a philosophical view of the social totality.

Science in the Field

Recent histories of disciplinary knowledges and their institutionalisation in higher education indicate that there is much to be learnt about the relationship between the classroom and its outside from those engaged in social movements in Telugu-speaking regions in India. Vemula was a student of chemistry before beginning his studies in sociology. Gita Ramaswamy, occasional contributor to *EPW* and the author of this timely book titled *Land, Guns, Caste, Woman: The Memoir of a Lapsed Revolutionary*, began her studies in science, as did mathematician-turned-civil liberties advocate, K Balagopal (2011), with whom the readers of *EPW* are undoubtedly familiar. Early on, Ramaswamy reflects on her schooling and the "revolutionary" nature of textbooks, signalling how children straddle and struggle between knowledges at home and at school. "Science," she writes, "gave me a firm ground to steady myself in this quiet rebellion" (p 30). Rather than seeing these activists as turning away from the "introspective life of the mind" towards the political and the social, we might recognise the university and public education as key sites that enable exchange and a critical temper.

Further, scientific knowledge may arise from encounters in the field. A feminist critique of medicine may be found in *Taking Charge of our Bodies: A Health Handbook for Women* (2004), a handbook on women's health that Ramaswamy co-edited, which evaluated scientific knowledge by drawing on women's experiences. Inspired by David Werner et al's *Where There Is No Doctor: A Village Health Care Handbook* (1977) and impelled by her own experience with postpartum depression, such an effort resists the abstract, does not purport to establish facts but creates new possibilities in the fields of knowledge. Perhaps, this is why, later in the book, she reflects on a life in activism and cautions against abstraction to say that "the desire for justice often overshadows good sense" (p 411). In anecdote after anecdote, we are treated to this immanence, staged as encounters with an unsympathetic legal–bureaucratic machine, where collectives cause authority to yield in unexpected ways.

Ramaswamy often prefaces her booktalks by saying that she is no academic, yet from the arc of her activist narrative emerge perceptive questions, from the fight to free and rehabilitate bonded labour, claim minimum wages for agricultural labour, to establishing a union, claiming compensation, and later to working on land rights for tenants and

the dispossessed ("more than 33% of the operative sections of the IPC [Indian Penal Code] relate to offences against property rights," p 322). If Balagopal's materialist analysis was sparkling in its attention to geography, the caste-historical aspect of the Indian ruling class, and state violence, Ramaswamy's memoir of her work in Ibrahimpatnam in the 1980s is a "how-to" in organising at the margins of peasant movements. Yet, she goes further, through the genre of the autobiography, to speak of the exigencies of the self, the torment of female friendships,[1] and a wry humour that inevitably accompanies long years of fieldwork.

Revolutionary Work

Born in 1953 in Solapur to a Tamil-speaking, Malayalam-reading Brahmin family with five daughters, Ramaswamy grew up in Madras, aware and annoyed by family strictures that governed everyday life. Education and social associations like the Hi-Y Club offered a new social with the possibility of intermingling between communities, and books provided a worlding grounded in rationality. If family became a site of "numbing grief" for young Ramaswamy, the university offered multiple ways to resist power. This period was also a time of crisis with drought, food shortages, and inflation in the country.

The reserved Ramaswamy ("I hated public confrontation"), drawn to articulations of multiple social movements in the early 1970s, began to participate in small awareness-building activities on campus, and peer groups facilitated her entry into the Communist Party of India (Marxist–Leninist) (CPI [ML]). In her narrative, the transition was seamless and provided for further organising, such as the first Progressive Organisation of Women on the Osmania University campus in 1974. The reader gets a sense of the heady times ("a mass movement is liberating for everyone"). In the CPI (ML), she met Cyril Reddy (brother of slain student leader George Reddy) whom she would marry and to whom she dedicates the book. The imposition of the Emergency and the resolute discomfort with the violent and opaque methods of Naxal leaders caused the activist couple to break away and flee to North India, where they lived and worked for a time among the poor in Delhi, but without the political radicalism with which she came of age.

Choosing to return to Andhra Pradesh and undertake fieldwork, Ramaswamy begins her narrative on Ibrahimpatnam thus: "I came here as a defeated idealist, in the hope that after the heady yet fruitless days of my youth I could still be of some use to someone" (p 18). Ramaswamy came to Dalit working-class concerns through her involvement with the people, not through reading Ambedkar, whom she would later read and publish. In this regard, I was reminded of Susan Buck Morss' (2019) comment on revolution:

> Revolutionary subjectivity is the consequence of conjunctural organization. You cannot know how to act without others, without *seeing* others act. The twenty-first century has already witnessed unprecedented popular mobilizations worldwide; they are in themselves a chain of signifiers, creating solidarity across language, religion, ethnicity, and every other difference. A populist leader as *point de capiton* of this signifying chain is not a practical necessity.

In contrast, Ramaswamy shows what has become a predictable script for the Communist Party of India (Marxist) (CPI[M]): that communist leaders repeatedly sought to secure power through their "constituency of middle and rich peasants" (p 231) and delegitimise Madiga and marginalised workers' unity. As the Ibrahimpatnam Taluka Vyavasaya Coolie Sangam (ITVCS)—which Ramaswamy helped to organise—established its presence, backward-caste "middle peasants" also approached them with various problems of land dispossession, characterised by local and historical modes of usurpation (pp 245–46). Ramaswamy depicts what the sangam was up against by tracing how Reddy caste networks capture power at the local and important nodal levels, including panchayat, ministerial, industrial, and bureaucratic positions.

Part of the sangam's resistance required locating land records to map changes in land relations (and the oral histories people shared), and the account is staggering. The activists accounted for protected tenancy till 1953, the Khasra Pahani records of 1954–55, ceiling legislations in 1961 and 1973, and lists of government land in every village in their mandal. To persuade the village *pairvarkar* to share land records, they cajoled or boycotted services to him, sat patiently with mandal officials, sent letters from universities and national institutes to access land records, used landlord rivalry strategically, mobilised Dalit youth to copy records, and wrote applications with the name of a *pattadar* to the Hyderabad land survey office for maps (pp 268–69).

Ramaswamy's book is riveting in its plural strategic approaches: in Jabbargudem against the Manchireddy landlords (who occupied land of the fleeing terrorised Muslim landlords in 1948) whose fraudulent claims were secured through fake documents of an injunction against poor families, Ramaswamy, her lawyer husband, and the sangam set to work. First, they drew a diagrammatic map of what papers the Dalits possessed and what was missing. Then, they found a "friendly face" in the mandal office to locate some documents, pestered officials at home and won the sympathy of their wives, returned to the revenue court, and demanded government accountability. They also encouraged people to till the land (prompting Section 144 of the IPC) proving that "possession is nine-tenths ownership" (p 256), which unsettled the Reddys.

A Work of Collective Memory

In a recent, classic work in agrarian history, Neeladri Bhattacharya (2019) writes about the classificatory zeal of the British colonial regime that forced all social relations into master categories of "proprietor" and "tenant." Easier said than done, this project of reclassification was secured through juridical categories, for in Jeremy Bentham's words, "property is nothing but the basis of expectation; the expectation of deriving certain advantages … now this expectation can only be the work of the law" (cited in Bhattacharya 2019: 175). Through its normative character, law sought, on the one hand, to govern and produce an orderly vision of the agrarian, while, on the other, to secure individual liberty and guarantee the possibility to make one's future. Yet, practices and everyday spaces like the courtroom often unravel law's expectation. It is in

this light that we might appreciate Ramaswamy's memoir. Take, for instance, her passing remark on the common term for legal papers in Telangana—*addam*, or mirror—which "literally reflected a person's identity, security and status in life" (p 266). If the law functions as a mirror, Ramaswamy's book assembles "dialectical images" that, in the Benjaminian sense, explode the continuum of history (Traverso 2021).

Twenty-five years ago, V Geetha and S V Rajadurai (1998) dedicated their path-breaking book titled *Towards a Non-Brahmin Millennium: From Iyothee Thass to Periyar* to the "memory" of the Self-Respect Movement. Much of the research for that book was made possible by the labour of amateur archivists who recognised the value of collecting and recording before professional historians. To this end, we might think of memoir, memorials, and collective memory together. Is it not time then that we begin to formally archive the numerous histories of our social movements? We would have a comparative perspective with which to think through the demands and foreclosures of resistance, and importantly, a record of the postcolonial Indian state that may not be found in state archives (Nerlekar and Orsini 2022).

The economy of the fullness of time requires not memory but recapitulation, as philosopher Giorgio Agamben reminds us. To reconstruct the timelines, incidents, and methods in this memoir, Ramaswamy relied on articles and pen portraits she wrote for *Mainstream* beginning in 1985 and for *Nalupu* from 1989, a paper she authored for *Anveshi* in 2002 called "Judicial Processes and Women: Notes on Revenue Courts," records of newspaper clippings, and legal files. In this rich work, the challenge for us is to enquire about the registers of forgetting as much as memory, what eludes consciousness and how we might read for a "new and different experience of history, of life and of time" (Agamben 2018: 12).

For years, scholars were taken aback by the quiet distress of farming households as members were driven to suicide—a stark contrast to much-studied historical rebellions in the countryside. Now, a new historiographical turn is upon us, it seems, of which this book is a part. These works are not studies or reflections as much as they are manifestos in organising communities. One recent book is *The Journey of the Farmers' Rebellion: A Compilation of Interviews on the Farmers' Movement in India (2020–2021)* (GroundXero 2022). Another one is an Indian take on the professionalisation of human rights work, which has recently been offered in the *Anarchist Cookbook* (Patel 2021).

Memoirs of left-wing activists are available in many Indian languages, but this account in English deserves special mention for the editorial attention lavished on it. As Ramaswamy remarks in her book talks, much of the labour in writing this book was expended in responding to editorial demands for details and follow-through in narrative. As Ramaswamy is herself a publisher of the well-known Hyderabad Book Trust, we might see in this book the continued role and contribution of a concert of independent publisher–editors towards critical thought in India. To their credit, the numerous persons mentioned through the book appear as ones "making" history. So rapid is the narrative—25 chapters—that the emphasis remains on collective action rather than individuals; those better known outside the Telugu world—Bhoja Thakkaram, Gaddar, K Balagopal, Satyamma, Paul Diwakar, Volga, K G Kannabiran, Veena Shatrugna—are presented in their relation to Ramaswamy's work with the Sangam.

Remarkably, for a book so committed to building consensus, solidarity, and unity against the vicious operation of caste networks, each step involves a withdrawal. As Ramaswamy's reputation spreads, women throng to shit with her in the mornings, but she defends her privacy; moving court and appeals to bureaucracy are accompanied by a resolute knowledge that little comes from petitioning the government; as the ICVTS goes from strength-to-strength, Ramaswamy suspends her involvement in 1993; radicalism is also intimate and awash with doubt: "Did the idea of revolution sublimate the sex drive?" (p 45). We may be reminded of *The Eighteenth Brumaire of Louis Bonaparte* where Marx (2019: 457) says of proletarian revolutions that "they shrink back again and again before the indeterminate immensity of their own goals," yet a reader wonders why, for instance, a candid and courageous memoir remains largely silent on Naxal operations or the nature of revolutionary companionship. Perhaps, it implies not distance so much as an insight about how belief (or love) is also riven; it is not identical with itself.

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NOTE

1 Ramaswamy may be read fruitfully with literary pathbreaker, Elena Ferrante (2015), whose nuanced writing about abandonment and suffering in intimate female relationships comes to the Anglophone world just as the affective thrill of women's collective solidarities and consolation as we knew them, between the 1970s and 1990s, is on the wane.

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Science, Technology and Agriculture

R RAMAKUMAR

The relationship between science and agriculture has increasingly become the subject matter of contentious debates. While the literature has grappled with these questions and contrary views have persisted, there is a degree of scientific consensus that the achievements of new agricultural technologies over the past two centuries, and especially in the second half of the 20th century, had momentous consequences. Between 1960 and 2020, while the world population more than doubled, the quantum of food production nearly quadrupled even though the land put into cultivation rose only by about 15%–16%. This achievement must be counted as an extraordinarily important long-term success of the green revolution technologies that spread during and after the 1960s.

The ability of the world to feel confident about feeding its population during the COVID-19 pandemic—notwithstanding the continuing geographically unequal distribution of production—was a recent illustration of this achievement. In 2020–21, the world produced 518 million tonnes of rice and 775 million tonnes of wheat, which were higher than their actual global annual utilisation. In fact, the supply of rice and wheat was higher than their production due to the presence of stocks from previous years. Consequently, the global stocks-to-use ratios in 2020–21 (that is, the proportion of utilisation available as stocks) were comfortable at 37.3% in rice and 38% in wheat.

But these advances still provide little room for complacency. The global population is expected to rise from 8 billion in 2022 to 9.7 billion in 2050 and peak at 10.4 billion in 2085. Global food consumption—already at lower-than-adequate levels that lead to adverse nutritional and health outcomes—is expected to rise not only due to a rise in population but also due to an expected rise in demand alongside a rise in average per capita incomes. Without falling for Malthusian overstatements, it remains the case that global food production must continue to rise over the next 70 years.

There are also the emerging challenges thrown up by climate change. Land is both a source and sink for greenhouse gases. However, the need for sustainable management of land cannot be divorced from the need to exert less pressure on land, particularly in agriculture. Risks in cultivation are also likely to increase with higher incidences of extreme weather events, desertification, outbreaks of pests and diseases, and soil salinity. Meeting these climate-induced challenges, even as we strive to meet the higher demand for food through higher production, requires the application of more and better science.

But despite these facts, there are debatable binaries that mark the current discussions on the relationships across science, agriculture, and nature. If some scholars consider agriculture as a technological practice—fine-tuned from over history in a dialectical relationship with nature—others consider agriculture as a pristine part of nature itself. If some scholars highlight the importance of raising agricultural productivity in the context of rising population and food insecurity, others reject the emphasis as a "productionist" argument that does not respect pressing environmental concerns. While some scholars study the evolution of agriculture as distinct, though not necessarily delinked, from the rise of agrarian and industrial capitalism over the past four centuries, others connect the advance of technology in modern agriculture as intrinsic to the expropriation of peasants. If some scholars believe that the emergence of green revolution technologies was a political-strategic phenomenon linked to superpower foreign policy after the 1950s and the imperatives of "postcolonial" states, others acknowledge an amount of relative autonomy to the growth of agricultural technologies.

The contemporary concerns on climate change and agriculture have endowed these debates with a new salience, with some holding modern agricultural science itself as having contributed to climate change, while others believe that meeting the challenge of climate change requires more science and warn against a walk back from modern science towards traditional techniques. While there is considerable middle ground in these debates, the binaries we have pointed out are not schematic or caricatures and have found increasing space in the current global discourses.

The objective of this issue of Review of Rural Affairs is to discuss some of these critical issues in the Indian context. Five research papers are included in this issue that historically, conceptually, and empirically analyse the role of science and technology in increasing food production in India as well as positioning Indian agriculture in the era of climate change. The papers in this issue also attempt to respond to some, if

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not all, of the critical questions raised in the contentious literature that we referred to earlier.

At the outset, R Ramakumar (p 33) takes a "long view" of the growth of agricultural science and technology in India from the 1960s till the contemporary period by tracing the institutional development of a National Agricultural Research System in the public sector. He argues that the success of India's green revolution strategy after the 1960s lay in ensuring that foodgrain production—driven by wheat and rice—could be raised without any significant increase in the area cultivated. Indeed, if yields had not risen—due to the "genetic destruction of yield barriers"—India would have had to bring fresh land areas in the range of 94 million hectares (ha) to 119 million ha into cultivation to maintain foodgrain production at the current levels.

In the 1980s and after, India's green revolution spilled over into new crops and regions even as rice and wheat yields continued to grow. Ramakumar argues that, subsequently, even as economic liberalisation from the early 1990s led to a squeeze on the incomes of small and marginal farmers, there is evidence of a continued advance of productive forces in India's agrarian economy. But he cautions that stagnant public investment in agricultural research and a vigorous promotion of private corporate research are likely to undo the gains from the past and push future research agendas away from socially desirable goals.

In the second paper, Chandra S Nuthalapati, David Zilberman, Matin Qaim and Prabhu Pingali (p 47) assess the economic and nutritional implications of DMH-11, the genetically modified (GM) mustard hybrid developed in the public sector—at the University of Delhi—in 2002 but provided with a conditional approval for environmental release in 2022. They provide a detailed review of the technology and the regulatory process followed by its developers led by Deepak Pental. Their analysis brings forth a key point: regulatory compliance vis-à-vis GM technologies is extremely expensive in India, and this has emerged as a serious disincentive for investment in research on GM crops. For example, they note that DMH-11 had a 37% higher yield over the national check variety in the early field trials. But by the time the regulatory approval came after two decades, "new varieties with higher potential were available in the market." Nevertheless, they hope that DMH-11 will lead to newer, even higher-yielding, hybrids in the future.

Nuthalapati et al also provide estimates of the foregone monetary gains—or the cost of regulatory delays—from DMH-11 between 2016 and 2024. According to them, the foregone gains could be estimated at ₹1,24,306 crore (or ~$16 billion) over the nine-year period.

Sandipan Baksi's (p 55) paper deals with an important emerging issue: the proliferation of "alternative" approaches that purport to advance sustainability in agriculture. Baksi begins with a review of what the phrase "sustainable agriculture" has meant in scholarly international discussions. He notes that the United Nations Sustainable Development Framework was an important landmark in evolving a consensus around the phrase where the need for higher food production was recognised and the developmental concerns of hunger, nutrition and food security were foregrounded.

Baksi's major concern, however, is that many emerging discourses around "alternative" agriculture disrupt this consensus. They reject the importance of raising agricultural productivity. They downplay the key role that higher agricultural productivity could play in ensuring environmental sustainability. They undermine scientific temper by adopting an anti-science stance and ignoring the "dialectical nature of development of agricultural science and technology." They uncritically romanticise the "local," display "a lack of understanding of the nature and limitations of local ways and practices of agricultural production" and fail to appreciate "the nature of interplay between experiential knowledge and modern science."

From the colonial era, the global North has placed several constraints on the possibilities of economic development in the developing world. Is the new emphasis on environmental sustainability and climate change mitigation in the global discourse emerging as a new instrument of the dominance of the global North, which will yet again present a new set of constraints on the choices of developing countries like India? The last two papers in this Review of Rural Affairs pertain specifically to this aspect of climate change with a special reference to Indian agriculture.

Goutham R (p 64) reviews the contemporary scientific and policy literature to argue for the significance of the global carbon budget as a global commons. Based on equity and climate justice, each country should have a rightful share of cumulative carbon emissions depending on their population and other developmental requirements. However, the carbon budget has been appropriated by the developed world over the past 150 years. While the developed world (Annex 1 countries) was home to only 19% of the world's population in 2019, their share in the global cumulative carbon emissions was 81% between 1850 and 1990 and 49% between 1991 and 2019.

Developing countries like India need their due share of the global carbon budget to increase per capita incomes and reduce poverty. Yet, the developed world is trying to block this need in climate change negotiations. Limiting emissions from agriculture in the developing world and sequestering carbon in their biosphere has become a major goal of the global North. They argue that Indian agriculture must be the site of mitigation and adaptation, while India has thus far officially opposed the efforts to include mitigation in agriculture as part of its obligations. Goutham's paper traces the ways in which developed countries successfully introduced mitigation in agriculture to the negotiations related to climate change. Consequently, several global non-governmental organisations, multilateral institutions, and global philanthropies have joined developed country governments in advocating "nature-based solutions" in agriculture, including unscientific practices like zero-budget natural farming, in developing countries like India. In essence, these advocacies imply that Indian farmers must bear the burden of contemporary mitigation of carbon

emissions, even as science is clear that they have contributed next to nothing by way of cumulative emissions and rising global temperatures.

T Jayaraman, K Aparajay, Charu Chandra Devshali and Sreeja Jaiswal (p 71), in their paper, take this point forward to argue that a singular emphasis on mitigation-centric interventions, or mitigation-oriented interventions as co-benefits, diverts time and scarce resources away from the required investments in adaptation. They focus in their paper on the idea of "carbon markets" and the associated themes of carbon pricing and green credits. They provide a detailed review of emissions pricing instruments and emissions trading systems in the developed world. They find that most such initiatives do not cover agricultural emissions and conclude that there is "limited progress both in pricing agricultural emissions and in trying to mitigate agricultural emissions" in developed countries.

They then turn their attention to carbon pricing as a form of taxation. Their review of global experiences shows no benefit accruing to farmers from carbon taxes or cap-and-trade schemes. Instead, they warn that the promotion of large-scale carbon trading might weaken the efforts to ensure and maintain global food security. They also critically discuss the recent schemes in India that aim to facilitate carbon trading. According to them, it is doubtful if these schemes can be upscaled. Such schemes may end up raising input prices for Indian farmers. Given the predominance of small and marginal farmers, they could also present the government with a regulatory nightmare. In conclusion, they warn against "any rush to develop carbon markets in agriculture" in India.

We are happy to present this issue of Review of Rural Affairs to the readers of *Economic & Political Weekly*. I thank the editorial board of the journal for inviting me to edit this issue. As we put the issue into publication, we remember M S Swaminathan who passed away on 28 September 2023. The face of India's green revolution, Swaminathan's contributions to the use of science to advance human well-being are historic. This issue of the Review of Rural Affairs is a modest tribute to his memory and contributions.

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Public Agricultural Science and Yield Barriers in Foodgrains

A Long View on the Indian Experience

R RAMAKUMAR

A descriptive analysis of the building of a national agricultural research system and its role in increasing yield and production of foodgrains in India between the 1950s and the contemporary period is presented. The changing emphases of the scientific establishment in guiding plant breeding efforts given the refinement of technological tools and the larger policy and socio-economic context are traced. Assessing the long-term outcomes of India's green revolution, selected contrary views on the subject are responded to. Even in the absence of a transformation of production relations and the recent policy shifts that have fostered a crisis of profitability for small and marginal farmers, the achievements of the NARS facilitated a growth of productive forces in India's agrarian economy.

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From the late 19th century, advances in science and technology played a major role in raising agricultural growth and contributing to human well-being. At a fundamental level, these advances facilitated a shift from extensive agricultural growth to intensive agricultural growth. If clearing forests and fragile lands and bringing more land into cultivation—a thoroughly unsustainable pathway—was an inevitability of the past, the new strategy focused on raising productivity. Further, if uncertainty in outcomes was unavoidable in the earlier efforts at crop improvement, the new efforts bore results that were more predictable.

From the 1960s, India has been a site for considerable experimentation in, and refinement of, new agricultural technologies. Its green revolution was driven by these new technologies, supplemented by support measures like administered prices, input subsidies, cheap credit, and marketing support. The green revolution allowed India to overcome its "ship-to-mouth" status of existence prior to the mid-1960s and achieve self-sufficiency in the production of rice and wheat. Self-sufficiency also allowed India to enhance its political sovereignty; it could no longer be arm-twisted by imperialist powers to implement economic or foreign policies of their choice.

This paper is essentially a long view on the contribution of science and technology to food production in India between the 1960s and the contemporary period. First, the paper discusses the evolution of science and technology in agriculture under British colonial rule and soon after independence. Second, the paper reviews the institutional transformation in agricultural science between the mid-1960s and the 1980s. Third, the paper highlights specific achievements that spilled over into the 21st century, but in the context of the political economy of science policy under the regime of economic liberalisation.

Indeed, issues around science and technology in Indian agriculture are subjects of contentious debates. Arguments fall into polarised extremes, which unfortunately shrinks the spaces for more comprehensive analytical frameworks. This paper is not structured to respond to every argument raised in these debates. It refers to a few major criticisms of the path India chose to adopt but retains focus on the institutional changes in the conduct of science policy, and the changes science policy wrought on Indian agriculture. While there have been previous efforts towards this end, this paper tries to weave multiple analyses together into one longer-period narrative.

This paper does not delve into the policies of economic liberalisation in agriculture that have led to a state of agrarian distress in the Indian countryside after the 1990s. The author and a set of scholars have recently attempted to address those questions in detail (Ramakumar 2022). Here, the questions on science and technology are considered—not as delinked from economic liberalisation—but as evolving in that context with some relative autonomy.

Origins of Modern Agricultural Science in India

Globally, the birth of modern agricultural science—defined in terms of the discovery and substantive use of new technologies in agriculture—was a post-industrial revolution phenomenon. By the 18th century, the increase in the average size of the farms in England and North America had necessitated labour-saving mechanisation, and this became the motivation for the development of the plough, the seed drill, and the threshing machine (Ruttan 1977). Mechanisation intensified when steam power was applied to threshing machines, reaping machines, and water pumps. Crop rotations across cereals and legumes also were experimented with. But two developments in the second half of the 19th century truly revolutionised agricultural production: first, the new advances in chemistry pioneered by Justus von Liebig in the mid-1800s and followed up by John Bennett Lawes, Fritz Haber, and Karl Bosch; and second, the emergence of Mendelian genetics in the 1860s (Paarlberg and Paarlberg 2000).

With these two developments, agricultural science was ready for a take-off by the early 20th century. Yet, its progress was disrupted by the two world wars and the Great Depression. Consequently, it was only after World War II that large-scale adoptions of these technologies began in various countries including in the West.

'Extreme poverty and primitive technique': In India, the British colonial state adopted some supportive measures and established new institutions in the field of agricultural research and education (Randhawa 1983). The establishment of these institutions and other measures led to increasing appreciation of modern technologies in agriculture (Jayaraman 2016). However, the political intent of the colonial state could not be divorced from the nature of measures adopted (Nanavati and Anjaria 1947). First, the focus of research was closely linked to the commercial needs of the British state, as was visible in the interests in wheat, cotton, jute, and tea. Second, frequent famines in the late 19th century—followed by the reports of the Famine Commissions in 1878, 1897 and 1901, the John Voelcker Committee in 1889 and the Royal Commission of Agriculture in 1926—forced the colonial administrators to see the application of modern methods as inevitable to provide relief to the farmers.

It was no surprise then that the outcomes of these measures were uninspiring. Selected improved technologies were available, but neither were agrarian relations conducive to their absorption nor was a well-funded institutional network established for adaptive research and extension (Thorner and Thorner 1962; Pray 1981). Even by the late 1930s, not more than 10% of the cultivated area was sown with "improved varieties" of the period (Burt 1942). In food crops, yields were low, stagnant, and even declining at times and places; soil quality was deteriorating; seeds were of poor quality; regional imbalances were widening; large extents of cultivable land were left fallow; and irrigation facilities were underdeveloped except outside favoured regions like the canal colonies of North–Western India, or parts of Deccan peninsula with canals built by Arthur Cotton (Habib 2006; Thorner and Thorner 1962). As Rajani Palme Dutt (1955: 76) was to describe, Indian agriculture was marked by "extreme poverty and primitive technique."

The problems of India's agrarian society, which led Dutt and others to their grim analysis, were not just technical in nature. For Thorner (1956), agrarian relations of the colonial period—a complex of legal, economic, and social relations—entrenched a structure of disincentives that created a formidable block to agricultural modernisation; he called this complex a "built-in depressor." The built-in depressor had to be undermined through agrarian reform, which would, in turn, have expanded the incentives for agricultural investment. The technical problem, then, was closely intertwined with the political economy of agrarian relations, a link that would demand better appreciation in the post-independence years.

The post-independence tasks: The Great Depression, food shortages during the war and the Bengal Famine of 1943 had convinced leaders of the national movement of the need to strengthen India's rural economy. Its overarching precondition was a transformation of agrarian relations, which was the post-war lesson from China, Korea, and Taiwan. However, the grasp of this precondition was lost in the din of arguments that, on the one hand, traced the origins of India's food crisis to a population glut and, on the other, diagnosed the problem as purely technical (see Davis 1951 for the former; and Bowles 1954 for the latter). Both these arguments helped divert attention from the need for institutional reform as a precondition for broad-based technological modernisation (Ross 2003).

The diversion was hardly accidental. The design of American foreign policy, in the background of the Cold War, was heavily inclined to suggest a supply-side solution to India's food problem in gross disregard of the demand-side imperatives (Rao 1994). The class basis of the post-independence Indian state was also founded on an alliance with rural landlords, who eschewed institutional change. These political persuasions were reflected in the arena of agricultural science policy. To paraphrase Theodore Schultz, the transformation of traditional agriculture was not seen as requiring institutional change followed by or associated with a technical impetus; instead, it was seen as demanding a purely technical solution not necessarily linked with institutional change (Dantwala 1970). The leaning of the Indian state towards American assistance in agriculture must be seen and studied within this political context of the time.

Building a National Agricultural Research System

The context: Right since the early 1950s, India faced a deficit in the availability of foodgrains. In 1949–50, India imported

2.91 million tonnes of foodgrains, spending ₹150 crore in current prices (Planning Commission 1953). Assuming a certain rise in population and an unchanged per capita consumption, a target of 65.5 million tonnes of foodgrains was set for 1955–56. Also due to the momentum of the Grow More Food campaign that began in 1948, actual production increased to 66.8 million tonnes in 1955–56.

In 1960–61, a new target of producing 80.5 million tonnes of foodgrains was set. The actual production in 1960–61 was higher at 82 million tonnes. Looking back at the decade, the Third Five Year Plan document noted that "agricultural production has expanded by about 41%, and output of foodgrains by 46%" (Planning Commission 1961: 34). Per capita availability of foodgrains rose from 144.1 kg in 1951–52 to 157.6 kg in 1956–57 and 171.1 kg in 1961–62. Thus, the Third Five Year Plan set a target of 100 million tonnes of foodgrains for 1965–66. However, due to the drought of 1965–66, production did not exceed 75 million tonnes and per capita availability fell to 149 kg. Even if we discount the drought, trends in production between 1961–62 and 1964–65 were hardly inspiring.

The above trends in foodgrain production and availability have been read differently to argue that there was no food shortage in India in the 1950s and 1960s that justified any drastic policy shift (Stone 2023; Kumar 2019). That would be a wrong reading of the then reality based on a narrow and mechanical reading of official figures.

Two considerations must be highlighted in any analysis of the 1950s and the 1960s. First, population, average per capita income and foodgrain consumption were on the rise. Consequently, requirements of foodgrains were increasing at a faster rate than before. Requirements were increasing also because, with a rise in per capita incomes among a section of the society, there was a tendency to substitute "superior" foodgrains with "inferior" foodgrains. Thus, there was a "continued uptrend" in food prices in the second half of the 1950s; cereal prices in 1960–61 were 37% higher than in 1955–56 (Planning Commission 1961: 123). Prices rose because of the significant shortfall of foodgrain production in 1957–58 (a drought year) and 1959–60 (when production was 6 million tonnes less than in the previous year). According to the Planning Commission, foodgrain prices could have been even more unstable in the absence of imports under the PL–480 scheme.

Second, targets set for foodgrain production by the plans aimed for either an unchanging level of nutrient intake or a moderate rise in nutrient intake. In fact, nutritional deficit was acute in the 1950s and 1960s. Average per capita availability of calories (from cereals and pulses together) between 1951 and 1955 was 1,388 kcal per day (Namboodiri and Chokshi 1977). This average rose to 1,457 kcal per day between 1956 and 1960, and 1,489 kcal per day between 1961 and 1965. Even then, they compared poorly with the per capita daily recommended dietary allowance of 2,400 kcal for sedentary work and 3,600 kcal for very hard work as specified by the Indian Research Fund Association in 1944 (Patwardhan 1960), or of 2,250 kcal defined later as a nutritional norm.[1] As Schertz (1973) was to remark, "to lift India's diet to the level of Western Europe or the United States means three to four times the present consumption of cereals" (p 7).[2] This was the context in which the Fourth Five Year Plan identified "widespread malnutrition" as a serious problem, and noted that "where so many are undernourished, more food is the first step towards better nutrition" (Planning Commission 1969).

Terming the production and per capita availability of foodgrains in the 1950s as sufficient would be wrong for one more reason. Much of the rise in production during the 1950s was driven by an area-effect. The compound annual growth rates of area cultivated with all crops was 2.6% between 1951–52 and 1955–56, which fell to 1.3% between 1956–57 and 1960–61 and just 0.6% between 1961–62 and 1964–65 (Planning Commission 1969). On the other hand, yields were increasing slowly over the first and second plan periods. Yields recorded a compound annual growth rate of 1.4% between 1951–52 and 1955–56, and 1.8% during 1956–57 and 1960–61.

Even the moderate growth rates in yield were primarily due to improvements in minor irrigation, land reclamation and soil conservation, as well as higher application of fertilisers (Planning Commission 1961). Between 1950–51 and 1960–61, the net irrigated area increased from 51.5 million acres to 70 million acres that helped raise the share of double-cropped land; land reclamation was undertaken in about 4 million acres; land improvement was undertaken in 1.5 million acres; about 2.7 million acres were covered by soil conservation measures; and the consumption of nitrogen and phosphatic fertilisers rose from 62,000 tonnes to 3,00,000 tonnes.

All these impulses had limits. No significant extents of new area were available by the mid-1960s, and a significant yield-effect was the only possible way to expand—or even maintain—per capita production. To illustrate the imperative, Swaminathan (1977) referred to the Red Queen's Race in Lewis Carroll's *Through the Looking-Glass*, where the Red Queen told Alice: "it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!"

Indeed, the area under irrigation needed to rise further, but its impact on cropping intensity was circumscribed by the lack of availability of short-duration seeds. The expansion of double cropping also required seeds that were photoperiod-insensitive, that is, whose yields were less affected by changes in the length of days. The yield impacts of higher application of fertilisers were also limited by the fertiliser responsiveness of the old varieties. India's efforts to develop its building a national agricultural research system (NARS) must be studied considering such a wider set of agronomic and physiological constraints to increase production, and not based on pre-determined notions on the choice of technologies.

Collaborations and institution building: The first phase of establishing the NARS spanned from the early 1950s till the mid-1960s (Parayil 1992). The developments of this period were complex, and intertwined across global geopolitics, domestic political compulsions, and the advancements in technology. This paper does not focus on these political considerations of

global and domestic policymaking. Instead, its focus is on the process of institution building in agricultural science.

In 1954 and 1959, two joint Indo-American teams examined the functioning of the Indian Council of Agricultural Research (ICAR) and provided recommendations (NCA 1976). The Rockefeller Foundation and the Ford Foundation played an influential role in these deliberations. The Nalagarh Committee on reforming agricultural administration submitted its recommendations in 1958. Then, in 1963, an Agricultural Research Review Team recommended a reorganisation of the ICAR. In 1964, the ICAR was reorganised with an agricultural scientist as its director general. An Agricultural Research Service (ARS) was initiated to select and nurture agricultural scientists in the research institutions.

In 1949 itself, the University Education Commission, headed by S Radhakrishnan, had identified the Land Grant Colleges of the United States as a model for India (GOI 1962). The Radhakrishnan report led to an official contract with the United States Agency for International Development (USAID) to help develop agricultural colleges and rural universities. New agricultural universities began to be established in various states. In 1962, the Ralph Etienne-Cummings Committee drafted a Model Act for State Agricultural Universities.

In 1957, India invited the Ford Foundation to study its food problem; their report of 1959 became significant in the context of the drought in 1957–58. This report reached "the in escapable conclusion that an immediate and drastic increase in food production is India's primary problem of the next seven years" (GOI 1959: 3). The report estimated that, at the then rates of agricultural growth, there would be a supply deficit of 28 million tonnes of foodgrains by 1965–66.

The action plan suggested to address the supply deficit was significant: concentrate efforts on "selected crops" and "selected areas" (p 5). The selected crops were to be rice and wheat, and the selected areas were to be "the potentially most productive areas" (p 18), that is, areas "which have had the most rapid rate of increase in the recent past, and which have also the highest potential for rapid large increases …" (p 5). The report also recommended a more abundant use of chemical fertilisers alongside a "fuller use of manures, composts, and green manures."

The Ford Foundation report, thus, set the basic terms for the initiation of a pilot project in 1960–61 named Intensive Agricultural District Programme (IADP), which was later expanded into the Intensive Agricultural Area Programme (IAAP) in 1964–65. From 1966–67, the IAAP was made a national programme, which came to be called as the New Agricultural Strategy (NAS, henceforth) or in short, the green revolution.

Advances in agricultural science: What allowed agricultural scientists to hasten crop improvement was the global advances in the breeding of wheat and rice—particularly at the International Maize and Wheat Improvement Center (CIMMYT), Mexico and the International Rice Research Institute (IRRI), Philippines—under the aegis of the CGIAR (formerly the Consultative Group for International Agricultural Research). In wheat, Norman Borlaug was part of a Mexican–Rockefeller Foundation team that developed seeds resistant to stem rust in the Sonora valley of Mexico (Borlaug 2007). With better seeds and the restoration of soil fertility through fertilisation, Mexico had become self-sufficient in wheat production by 1958.

The success of Mexico was sought to be replicated in India in wheat to start with, and subsequently in rice too. There were three objectives that Indian scientists chose to pursue: (i) actively and consciously select new varieties based on potential for higher yields; (ii) breed new varieties that would respond to improved agronomic practices, such as presence of sunlight, availability of water and application of fertilisers, and not respond to variations in day length; and (iii) purposively select plants with a morphological architecture and a developmental pattern that were conducive to such responses (Swaminathan 1969).

Wheat: India had a relatively large cadre of agricultural scientists even before independence. The then IARI had developed two wheat varieties—NP 4 and NP 52—that yielded 3 tonnes per ha. In 1935, scientists led by Benjamin Peary Pal developed newer varieties of wheat—NP710, NP718, and NP770—that additionally had the qualities of resistance to stem rust, leaf rust and stripe rust (Pal 1966). Yet, the vexing question for wheat breeders was the preference among farmers for bold, hard, amber, and lustrous grains that also allowed for protection from weevils during storage (Swaminathan 1969). There were other problems too, such as the predominance of tall-statured plants that were prone to lodging, and susceptibility to loose smut.

That was when Swaminathan and his team of botanists at IARI learnt of the Norin-10 wheat variety from Japan, which were available with Borlaug in Mexico and had the traits of being short-statured and non-lodging (Menon 2000). Borlaug visited India in 1963 and became convinced of the possibility of crossing them with Indian varieties. The Mexican government agreed to provide these seeds to India in 1964. Yet, it was only after 1965 that India officially decided to adopt such a path under the NAS; in 1966, it imported about 18,000 tonnes of wheat seeds—of Lerma Rojo64A, Sonora 63, Sonora 64, and Mayo64—from Mexico (Borlaug 2007). The Indian team found that, combined with nitrogen application of 80 kg per ha, these seeds provided yields of 6 tonnes to 8 tonnes per ha in Indian conditions (Swaminathan 1969).

A new frontier had been opened in wheat yields. After several rounds of selections and segregations, the Indian varieties of Kalyan Sona, Sonalika, Safed Lerma, and Chhoti Lerma were released in and after 1967. The Mexican varieties were also crossed with Indian varieties like NP 875 and NP852 and bred as newer varieties with an expanded footprint of Indian landraces.

Rice: The scientific breakthroughs in rice came later. The indica subspecies presented formidable challenges to breeders: they were susceptible to lodging due to tall and weak straw; their record in trapping calories in cloudy monsoon seasons was poor; they were considerably photoperiod-sensitive; their utilisation of sunlight was poor due to leaves shading each other; and they were heavily infested with pests and diseases (Swaminathan 1969).

The Chinese scientists had identified a mutant variety of rice called Dee-gee-Woo-gen, which was dwarf, had erect leaves that allowed sunlight to pass through, was photoperiod-insensitive, and was devoid of seed dormancy (Siddiq and Vemireddy 2021). In 1956, Taiwan had crossed one of its tall indica rice varieties with Dee-gee-Woo-gen to produce Taichung Native-1 (or TN-1), which became the world's first semi-dwarf rice variety. The prototypes of TN-1, that is, IR-8 and IR-5 were brought to India from IRRI. IR-8 was already partly Indian, as it had Latisail—a Bengali indica rice variety—in its parentage (Swaminathan 1969). In India, it was crossed with a tall variety from Odisha called T-141, whose offsprings were Jaya and Padma followed by Hamsa, Krishna, Cauvery, Bala, Ratna, Vijaya CO-34, Jamuna, Sabarmati, Pankaj, and Jagannath.

Japonica rice varieties were also used in these crosses; in 1965, one such cross of an indica and a japonica variety produced ADT-27, a high-protein variety of 105 days duration, which yielded 5 tonnes per ha in Thanjavur in 1967–68. The success of ADT-27, Francine Frankel (1971: 90) was to write, "unexpectedly transformed the public image of Thanjavur from one of stagnation and failure to dynamism and success as the vanguard district of the green revolution in the rice areas." Thus, a yield of 8 to 10 tonnes per ha in rice looked realisable. A new yield frontier was opened in rice too.

Research inputs and outputs: The success in rice and wheat research would not have been possible without higher public investment in agricultural research. Public investment of the union government rose (Mohan et al 1973). But more important was the expanding role of state governments, which helped enhance the scope of location-specific breeding and trials. If the share of states in the total investment in agricultural research was 50% in the early 1960s, it rose to about 66% in 1968 (Evenson et al 1999). According to Swaminathan, the press also played a critical role; when journalists visited demonstration plots and "wrote ecstatically about the new opportunities opened up by the high-yielding varieties," it "put pressure on the state-level political systems" to increase resources allocated to agricultural research (Menon 2000).

Research output also expanded. The total number of publications by agricultural scientists rose from 1,564 between 1948 and 1954 to 3,456 between 1962 and 1968 (Mohan et al 1973). The number of publications per $100 million value of production also rose from 3.9 between 1948 and 1954 to 6.0 between 1962 and 1968. According to Swaminathan, "there was a genuine commitment [within the NARS] to poverty alleviation and to problems of national development in the 1950s and 1960s … Scientists and students were fired with a lot of enthusiasm" (Menon 2000).

Progress and diversification in the 1970s and 1980s: In wheat and rice, breeding techniques were refined to develop second-generation types by the late 1970s and 1980s. Research focused more on hybrids, where resistance to pests and diseases was stronger (Siddiq and Vemireddy 2021). In the 1980s and after, heterosis breeding increasingly incorporated traits from Indian landrace plant materials into the new varieties. In wheat, Evenson et al (1999) noted that

> in 1966–70, 14% of Indian varieties had two Indian parents, 71% had an Indian parent and a foreign parent, and 14% had two foreign parents. In 1986–91, 36% of the crosses had two Indian parents, 57% had an Indian and a foreign parent … and 7% had two foreign parents. (pp 31–32)

Some critics note that the NAS privileged "wide adaptability" in the new varieties rather than "local adaptability" (Baranski 2015). Baranski's argument is that seeds with wide adaptability perform better under irrigated and fertilised conditions. Hence, the NAS ignored developing seeds that fulfilled the specific needs of marginal and rainfed agricultures. Baranski's line of criticism is problematic for multiple reasons.

To begin with, there is nothing inherently wrong in choosing wide adaptability as a breeding strategy. Yet, agricultural scientists typically choose their strategies flexibly for different contexts and needs. On many occasions, widely adaptable seeds have had better consistency and performance than narrowly adaptable seeds. The reverse is also true in other instances. Indian breeders have never followed a single rule on what to choose for each agroecological context.

Second, to choose a trait—say, short-stature—as a desirable feature and endeavouring to introduce it across many varieties is not an inferior breeding strategy. In countries like India, marked by varied agroecological conditions, ensuring intertemporal and interregional stability of yields is an important concern. Ensuring yield stability becomes much more important in the context of volatilities induced by climate change. Given that lodging was a universal concern across rice and wheat growing regions, it was only appropriate that scientists looked for a common short-stature trait. Even then, scientists did not recommend one variety for all regions. The useful trait was typically incorporated in many experimental varieties, which were tested in multilocational trials and the best seed that had more than one useful characteristic—including universal and local features—was chosen and recommended for each agroecological region. In Punjab, different varieties of wheat were recommended for the north-western mountainous tracts to ward off the incidence of leaf rust. Unfortunately, in accounts like Baranski's, a caricaturisation of wide adaptability leads to a lack of appreciation of the complex steps involved in plant breeding strategies.

Third, as an illustration of her argument, Baranski makes a specific point about the wheat variety C 306. A tall variety suitable for rainfed conditions, C 306 is argued by her to have been widely preferred by farmers in states like Madhya Pradesh (MP). From this, she draws the inference that wheat varieties with wide adaptability were inferior to those with narrow adaptability. But C 306 was popular not just because it was heat-tolerant but also because it had good *chapati*-making qualities. In 2018, an ICAR document introduced C 306 with the following prefatory sentences: "yield enhancement has been the main aim of wheat breeding in India. However, quality

(consumer preference/grain characteristics) components were also given due emphasis in varietal development" (Gupta et al 2018: 1). More importantly, C 306 was developed by the undivided Punjab Agricultural University in 1962. Its release at the height of the IADP was itself evidence that Indian breeders did not privilege wide adaptability.[3]

Finally, the need to apply external fertilisers or irrigation to raise yields in the developing world is sought to be unreasonably demonised. The soil is not an infinite source of nitrogen and other minerals for the plants. External application of chemicals is necessary to supply and/or replenish adequate quantities of nutrients in the soil. If higher yields are an objective, such external application is an inevitability. It would then be the role of public policy to ensure that external inputs are made available at reasonable prices to the cultivators, and that overuse of chemicals is discouraged through effective extension networks that promote integrated nutrient management.

Basmati rice: The development of improved basmati rice varieties was another feature of the 1980s. From 1933, when Basmati 370 was released, its spread as a commercial crop was slowed down by persistent morphological constraints. But in 1989, building on the work of breeders in Punjab, Pusa Basmati 1 was released. Pusa Basmati 1 was the "world's first semi-dwarf, photoperiod-insensitive and high-yielding Basmati ricevariety" (Singh et al 2018: 2). From then on, research focused on developing superior grain length and linear cooked kernel elongation. These efforts bore fruit in 2003 when Pusa Basmati 1121 was released, a variety with wide adaptability that reduced crop duration from 160 days to 140–145 days and doubled yields from 2.5 tonnes per ha to about 5 tonnes per ha. Exports of basmati rice from India received a big boost with these developments from the late 1980s.

Oilseeds: In the 1980s, the impacts of public agricultural research spread into oilseeds. Given the absence of technological breakthroughs, India was importing about a third of its oilseed consumption in 1979–80. About 85% of oilseed cultivation in India was in rainfed areas with poor soils (MoA 1988). The crop was highly susceptible to pests and diseases. These features reduced the economic attractiveness of oilseeds as compared to rice or wheat. This was the context in which the Technology Mission on Oilseeds (TMO) was launched in 1986.

The TMO was designed to attain self-sufficiency in oilseeds by focusing on crop production technology, post-harvest technology, input support and price and marketing support (MoA 1988). Larger investments were channelled into research on "technologies related to genetic enhancement [and] crop and resource management" in crops like soyabean, groundnut, rapeseed/mustard, sunflower, and safflower (Chandel and Rao 2003: 4618). The focus was on developing varieties of oilseeds that had the potential for 20% to 50% higher yields, 6% to 25% higher oil content, resistance to pests and diseases, and maturing early by about 5 to 25 days so that farmers could sow one, or even two, additional crops annually. Significant levels of price support and protection from imports were also to be ensured.

Developments in the 2000s

In and after the 2000s, developments in agricultural research spread further to two more crops: pulses and maize.

Pulses: The area cultivated with pulses had declined after the late 1960s owing to substitutions with the relatively higher-yielding and profitable wheat and rice. Further, unlike rice and wheat, there was no assured minimum support price or procurement in pulses. Research was constrained by the absence of scope for heterosis breeding. Seed replacement rates were in the range of 2% to 7%. Farmers required short-duration "super-early" seeds in crops like chickpea (~60–70 days), pigeon pea (~120 days) and green gram (~60–65 days). Abiotic stresses were abundant as only about 15% of the cultivated area was irrigated. Biotic stress tolerance was also poor because of infestations of weeds, borers, rot, and wilt (Gowda et al 2015).

There were a few early maturing varieties of pulses from the 1970s itself, but it was in the 1990s that research accelerated and showed results. There were collaborations established between the ICAR, the Indian Institute of Pulses Research (IIPR), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and International Centre for Agricultural Research in the Dry Areas (ICARDA). Partnerships with ICRISAT yielded new varieties in chickpea and pigeon pea like JG 11 and JAKI 9218. Partnerships with ICARDA yielded new varieties in lentil, chickpea, and grasspea. Partnerships with the World Vegetable Centre yielded new varieties in green gram and black gram (Gaur 2021). Government schemes like the Integrated Scheme of Oil Seeds, Pulses, Oil Palm and Maize (ISOPOM) between 2002 and 2007, and the National Food Security Mission (NFSM) between 2007 and 2012 complemented these efforts (IIPR 2015). Higher procurement of pulses by the National Agricultural Cooperative Marketing Federation of India Ltd (NAFED) at a minimum support price helped farmers with a stable market and a remunerative price.

Maize: During the early-green revolution days, maize was expected to be the next success story after rice and wheat. Yet, for a prolonged period till the 1990s, the area cultivated with maize in India—used as food, feed, and fodder—was constant at around 6 million ha with a yield of about one tonne per ha. Research on maize was ongoing in the NARS from 1957 in multi-parent hybrids and open-pollinated varieties, but efforts at developing single-cross hybrids became the focus in the 1990s. Single-cross hybrids in normal maize, quality protein maize (QPM), babycorn, sweet corn, and popcorn had wider adaptability to varied cropping systems and management practices (DMR 2011). Given strong commercial linkages and hybridisation, a strong private sector also emerged in maize research.

In maize, the key challenges in breeding were not just to improve the genetic yield potential, but also to increase nutritional quality, improve the quality of speciality corns, create resilience to biotic and abiotic stresses, widen industrial

applications, induce resistance to pests and diseases, and minimise post-harvest losses.

Long-term Outcomes

Just as the strategy, the production achievements of the NAS too are contested. First, some argue that the green revolution did not raise production or per capita availability of foodgrains (Stone 2023; Kumar 2019). Second, others argued that the NAS was biased in favour of calories, as opposed to proteins, as evident from the fall of area cultivated with pulses (Anonymous 1973). Third, still others argued that coarse cereals were a casualty of the green revolution, which resulted in a disruption in the traditionally evolved cropping patterns and diets (Nelson et al 2019). Finally, it was argued that the NAS led to a promotion of unequal outcomes in the agrarian economy (Baranski 2015; Stone 2019).

Many of these claims are based on a one-sided and inadequate understanding of data as well as the technical and socio-economic context in which the green revolution unfolded in India. Others are hardly new inferences.

Trends in production: Conceptually speaking, an analysis of foodgrain production divorced from the area available for cultivation would be misleading. By the early 1960s, the rise in gross area being cultivated had tapered off. The real question, then, is: assuming no significant rise in yields, would per capita production have risen after the mid-1960s? If the answer is yes, the inevitable reason would have been a massive encroachment into fragile lands and forest margins. If such encroachment was checked, per capita production would have fallen. In other words, even to maintain per capita production, a fresh impetus to yields was essential.

In Figure 1 (p 40), I have provided three-year moving averages of area, production, and yield between 1950–51 and 2019–20 of six crops/crop groups: foodgrains, cereals, rice, wheat, coarse cereals, and pulses. The area cultivated with foodgrains remained largely stagnant between 1967–68 and 2019–20. But production of foodgrains rose sharply after the mid-1960s driven by a rise in yields—a phenomenon termed as the "genetic destruction of yield barriers" (Swaminathan 1968). Index numbers of foodgrain yields grew annually at 1.2% between 1949–50 and 1964–65, 1.8% between 1965–66 and 1980–81 and 2.6% between 1981–82 and 1991–92 (Ramakumar 2022).

The rise in yields led to green revolution's most important success: foodgrain production could be raised without increasing the area under cultivation. In Figure 2 (p 41), I have provided four possible scenarios for the requirements of cultivated area if foodgrain yields had risen at slower rates, and foodgrain production was to be maintained at the actual levels attained.[4] In 2019–20, India cultivated 127 million ha to produce 297 million tonnes of foodgrains. But to attain the same level of production, if yields had not risen at all after 1965–66, an additional area of 335 million ha would have been required to be cultivated; if yields had risen at 0.5% per annum, an additional area of 228 million ha would have been required to be cultivated; if yields had risen at 1.2% per annum (which was its actual rate of growth between 1949–50 and 1964–65), an additional area of 119 million ha would have been required to be cultivated; and even if yields had grown at 1.4% per annum, an additional area of 94 million ha would have been required to be cultivated.

In sum, India's green revolution could be termed as "forest-saving" to the extent of at least 94 million ha to 119 million ha after 1965–66.

Shifts in cropping patterns: While the area under foodgrains remained largely the same, there were internal shifts of area across specific crops (Figure 1). In rice and wheat, high-yielding seed technologies were readily available along with minimum support prices, which depressed the relative profitability rates in coarse cereals and pulses. Thus, due to substitutions with rice and wheat, the area cultivated with coarse cereals fell sharply while the area cultivated with pulses fell moderately. Even then, the increase in the total production of rice and wheat far outstripped a pure area-effect as yields rose rapidly after the early 1970s.

In rice, there was yet another factor that drove up national production in the late 1970s. There was a major increase in rice production in West Bengal that followed its tenancy reforms—or Operation Barga—undertaken after 1977–78 (Mishra 1991). These agrarian reforms, combined with an increased supply of bank credit, input support and rural electrification, were instrumental in West Bengal recording the highest agricultural growth rate among all states in the 1980s and 1990s (Ramachandran et al 2003). As Sen (1992) noted, "West Bengal, with a growth rate of over 7% per annum in agricultural value added—more than two-and-a-half times the national average—can be described as the agricultural success story of the eighties" (p 10). West Bengal's experience was demonstrative of the potential of green revolution technologies if they were preceded by, or associated with, agrarian reforms.

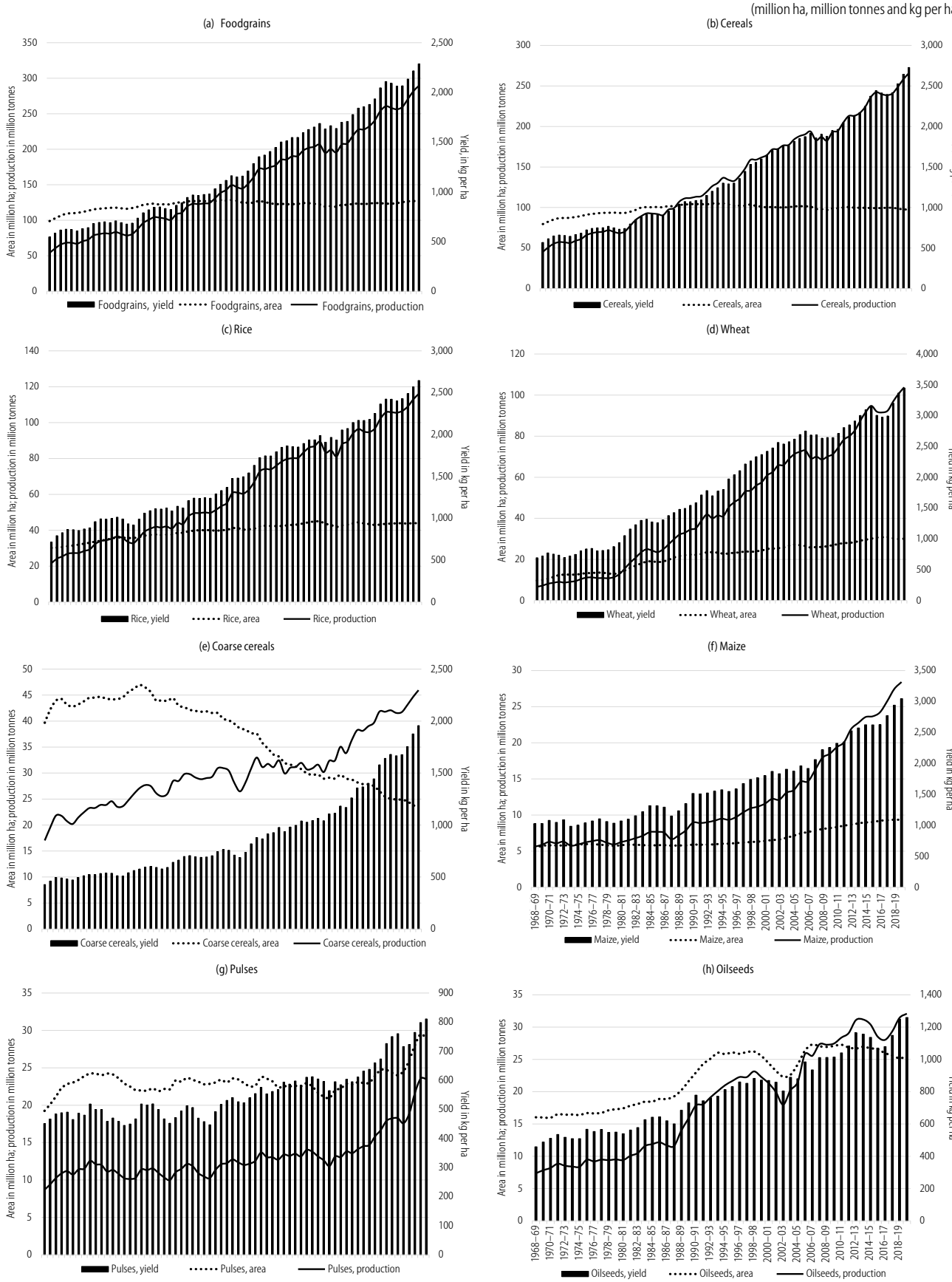
The decline in area cultivated with coarse cereals continued into the 1980s. But in the 1980s, coarse cereals were also increasingly substituted with oilseeds. The TMO was instrumental in driving such a change in cropping pattern in specific regions.

The average yield in oilseeds was 605 kg per ha in 1986–87. But by 1988–89, the average yield rose to 824 kg per ha (Figure 1). Supported by better price and marketing facilities under the TMO, higher yields incentivised farmers to shift from coarse cereals to oilseeds (Dantwala 1996). From 19 million ha in 1986–87, the area cultivated with oilseeds rose to 27 million ha by 1993–94. Dantwala attributed this rise in production, among other factors, to the "substitution of some low-yielding coarse cereals by oilseeds" in MP, Rajasthan, and Karnataka. In MP, new oilseed varieties that matured in 90 days occupied 1.6 million ha of kharif fallow lands by 1990; in Maharashtra, a new high-yielding variety of soyabean released in 1994—PKV 25—and that matured in 74 days allowed a second rabi crop of safflower, gram, or castor.

But the success story in oilseeds was short-lived. Area and production fell after the mid-1990s due to perverse trade policies that wiped out all gains from technologies (Figure 1). Trade in

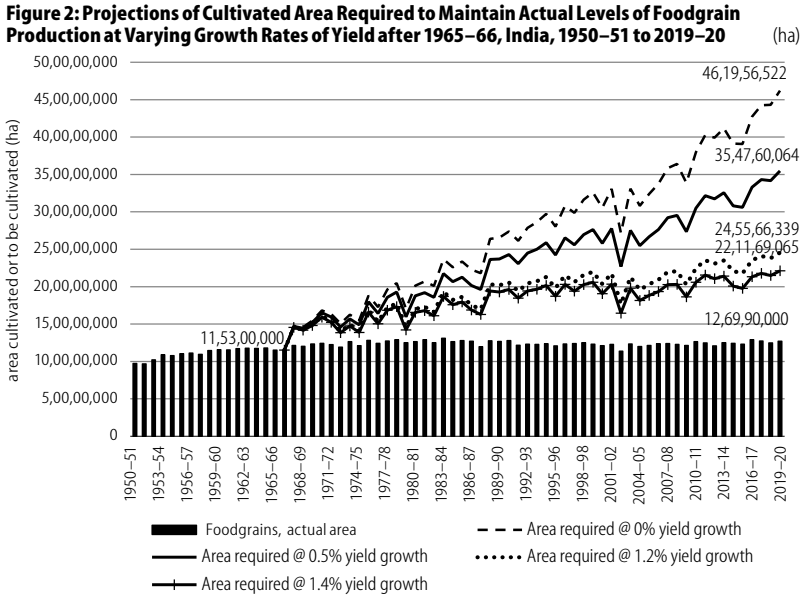
Figure 1: Trends in the Area, Production and Yield in Selected Food Crops, Three–year Moving Averages, India, 1950–51 to 2019–20

(million ha, million tonnes and kg per ha)



Source: *CMIE Economic Outlook*; Indiastat.

Figure 2: Projections of Cultivated Area Required to Maintain Actual Levels of Foodgrain Production at Varying Growth Rates of Yield after 1965–66, India, 1950–51 to 2019–20



Source: Computed from sources in Table 1.

oilseeds was brought under the Open General License (OGL) under the World Trade Organization's Agreement on Agriculture in 1994. Import duties were reduced. Cheaper imports flooded the Indian market; edible oil imports rose from 2 million tonnes in 1997–98 to 5 million tonnes in 2001–02 (Vyas and Kaushik 2020). Consequently, if India was close to self-sufficiency in oilseeds in 1998, it became one of the largest importers of vegetable oils a few years later. In short, a policy failure, marked by a free trade dogma, undermined a technological success story. Yet, even as the area cultivated with oilseeds stagnated, production rose after 2002–03 owing singularly to a continuing rise in yields.

Most importantly, the stagnation or fall in the production of coarse cereals and pulses in India was not permanent (Figure 1). Even when the area cultivated with coarse cereals fell, production rose from 31 million tonnes to 48 million tonnes between 1987–88 and 2019–20 due to a rise in yields. The story in pulses was one of a turnaround between 2000–01 and 2019–20; there was a rise in the area cultivated accompanied by a rise in yields, leading to a more than doubling of production. Similar was the case with maize, though the area-effect in maize was more moderate than in pulses.

In sum, agricultural research after the green revolution can no more be characterised as a rice–wheat phenomenon centred around north-western India. New technologies spread to new areas and new crops in the decades that followed. As yields continued to increase in rice and wheat, fresh yield impulses led to increased production in crops like (i) coarse cereals, even when there was a fall in the area cultivated; (ii) maize, where area rose moderately; and (iii) pulses, where area increased considerably.

The task of closing the yield gaps: While average yields rose in a range of crops over five decades, they remain below the "potential yield" in many states in most crops. Summary data in Table 1 show that average Indian yields in most crops in 2022 were lower than the best achieved yields across states, as well as the corresponding global averages.

Detailed and disaggregated data on yield gaps are available only till the mid-2010s (hence, would be at slight variance with those in Table 1). In rice, there were 11 states with average yields below 1 tonne per ha, of which five were eastern Indian states; eastern India accounted for 61.6% of the total area cultivated with rice in India (GOI 2018). In wheat, the range of yields were from 4.3 tonnes per ha in Punjab to 2.3 tonnes per ha in Uttar Pradesh (UP), that is, the yield gap in UP vis-à-vis Punjab was 46.5%. MP too had low yields in wheat at 2.9 tonnes per ha.

In maize, the range of yields were from 6.4 tonnes per ha in Tamil Nadu to 1.9 tonnes per ha in MP (yield gap: 70.3%), 3.2 tonnes per ha in Karnataka (yield gap: 50%) and 3.3 tonnes per ha in Telangana (yield gap: 48.4%). In sorghum, if the best yield was in MP at 1.7 tonnes per ha, the lowest yield was in Maharashtra at 0.6 tonnes per ha with a yield gap of 64.7%. In pigeon pea, if the best yield was in Gujarat at 1.1 tonnes per ha, the lowest yield was in Maharashtra at 0.6 tonnes per ha with a yield gap of 45.5%.

Clearly, there is enormous potential to raise yields in a range of crops in most Indian states. Closing the yield gaps are important for multiple reasons: first, they allow a rise in production without increasing the area cultivated; second, they allow a reduction in per unit costs of cultivation making possible higher profitability rates and incomes; third, as the same level of production can be attained from a smaller area, it becomes possible to divert land for other crops of improved environmental and nutritive value, and contribute to local food security.

Trends in per capita availability: The net availability of each crop can be obtained from the figures for gross production by deducting the needs of seed, feed and wastage and

Table 1: Comparisons of Yields in Major Crops, India and the World, 2022

(tonnes per ha)

Crop	Average Yield, India	State with Highest Yield	Global Average Yield	World's Highest Yield
Wheat	3.54	4.70; Punjab	3.47	7.82; Germany
Rice	2.90	4.34; Punjab	4.40	6.60; Australia
Maize	3.40	7.20; West Bengal	5.88	12.80; Spain
Pearl millet	1.43	2.53; Madhya Pradesh	0.92	1.43; India
Sorghum	1.10	3.37; Andhra Pradesh	2.55	4.92; Egypt
Chickpea	1.26	1.91; Gujarat	1.06	5.43; China
Lentil	1.00	1.46; Himachal Pradesh	1.00	4.44; Jordan
Soyabean	1.05	1.84; Andhra Pradesh	2.48	2.93; Brazil
Groundnut	1.69	2.61; Tamil Nadu	1.78	4.50; US
Mustard	1.47	1.99; Rajasthan	1.99	3.95; Germany
Sugar cane	84.00	105.00; Tamil Nadu	77.00	121.00; Guatemala
Cotton	0.44	0.64; Gujarat	0.81	2.27; Australia

Source: Pathak (2023).

Figure 3: Trends in the Per Capita Net Availability of Foodgrains, Three-year Moving Averages, India, 1950–51 to 2020–21 (kg per year)

Source: Indiastat.

exports, adding imports, and adjusting for change in stocks from the previous years. These figures are divided by projected annual population figures to estimate per capita annual availability (Figure 3).

The plots in Figure 3 may be summarised as follows: (i) In both foodgrains and cereals, the per capita availability rose between 1950–51 and 1965–66 driven by an area effect. Indicative of the extent of rise in population, though overall production rose, per capita availability did not rise between 1965–66 and 1985–86. Afterwards, the figures rose till 1997–98, fell till 2011–12 and then rose again till 2019–20. The peak attained in the late 2010s was the same as the peak attained in 1997–98.

(ii) In rice, the per capita availability rose from the mid-1960s till 1990–91, and then fell till 2019–20 even though rice production was rising over this period.

(iii) In wheat, on the other hand, the per capita availability rose till the mid-1990s and then fell occasionally but largely stagnated till 2019–20—again, even though overall production was rising.

(iv) In pulses, the per capita availability fell from the mid-1960s till 2008–09 after which it rose till 2019–20—even though the levels in 2019–20 remained lower than in the 1950s.

(v) In coarse cereals, the per capita availability fell from the early 1970s till 2013–14, after which it rose till 2019–20.

In short, a fair argument could be made that even when area cultivated with foodgrains had plateaued by the mid-1960s and population continued to rise, per capita availability could be maintained or even raised in a range of crops. In the case of foodgrains, cereals, rice and wheat, the trends in per capita availability in the period of economic liberalisation were not promising—indicating an urgency for policy to renew focus on raising yields. While the trends in coarse cereals and pulses in the period after 2010 were promising, there is a need to further increase production through fresher yield impulses and improved policy support.

The question of nutrient availability: It is an old wisdom that while all nutrient requirements of human beings could technically come from consuming one or two food items, the quality and richness of the diet is vastly improved by a diversified intake of food items. From the early days of the green revolution, a key critique was that the promotion of calorie-rich wheat and rice, and the reduction of area cultivated with pulses, led to a decline in the quality and quantity of proteins in the diets.

But another set of studies in the 1970s argued that this line of criticism was unfounded (Ryan and Asokan 1977). In the Indian diets, calories were the most important limiting nutrient. The supply of calories increased with the spread of the new high-yielding varieties of wheat, and rice. Higher availability of calories from cereals met the needs of energy production in the human body, allowing the availability of proteins from other sources to meet the needs of essential body functions more effectively. Ryan and Asokan argued that if there was calorie deficiency, a part of the proteins from other sources would have had to be diverted for the roles of energy production.[5]

But cereals supplied not just calories but proteins too. The new high-yielding varieties of wheat were not inferior in proteins. In wheat, before and after the green revolution, proteins accounted for a stable 12% on a wet basis and about 13% on a dry basis (DWD 2016). In some wheat varieties released after the 1960s, the protein content was estimated to be even higher at up to 14.3%. At the same time, within the protein content, while the presence of methionine, cystine, tryptophan, leucine and isoleucine were found to be higher in the post-green revolution varieties, the presence of lysine was found to be lower by about 6% (Ryan and Asokan 1977). The lysine deficiency in wheat was not considered a serious drawback then because lysine was not considered a limiting nutrient within proteins.

In short, it was argued that the priority given to calorie-rich high-yielding varieties of wheat (and rice) did not lead to any quantifiable protein deficiency. The problem, however, was the quality of the protein intake. The biological value of proteins in pulses was higher than the biological value of proteins in cereals, which demanded a yield-oriented strategy in pulses too. Recent developments in nutrition science have further underlined this requirement. Between the WHO/FAO/UNU Consultations of 1985 and 2007, the requirements of indispensable amino acids (IAA) were revised upwards by a multiple of

two to three. Overall, the IAA requirements for adult humans were increased from 93.5 mg/kg/day to 184 mg/kg/day (Swaminathan et al 2012). The requirement of lysine was also raised from 12 mg/kg/day to 30 mg/kg/day.

The revisions in the 2007 WHO/FAO/UNU Consultation demand that urgency is accorded to (a) the promotion of pulses and legumes in the cropping patterns and diets and/or (b) intensification of research to increase lysine content in cereals. On (a), as we discussed, the area, production and yield in pulses did rise in the period after 2000–01. The delay in success was owing primarily to constraints in breeding and secondarily to the absence of institutional support. On (b), scientists in the NARS note that increasing lysine content in wheat continues to present a challenge in genetics. But even if genetics succeeds, deriving all nutrients and amino acids from one source may not be desirable and is suspected to be the cause of diabetes, blood pressure, metabolic syndrome, and fatty liver. The optimum solution is that people derive many nutrients from one food, and every nutrient from more than one food.[6]

All said and done, the above discussion assumes that Indians receive their proteins—and especially lysine—from vegetarian diets alone. Apart from pulses and legumes, a higher consumption of animal proteins—from meat, milk, eggs, and fish—can also achieve a similar outcome. Especially for the non-vegetarian poorer sections of the population, higher availability of animal proteins can help better address the problem of poor protein quality in cereals. According to Shatrugna (2012), the dominant argument in the post-1947 nutritional debates in India was in favour of "least-cost … vegetarian" diets that ignored the relatively low biological value of crop proteins and subordinated the importance of animal proteins with higher biological value—branding them as "costly" (Harriss-White 2023).

Yet, more recent data show that the skewness against animal proteins too may be disappearing, at least at the margins. Between 1993–94 and 2020–21, the total supply of proteins from different food items produced in India rose from 24.7 million tonnes to 51.9 million tonnes (NABARD 2022). Though food items of crop and animal origin contributed to the higher supply of proteins, supply of animal proteins grew at a much faster rate than crop proteins. Over this period, if the supply of crop proteins increased by 82%, the supply of animal proteins increased by 272%. Consequently, per capita annual production of proteins increased from 28.3 kg in 1993–94 to 38.7 kg in 2020–21.

In other words, there is extensive potential to increase protein consumption through an integrated strategy of focusing on not just pulses and legumes but also on meat, milk, eggs, and fish.[7] At the same time, given the rising direct and indirect demand for cereal grains and the continuing and acute levels of mass undernourishment in calories, India must not prematurely dismantle the gains of green revolution vis-à-vis cereals. India needs more calories, and more proteins and fat in the immediate future. Of course, more land may be required to be set aside for the cultivation of non-cereal crops like pulses and legumes. Such land can only be found by closing the yield gaps in cereals.

Inequality and the green revolution: For all its technological advantages, the outcomes of the NAS were unequal and below potential.[8] Recent critical accounts of green revolution pose it as a new finding and miss the long history of this criticism in the Indian context. In his substantive critique of the Indian strategy from the standpoint of political economy, Rao (1994: 133) argued that the NAS was marked by a "failure of planners … to see agriculture as a strategic, system transforming sector." According to Rao, what was required was a "focus away from the supply side to the centrality of property relations and mass demand as a propellant for the whole economy." The NAS chose to circumvent this strategic choice.

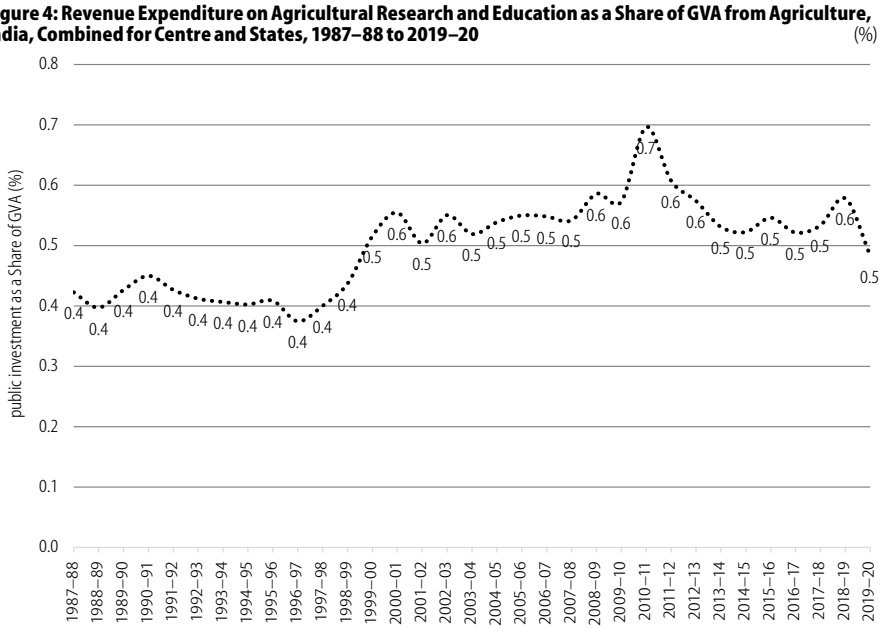
The spread and depth of diffusion of green revolution technologies—outside areas with a history of land consolidation—depended on the extent of implementation of land reform. Consequently, the benefits of green revolution were distributed unevenly with a "region-wise, crop-wise and class-wise concentration of production" (Patnaik 1975: 28). The NAS had chosen to bet on the best; it focused on regions well-endowed with irrigation, on just two crops (rice and wheat) and on sections of the peasantry that could mobilise the investment necessary for adopting the new technology. These three biases became the basis for rising agrarian inequality in India (Patnaik 1986).

There were scholars who held a contrary view. Following Theodore Schultz, Dantwala (1970) noted that "the transformation of traditional agriculture is a qualitative technical phenomenon." According to him, technical change under the NAS had rendered institutional changes like land reforms "practically sterile and ineffective." But Dantwala's "technocratic" view was rejected by others. Comparing Taiwan, Mexico and India, Raj (1969) argued that the transformation of traditional agriculture—*sans* institutional change—would amount to a promotion of dualism. Similarly, Chakravarty (1977) argued that the diffusion of agricultural innovations would be ineffective if the system of property rights "inhibits risk-taking or channelisation of scarce resources" (p 228).

In short, technological diffusion was indeed below its actual potential, especially in the early phases of India's green revolution. The example of West Bengal's agricultural growth in the later phase of the green revolution, based primarily on small and marginal farmers, was a demonstration of the utility of land reforms in helping accelerate technological diffusion.

The point, however, is that the burden of the Indian state's failure to initiate rural institutional change cannot be placed at the door of science. It is possible that scientists were less appreciative of the institutional pre-conditions for technological diffusion, and an argument could indeed be raised that this was an indefensible stance. Yet, among the five long-term challenges in Indian agriculture listed by the National Commission of Farmers, its chairperson Swaminathan listed "unfinished land reforms" as the foremost (NCF 2005). Globally, even when Malthusian warriors of American foreign policy

Figure 4: Revenue Expenditure on Agricultural Research and Education as a Share of GVA from Agriculture, India, Combined for Centre and States, 1987–88 to 2019–20



Source: Finance Accounts, CAG, various issues.

like Frank Notestein (1953) demanded that "immediate increases in the production of food" must be achieved by "minimizing the changes in the institutional organisation," agricultural scientists like Borlaug did not appear to concur. According to Borlaug:

> … agronomists alone cannot solve the problems of distributive justice in agriculture and cannot be made responsible for shortcomings in this regard … the new technology is not the primary cause of the social imbalances in the countryside in many developing countries. The imbalances are the result of all the social, religious, economic, and political forces which have governed villages for centuries. It is not the fault of the green revolution that because of the power structure in Indian villages … the land reforms approved by law about two decades ago have not been implemented, that security of tenure has not been given, that ceilings on land ownership are often still nominal, that the multitude of landless labour is growing … (Borlaug and Aresvik 1973: 400–01)

Shifts in the 1990s and After: The Political Economy

The discussion on agricultural research in the 1990s and after cannot be divorced from the new developments in agricultural science, such as genetic engineering and gene-editing. Parayil (2003) calls this a shift from "green revolution" to "gene revolution." The gene revolution had continuities with the green revolution but also broke sharply from it. Continuity came from the fact that "genetic modification is the history of agriculture" and that "all existing crops are genetically modified" (Herring 2007). At a basic level, the recombinant–DNA technology that drove genetic engineering enhanced precision and predictability in breeding. On the other hand, it was a break because the majority of investments in gene revolution came from the private sector. The recombinant–DNA technology was invented in 1973, but it was the patent protection offered to genetically modified organisms by the US Supreme Court in 1980 that incentivised a large inflow of corporate investment in research (Paarlberg 2000).

In the era of gene revolution, private research firms used intellectual property rights to enclose knowledge and block the free availability of germplasm for open research. Priorities in agricultural research shifted out of social goods—such as food security—and increasingly aligned with the interests of private profits and global finance. Globally, private sector research is considered by scholars as a poor substitute for public sector research. As Pardey and Beintema (2001) argued, private research covers "a small fraction of the needs of the poor," as their technologies are suited mostly to "capital-intensive forms of commercial agriculture with high value-added aspects off the farm." In India too, the private interests are confined to a few crops like maize, cotton, pearl millet, sorghum, and selected vegetables—with little interest in rice, wheat, or pulses.

If the private sector was interested in a few high-value crops, Pardey et al (2003) noted that "for the vast number of other crops, public and non-profit institutions are the principal source of genetic innovations in the foreseeable future." Unfortunately, the rise of private research in India has been accompanied by an undermining of public research.[9] A key indicator is the ratio of public investment in agricultural research to agricultural GDP. Across the developed world, the ratio stands between 2% and 3% (Byerlee et al 2003). The corresponding ratio for all developing countries is about 0.6% (Nin-Pratt 2021). In India, the ratio stood at 0.4% till 1996–97, rising to just 0.5% in 2019–20 (Figure 4). In other words, the Indian ratio was lower than the average for developing countries. During the ninth five year plan, a target of 1% was set for the ratio—an announcement that has remained only on paper (Ramakumar 2022).

Consequently, the role of India's public sector in fields like genetically engineered crops stands circumscribed. While several Bt cotton hybrids were developed by private firms, there are no Bt cotton varieties or hybrids developed by the ICAR available in the market. GM–Mustard, which was permitted to be commercialised in 2023, was developed by researchers in the University of Delhi and not from within the ICAR system. The GM–Rubber plant was developed by the Rubber Research Institute of India (RRII), which is under the Rubber Board. Crunch of funds—combined with regulatory intransigence—is threatening to cripple the NARS, and it is currently struggling to match the might of the private sector.

Reflecting on the crisis in the public sector, Swaminathan remarked in an interview that "the agricultural research system as a whole reflects the general malady of the country" (Menon 2000). If there was a commitment to end poverty and address national issues of development in the 1950s and 1960s, he

lamented that "our vision is getting narrower … we are getting increasingly parochial" (Menon 2020). The success of agricultural research depended on the effectiveness of cooperation and linkage between research, extension, input delivery systems and an assured and remunerative marketing policy. But the contemporary problem of agricultural research is that "the strands of cooperation [and] the linkages among various actors [are] getting weakened" (Menon 2020).

In an era where climate change and other related challenges threaten to undo the gains from agricultural science, there is an urgent need to upgrade public agricultural research. Improved adaptation requires that public agricultural research invests heavily in not just genetic engineering but also newer avenues like gene-editing to impart climate resilience to seeds, apart from other innovations like raising fertiliser—use efficiency, water—use efficiency, nanotechnology, integrated nutrient management and integrated pest management.[10] In the short term, then, public investment in agricultural research must rise to at least 1% of India's agricultural GDP. Fiscally conservative governments can evade this responsibility only at the peril of the future of India's agriculture.

Concluding Comments

This paper was a descriptive analysis of the contribution of modern science and technology to Indian agriculture with special reference to the role played by public agricultural science. It was not intended to be an exhaustive review of all the claims and criticisms related to the NAS. The focus, instead, was on the institutional development of the NARS and a study of the evolution of agricultural science within it—given the larger policy and socioeconomic context.

The short point in conclusion is that even in the absence of a transformation of production relations, the NAS led to a substantive growth of productive forces in India's agrarian economy. Even though poor levels of public investment in agriculture and policies of economic liberalisation led to a squeeze on the real incomes of cultivators and a slowing down of agricultural growth rates, there was a continuity in the long-run increase in the yields that contributed to the growth of foodgrain production without any fresh area being brought into cultivation. This aspect of sustainability within the strategy of "intensive agricultural development" in India remains underappreciated in the literature. Also, even as India faltered in ensuring distributional equity in food consumption and nutritional intake, the overall record of achieving self-sufficiency in food production was commendable. Data on projected demand for foodgrains show that India's foodgrain production must keep rising. In the absence of any new cultivable area, and in the background of the need for new land to be devoted to other crops and allied activities, closing the yield gap and enhancing performance potential must be central to a future strategy of agricultural development in India.

As closing the yield gaps and enhancing performance potential become central objectives of policy, a deeper appreciation and promotion of modern agricultural science becomes inevitable. But recent fallbacks on pseudoscientific solutions like natural farming are likely to undo the gains of the past and leave the goal of closing yield gaps impossible to achieve.

Given the importance of equity and sustainability in agricultural growth, and the increasing number of challenges in adaptation thrown up by climate variabilities, India's future strategy cannot also be dependent on private agricultural research. As this paper argued, India's public investment in agricultural research is lower than the average for the developing world and must be raised to at least 1% of the agricultural GDP in the short-term. Entering the emerging frontiers of agricultural science—like gene editing, to cite just one example—cannot be realised without a fiscally equipped public institutional network.

NOTES

1 The Indian Research Fund Association was renamed as the Indian Council of Medical Research (ICMR) in 1948.

2 As Madalgi (1968) showed, the share of India's rural population that suffered from high to medium levels of undernutrition was 33.1% in 1960–61 and 34.9% in 1964–65.

3 Baranski further raises the question of why wide adaptability failed in rice and maize as they did in wheat. The reason for the popularity of narrowly adapted seeds in rice is that cultivation practices in rice vary widely across agroecological regions. But there were significant exceptions too, such as Pusa Basmati 1121 (see next sub-section). Similar is the case with maize where its cultivation in the kharif season renders it susceptible to drought, heat, and waterlogging in different regions.

4 It must be clarified that this is a simple and purely illustrative exercise. It does not consider the demand side of actual requirements. It takes the actually attained production as the benchmark and, under different scenarios of yield growth, estimates the area that would have been required to produce the same quantity of foodgrains.

5 Proteins are used for energy production in the body when there is calorie deficiency. But if calories and proteins come from the same source, that is, rice or wheat, there is no availability of excess protein for energy production in the face of inadequate cereal intake.

6 I am grateful to Veena Shatrugna for this important input.

7 Ritchie et al (2018) further highlight this point—using the FAO's food balance sheets—by noting that if India's protein supply continues to come predominantly from crop proteins, and if yield gaps in crops remain as large as they are today, India may be unable to provide all macronutrients to its population in adequate quantities by 2030 or 2050.

8 The discussion in this section draws from Ramakumar (2022).

9 See GoI (2000) for an official statement on the promotion of private agricultural research in India.

10 If 2,279 new varieties were released under the ICAR over the past decade, 1,888 of them could be called "climate resilient"—a record that the private sector would find tough to match (Pathak 2023).

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Hybrid Mustard and Biotechnology

Pathways for Doubling Farmers' Incomes and Nutritional Security

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The government's decision to move ahead on the much-delayed genetically modified mustard developed by the University of Delhi signifies a turnaround and bodes well for the country's food system. Numerous tests over the last 20 years prove its safety for food, feed, and the environment in the Indian context. The resultant hybrid DMH-11 gives a yield advantage of 37% with the same level of inputs. Our analysis shows that the farming community will get 99% of the additional monetary gains, leaving only 1% to the seed companies. Establishing a hybrid seed production system through this approval is a breakthrough, and several new hybrids with higher yields and desirable characteristics might follow in the next few years that can lead to a turnaround in mustard production.

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Rapid discoveries in biotechnology provide new technological options to increase production and make food systems more sustainable (Qaim 2020; FAO 2022). This is particularly relevant for India, which feeds the largest population that is likely to reach 171 crore by 2048 (Nuthalapati 2020). Huge gains from biotech cotton commercialised two decades back notwithstanding, policymaking came to a standstill in terms of approving new biotech applications in agriculture, which negatively affects research, product releases, and productivity growth. The logjam in the issuance of regulatory approvals causes huge financial losses through foregone yield gains, ameliorating poverty, malnutrition and hidden hunger (Wesseler and Zilberman 2014; Wesseler et al 2017; Biden et al 2018).

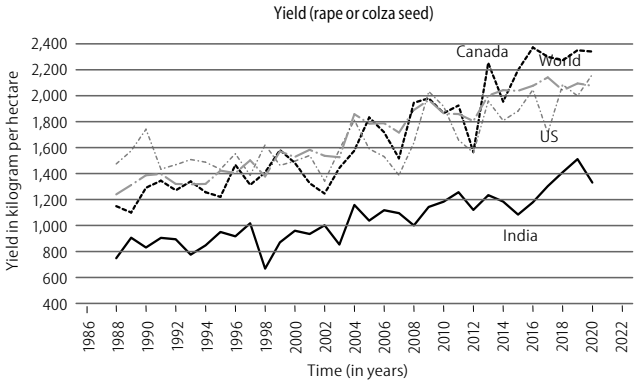
The conditional approval for the environmental release, of genetically modified (GM) mustard called Dhara Mustard Hybrid (DMH)-11 and its parental events bn3.6 and modbs2.99, given by the government in October 2022 signifies a shift in the policy stance adopted for more than a decade after a moratorium was imposed on GM crops in 2009 (Baksi 2022). GM mustard could become the second biotech crop to be released in India after Bt cotton and the first food crop to enter farmers' fields, if the additional hurdles of seed multiplication, post-release monitoring tests, and the ongoing litigation in the Supreme Court of India can be passed successfully.

The debate on GM mustard is confined mostly to newspaper columns and opinions, though it has occasionally spilled over into academic journals too (Gutierrez et al 2019, 2020; Pental 2020). On its part, the National Academy of Agricultural Sciences, New Delhi discussed it and resolved that GM mustard is safe (NAAS 2017). Despite the enormous significance of the decision to commercialise, there are no studies that critically analyse the GM mustard hybrid development and related issues. This paper examines the case for harnessing GM technology in mustard, its estimated yield advantage, its safety for food, feed, and the environment, likely gains for farmers and the nation, the evidence so far on the impacts of Bt cotton, and the potential of GM technology to improve the food system and promote its sustainability.

Why Genetic Modification Technology for Mustard Hybrid?

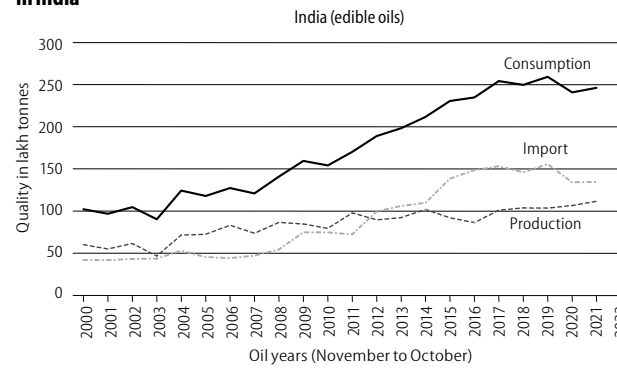
The history of crop production reveals the pivotal role of hybrids in improving yields, farmer profits, and achieving poverty reduction through food security. Prominent examples include the experience of the corn revolution in the United States (US)

Figure 1: Mustard Yields in India vis-à-vis Other Countries (kg/ha)



Source: FAOSTAT.

Figure 2: Surging Imports to Catch Up with Consumption of Vegetable Oils in India



Source: FAOSTAT.

in the 1940s (Griliches 1957) and subsequently of rice in China (Barker and Herdt 1985). Hybrid technology benefited several other crops like vegetables too. Leading oilseed producers, namely Canada, the US, the European Union (EU), and China shifted from open-pollinated rapeseed varieties to hybrids and thus broke yield barriers. In comparison, India's yields of mustard and other oilseeds have increased at much slower rates (Figure 1). The gap between edible oil production and consumption has even widened in India over the last 20 years, leading to rising and unsustainable imports (Figure 2). In 2022, imports accounted for around 60% of domestic vegetable oil consumption and required a whopping $19 billion (₹1,57,000 crore) of foreign exchange reserves.

Hybridisation results in hybrid vigour (called heterosis) and can catapult crop yields to surpass those of both parent lines. Breaking yield barriers and developing new cultivars with higher yields may require unlocking hybrid vigour by overcoming the narrow germ plasm diversity in the country. In this process, breeders at the University of Delhi discovered that the crosses between Indian and East European lines could lead to heterosis (Pradhan et al 1993; Srivastava et al 2001). However, they faced difficulties in achieving hybridisation by making cross-pollination possible in mustard. Mustard flowers contain both male and female organs and the crop is predominantly self-pollinating. This feature hinders the option of crossing two distant parent lines without specific control mechanisms. A cost-effective and less cumbersome option for hybridisation is the development of male sterility as an effective pollination control mechanism, along with an inbuilt mechanism to restore fertility. At the same time, it is critical to maintain seed purity while multiplying on a large scale for farmers' fields. Therefore, a workable hybridisation technology needs the three components of inducing male sterility, restoring fertility again after crossing, and then maintaining seed purity.

Conventional plant breeding (CPB) methods offer an opportunity in the form of cytoplasmic male sterility (CMS) to achieve hybridisation in self-pollinated crops. However, a CMS system has limitations for maintaining male sterility in large-scale seed production. The resultant male sterility with CMS system suffers from unstable sterility, ineffective fertility restoration, and yield penalties. Deepak Pental and his team initially endeavoured to employ the CMS system but could not stabilise male sterility in Indian mustard lines, except with Pusa Bold variety (CMS 126-1). Even with Pusa Bold, male sterility tended to break down in foggy and low-temperature conditions (Pental 2020). GM technology provides opportunities in such circumstances by inducing stable male sterility under all conditions, and the subsequent restoration of fertility to produce hybrids with pure seeds (Chand et al 2018). The resulting male sterility systems with GM technology lead to a versatile male sterility system with a wide range of adaptability.

The first GM technology-based male sterility system in rapeseed was developed by Celestine Mariani and her team at the plant genetic systems (PGS) in Belgium, leveraging common non-pathogenic soil bacteria in the early 1990s (Mariani et al 1990, 1992). The superiority and convenience of this technology found quick applications across countries and was successfully incorporated for rapeseed development in Canada (1996), the US (1999), and Australia (2008). Therefore, mustard breeders at the University of Delhi took recourse to the GM technology and developed the first GM hybrid, DMH-11, in 2002 employing the method developed by the PGS with some modifications (Jagannath et al 2001, 2002). It needs to be clarified here that University of Delhi owns this hybridisation technology and has patents for them.

Pental's research team was from a government university funded solely by public institutions. Among those funding the development of GM mustard were the Department of Biotechnology (DBT), and the National Dairy Development Board (NDDB). Financial assistance from the DBT-initiated public sector undertaking—the Biotechnology Industry Research Assistance Council (BIRAC)—enabled the safety testing process. Therefore, GM mustard is a product of India's public sector research.

Yield Gains with DMH-11 Hybrid

The field trials for testing the yield advantage compared the national check varieties of GM mustard DMH-11. These trials are undertaken as per the "Guidelines for the Conduct of Confined Field Trials of Regulated, GE Plants in India 2008" along with "Guidelines for Research in Transgenic Plants, 1998." All the trials were conducted in the universities or research institutes of the Indian Council of Agricultural Research (ICAR). The trails were monitored by the "Central Compliance Committee" constituted by the government with scientific experts

nominated by the DBT, Ministry of Environment, Forest and Climate Change (MoEFCC) and the ICAR.

The long list of field trials, ending with multilocation trials, revealed consistently higher yields over both the parents and local comparators (Table 1). The process of development of the transgenic DMH-11 hybrid comprised a series of field trials that started with confined field trials in 2004 followed by multilocation trials in 2006–07 and biosafety research level (BRL I) trials (2010–11 and 2011–12) and BRL II trials (2014–15) at various locations. Aggregation of results from the three BRL trials in eight locations showed yield gains of 37% over the national check variety. Further, the GM mustard hybrid yielded higher than both the parental lines, Varuna bn3.6 and EH-2 modbs2.99. That the resultant hybrid (DMH-11) yielded higher than both the parents was the essence of achieving hybrid vigour or heterosis. This finding was the proof of concept that the transgenic technology-based seed production system resulted in hybrid vigour and produced seeds that were heterotic in yield.

Table 1: Biosafety Research Level-I (BRL-I) and BRL-II Trials and Yield Gains in Different Locations for DMH-11 Hybrid vis-à-vis National Check and Parental Lines

(kilograms per ha)

Trials	Locations/Mean Yield	DMH-11 Hybrid	National Check Variety (Maya/ RL-1359)	Parental Lines	
				Varuna	EH-2
BRL-I trials in the first year (2010–11)	Kumher	2,285	2,057	1,866	1,793
	Naugaon	2,515	1,767	1,741	1,716
	Sri Ganganagar	3,000	2,287	2,670	2,182
	Mean yield	2,600	2,037	2,093	1,897
BRL-I trials in the second year (2011–12)	Kumher	2,892	2,195	2,375	1,873
	Naugaon	3,157	1,836	2,169	1,608
	Mean yield	3,025	2,016	2,272	1,741
BRL-II trials in 2014–15	Ludhiana	2,543	1,965	2,006	1,740
	Bhatinda	2,734	1,792	1,911	1,443
	IARI, New Delhi	1,879	1,571	1,746	953
	Mean yield	2,386	1,776	1,887	1,378

(1) BRL-I was conducted at three locations during 2010–11 and 2011–12 at Krishi Vigyan Kendra (KVK) at Kumher, Bharatpur, Rajasthan; Agricultural Research Station, Naugaon, Alwar, Rajasthan; and Agricultural Research Station, Sri Ganganagar, Rajasthan.
(2) BRL-II was conducted at three locations during 2014–15 at the Indian Agricultural Research Institute (IARI), New Delhi; Punjab Agricultural University (PAU), Ludhiana, Punjab; and Regional Research Station (RRS), PAU, Bathinda, Punjab.The field trial at Sri Ganganagar was discontinued prematurely (two weeks before harvest) in the CBRL I, second season trial.
(3) The trials were conducted under the overall guidance and supervision of the National Directorate of Rapeseed and Mustard, Indian Council of Agricultural Research, New Delhi.
(4) RL-1359 was the national check for mustard varieties/hybrids at the time of trial. Varuna and EH-2 were the parental lines for DMH-11.
Sources: GEAC (2016): Assessment of Food and Environmental Safety (AFES) (2016) for Environmental release of Genetically Engineered Mustard (Brassica juncea) hybrid DMH-11 and use of parental events (Varuna bn3.6 and EH2 modbs2.99) for development of new-generation hybrids, Genetic Engineering Appraisal Committee, Ministry of Environment, Forest and Climate Change, Government of India, New Delhi.

Achieving an efficient hybrid seed production system is a one-time breakthrough. The resultant parental events, bn3.6 and modbs2.99, could be leveraged to produce several new hybrids crossing recent varieties with greater yield advantages. DMH-11 is only the first-generation hybrid and subsequent development of hybrids will have even higher yields. The next generation of transgenic hybrids can usher in a further turnaround in mustard production and development, replicating the success in Bt cotton.

Developed in 2002 and delayed by more than two decades, DMH-11 is reminiscent of the delayed Bt cotton hybrids like MECH-12, 162, and 184 in the early 2000s. Several new varieties with higher potential were available in the market by the time these hybrids came out of regulatory processes, and questions were raised on the not-so-much higher yields. However, the second-generation Bt cotton hybrids dispelled doubts as companies dovetailed deregulated transgenic events, and the positive turnaround in cotton yields and production was proven. Similarly, DMH-11 will lead to many further higher-yielding hybrids in the course of time. Given the safety concerns, a higher yield itself is not adequate for the adoption of a plant hybrid. Therefore, we analyse the process followed for the development, the tests done for assessing the safety, the oversight mechanisms of the government, and its related issues in the subsequent sections.

Safety Issues in Transgenic Mustard

The regulatory system for GM crops in India is systematic, structured, and multilayered. They are established in compliance with the "Rules for the Manufacture, Use, Import, Export, and Storage of Hazardous Micro Organisms/Genetically Engineered Organisms or Cells, 1989" notified under the Environment (Protection) Act, 1986 (Nuthalapati 2004; Ahuja 2018; Navneet 2019). The GM mustard case went through this system of regulation, which is implemented by different committees of the DBT and the MoEFCC. On the one hand, the Review Committee on Genetic Manipulation (RCGM) functions as a body under the DBT, which reviews greenhouse/lab research-level data and recommends the conduct of field trials for event selection and BRL trials at the first stage. On the other hand, the Genetic Engineering Appraisal Committee (GEAC) functions under the MoEFCC as the apex committee for approving the conduct of confined field trials, including BRL II, the review of safety, and the commercialisation, including open field trials.

The GM mustard was subjected to this multilayered regulatory process for over 20 years. The GEAC, after prolonged testing, declared that the technology was safe for food, feed, and the environment and recommended the environmental release in October 2022 (GoI 2022). The details of these extensive tests, including their molecular characterisation, and their compositional, toxicological, environmental, and agronomic aspects, are provided in Table 2 (p 50). As can be seen from Table 2, all the studies were conducted at leading public sector laboratories and institutions like the ICAR Directorate of Rapeseed Mustard Research (DRMR), Bharatpur, the Food and Drug Toxicology Research Centre (FDTRC) of the Indian Council of Medical Research (ICMR)-National Institute of Nutrition (NIN), and the Council for Scientific and Industrial Research (CSIR), Institute of Microbial Research (IMTECH), Chandigarh.

Evidence on safety to food and environment: Evidence generated under these prolonged trials assured the safety of GM mustard for the use of its seeds and leaves (GEAC 2016). Experimental data showed that there were no unintended changes at the molecular level, leading to the conclusion that the plants were similar except for the desired changes. Compositional studies of the parental lines and DMH-11, following the molecular characterisation, endorsed the findings of the latter.

Modified parental lines, Varuna bn3.6 and EH-2 modbs2.99, were indistinguishable from their counterparts except for the

intended male sterility in Varuna bn3.6, while DMH-11 was the same as its handmade hybrid counterpart, VEH-2, with the same non-GM parents. The levels of glucosinolates, fatty acids, and other vitamins and minerals in the seeds and leaves were also similar. Toxicity studies, conducted at the FDTRC of the NIN, which administered doses several thousandfold higher than the estimated dietary exposure, revealed that the seeds or leaves did not pose any health problems. The study findings indicated that the three proteins were rapidly digested by pepsin in the human and livestock gut and hence posed no risk of allergenicity in food. Further, boiling leaves for two minutes degraded the proteins making them safe for food preparations like *sarson ka saag* and for use in Ayurvedic medicines.

Environmental studies also found no threat to biodiversity. GM mustard posed no weediness or aggressive growth patterns. Tests found the same level of foraging by honeybees and the presence of soil microflora. There was no interspecies gene flow. There were negligible chances of inter-species pollination with almost no chance of survival advantage in the absence of selection pressure.

Herbicide use for seed production: Even though Varuna (parental line), after the introduction of barnase gene, obtains male sterility, all its offsprings would not get the sterility trait because of segregation. Therefore, breeders had to physically remove all the plants without the male sterility trait to avoid self-pollination and maintain the purity of the seed. The bar gene was introduced to overcome this problem by conferring resistance to the weedicide, phosphinothricin. This enabled the breeders to spray the weedicide to remove plants that did not have male sterility and retain only those plants with the sterility gene; this would produce 100% pure seeds.

Breeders at the University of Delhi applied for the technology as a high-yielding crop and not as a herbicide-resistant crop. First, the farmers were not advised to spray the herbicide. Also, there was no packaging of the seed purchase with the herbicide purchase. Second, farmers were spraying the herbicide, gluphosinate, even before GM mustard arrived on the scene. Weed control posed a major challenge for mustard production in India and farmers faced labour shortages during the peak crop seasons (Gupta et al 2017). Third, before herbicides arrived on the scene, it were women who were employed in large numbers in the task of de-weeding, which involved drudgery and menial work.

Supply Chain, Sharing of Benefits, and Cost of Delay

The GM mustard technology was ready by 2016 when the GEAC came up with its assessment report. If introduced soon after, the seeds would have reached most of the mustard cultivated areas by now following the standard "s-curve," as vividly explained in Feder et al (1985), and as evidenced in the case of Bt cotton in India (Nuthalapati 2013).

The financial losses to the farming community due to risk-averse policies and delays in approvals of new technologies can be substantial. Studies show that reducing the approval time of GM crops results in generating economic gains, potentially contributing to reducing malnutrition and saving lives. It can also be an inexpensive strategy for attaining the Sustainable Development Goals (SDGs) (Wesseler et al 2017). Studies also document how the Indian government's perceived costs are substantially larger than the costs of introducing golden rice (Wesseler and Zilberman 2014).

In Table 3 (p 51), the foregone economic gains from GM mustard during the intervening period after 2016 are projected assuming two scenarios: likely yield enhancement of 25% and 35% with the introduction of the DMH-11 hybrid. This is juxtaposed to the likely area covered with GM mustard assuming an "s-shaped" adoption curve. The resultant losses of mustard seed production are monetised with the respective year's wholesale prices. Our estimates show that the cost of regulatory

Table 2: Detailed Tests Conducted for Developing Parental Lines, Varuna bn3.6 and EH-2 modbs2.99 and DMH-11 Hybrid and Aspects of Monitoring

Nature of Testing	Name of the Tests	Year	Overseeing Institution	If Government or Private
Molecular characterisation	Gene sequences, constructs, and molecular characterisation; expression studies of the three inserted genes—bar, barnase and barstar; cloning, expression, purification, and production of three expressed proteins	2000 to 2002	Experiments carried out by the Centre for Genetic Manipulation of Crop Plants, University of Delhi at the Premas Biotech Pvt Ltd, Manesar	Government
Research and development	Research and Development Phase, including primary field trials, 2004–07	2002 to 2007	All-India Coordinated Research Project on Rapeseed and Mustard under the National Research Centre on Rapeseed and Mustard, Bharatpur, Rajasthan under ICAR	Government
Field trials	BRL-I trials for two growing seasons (2010–11, 2011–12)	2010 to 2012	ICAR–DRMR, Bharatpur	Government
Food safety studies	Acute oral toxicity of the three proteins; sub-chronic toxicity of leaves and seeds containing the three proteins in rats; equivalence of the bar, barnase and barstar recombinant proteins produced in bacteria with that expressed in GE plants; bioinformatics analysis of the three proteins; peps indigestibility of the three proteins; heat stability of the three proteins; acuteoral toxicity of the three proteins in mice; compositional analysis	2011 to 2015	Food and Drug Toxicology Research Centre (FDTRC) of the NIN, Hyderabad	Government
Environmental safety studies	Weediness potential and aggressiveness parametres; crossability and pollen flow studies; impact on soil microflora during BRL-I and BRL-II trials; pollination behaviour, pollen morphology, and physiology	2011 to 2015	Conducted by Centre for Genetic Manipulation of Crop Plants (CGMCP), University of Delhi,Delhi and CSIR–IMTECH, Chandigarh of the CSIR	Government
Field trials	BRL-II trials for one growing season (2014–15)	2014–15	Directorate of Rapeseed–Mustard Research, ICAR	Government

All the results established that the parental lines varuna bn3.6 and EH-2 modbs2.99 as well as the resultant transgenic hybrid DMH-11 were safe for food, feed, and environment.
Sources: Compiled by the authors based on the documents submitted by the CGMCP, University of Delhi to the GEAC, Ministry of Environment, Forest and Climate Change, Government of India, New Delhi.

delays was large in the case of transgenic DMH-11 mustard. We estimate it to be ₹1,24,306 crore ($16 billion) over the nine-year period from when the technology was fully ready in 2016 till 2024 (Table 3).

How much of the additional economic gains are captured by the seed developers? The University of Delhi has already announced that it will license the technology to many companies with minimum royalty. A benchmark of 10% set forth by the IARI in a recent rice-breeding technology can be useful to predict. Even assuming a 25% yield increase, farmers will get 3.5 quintals per hectare (ha) of additional mustard seeds leading to a higher income of ₹21,167. On the other hand, the current average seed prices of ₹1,445 may go up by 10%, totalling up to ₹1,590. This will still leave more than ₹21,000 per ha of benefits to the farmer, while the seed companies will take 1% of the additional gains. Earlier studies showed that seed developers' share was 4% in the case of Bt cotton (Nuthalapati and Dev 2010) and similarly low in other countries (Qaim 2009).

Table 3: Foregone Yield, Production, and Monetary Gains Due to Delay in Approving Transgenic DMH-11 Hybrid from 2016–24

Year	Area Cultivated in Ha	Yield in Kgs/Ha	Wholesale Prices/ Quintal, in ₹	Projections							
				Likely Adoption Rate %	DMH-11 Covered Area in Ha	Additional Yield in Quintals		Additional Production Tonnes		Monetary Gains Foregone, in ₹ Crore	
						Scenario I (25%)	Scenario 2 (35%)	Scenario I	Scenario II	Scenario I	Scenario II
2016–17	60,74,000	1,304	4,113	5	3,03,700	326	456	99,006	1,38,609	407	570
2017–18	59,77,000	1,410	3,825	15	8,96,550	353	494	3,16,034	4,42,447	1,209	1,692
2018–19	61,24,000	1,511	3,868	25	15,31,000	378	529	5,78,335	8,09,669	2,237	3,132
2019–20	68,56,000	1,331	3,943	40	27,42,400	333	466	9,12,534	12,77,547	3,598	5,037
2020–21	74,65,507	1,368	4,641	60	44,79,304	342	479	15,31,922	21,44,691	7,110	9,954
2021–22	91,00,000	1,314	6,477	75	68,25,000	329	460	22,42,013	31,38,818	14,522	20,330
2022–23	98,00,000	1,307	6,473	85	83,30,000	327	457	27,21,828	38,10,559	17,618	24,666
2023–24*	1,00,00,000	1,330	6,470	90	90,00,000	333	466	29,92,500	41,89,500	19,361	27,106
2024–25*	1,05,00,000	1,330	7,000	93	97,65,000	333	466	32,46,863	45,45,608	22,728	31,819
Total								1,46,41,033	2,04,97,447	88,790	1,24,306

* Projected figures.

Source: FAOSTAT and DES, Ministry of Agriculture and Farmers' Welfare, New Delhi.

Further, production losses due to the delayed adoption amount to 15–20 million tonnes, which could have cooled the soaring oilseed prices and food inflation to help the poor. The additional production in 2024 would be equal to bringing around 3.4 additional million ha under the mustard crop. We have not factored in the likely release of the much more potent second-generation hybrids, and a potential surge in the area due to farmers' interest in mustard cultivation because of this spike in yields as had happened in several crops in the past. The high cross-substitutability and cross-price elasticity of mustard oil with soybean oil and palm oil are well-documented (Meena et al 2015; Santeramo and Searle 2019). The galloping mustard oil prices have forced people to shift to cheaper imported oils like soya and palm oils (Chakraborty et al 2022). Higher production and lower prices after the introduction of GM mustard are likely to bring back people to consume mustard oil, reduce India's import dependence, and lower vegetable oil prices.

The Bt Cotton Experience

A significant body of peer-reviewed research on the introduction of Bt cotton in India, with evidence from all cotton-cultivating states, shows positive yield gains, reduced pesticide applications, and higher profits (Crost et al 2007; Kathage and Qaim 2012; Herring and Nuthalapati 2012; Plewis 2019; Peshin et al 2021). The advent of Bt cotton increased yields in India because the bollworms were not effectively controlled earlier (Qaim and Zilberman 2003). Bt cotton adoption also contributed to poverty reduction (Subramanian and Qaim 2010) and employment creation (Subramanian and Qaim 2009; Nuthalapati and Dev 2009).

These results are consistent with studies elsewhere showing that the adoption of transgenic varieties led to an increase in cotton productivity, a reduction in pesticide use, and an increase in farmers' income, especially in developing countries (Klümper and Qaim 2014). Studies also show a reduction in greenhouse gas emissions and energy use (Bennett et al 2013; Qaim 2020).

India was a net importer of cotton in the 1990s. After the introduction of Bt cotton in 2002, India emerged as one of the leading exporters of cotton in the world, thanks to the significant productivity gains. Even though a comprehensive recounting of the benefits of Bt cotton is beyond the scope of this paper, it is worth reiterating that the introduction of this technology allowed for the doubling of Indian cotton yields in less than a decade, while it had taken 34 years from 1950 to 1984 to reach 200 kg of cotton lint per ha (Nuthalapati 2013). Nevertheless, ideological opposition against Bt cotton and faulty analysis about its impacts continue.

The claims that Bt cotton adoption has not caused yield growth and has led to a rise in pesticide use over time (as in Kranthi and Stone 2020) are largely based on unverifiable data, inappropriate statistical methods, and misleading interpretations (Plewis 2020). In their simple graphical analysis of time trends, Kranthi and Stone (2020) do not appropriately disentangle the effects of the Bt technology, input use patterns, and other factors that influence cotton productivity. Research with detailed micro-level data, and after controlling for confounding factors, clearly shows yield-increasing and pesticide-reducing effects of Bt cotton technology in India (Qaim 2020).

Despite the largely ideology-driven opposition to Bt cotton, farmers in India continue using this technology, even though conventional alternatives are still available (Flachs 2017). The fact that farmers continue to cultivate Bt cotton in more than 11 million ha demonstrates the technology's continued utility in raising cotton yields and incomes. The widespread adoption of Bt cotton has also resulted in area-wide suppression of Bt target pests, even benefiting non-adopting cotton farmers and farmers of other crops susceptible to bollworm attack (Wu et al 2008; Hutchison et al 2010).

One issue with Bt cotton is that—after a significant reduction of pesticide use in the first few years—farmers' use of chemical pesticides has increased more recently, which is largely due to

rising infestation rates of sucking pests (Peshin et al 2021). Pesticide use is still lower than it used to be before Bt cotton was introduced, but infestation of sucking pests has become a growing concern. While Bt technology effectively controls cotton bollworms, it does not control sucking pests. GM solutions to control sucking pests exist, but such varieties have not yet been commercialised.

It is worthwhile to examine further the debate around the question of increased pesticide use in Bt cotton in recent years. The latest study, using longitudinal primary data from Punjab, by Peshin et al (2021) showed that overall insecticide use went down substantially, though spending on fungicides and for sucking pests is higher. The analysis of cotton data from three north Indian states of Rajasthan, Punjab, and Haryana by Plewis (2019) revealed that there is good evidence that the introduction of Bt technology reduced the proportion of farmers' costs going to insecticides. Even the study by Kranthi and Stone (2020: 195) clearly showed that spending on insecticides for bollworms was much lower in 2018 relative to that in 2002, and that the spike was noticed in the case of sucking pests.

The problem, therefore, centres around issues with the incidence of other pests and diseases in cotton. While the farming community continues to prefer Bt cotton seeds for its effective control of American bollworms, research has come to a standstill with declining investments in breeding new hybrids in cotton because of organised resistance, seed price controls, and litigation (Pray and Nagarajan 2010). Monsanto withdrew its Bollgard 3 from the regulatory process in 2016, as did other companies for a few other applications. These new technologies could have addressed damages by pink bollworm and other pests. The Bt gene insertion also cannot solve other problems in cotton production, such as lack of irrigation or damage due to other pests and diseases. While Bt cotton is useful in addressing some problems, it should not be seen as a substitute for other innovations in agriculture. Stifling those innovations will only perpetuate the current yield stagnation and continued exposure to other pests.

Biotechnology in Perspective

GM crop cultivation has been continuing for more than 25 years with close to 190 million ha or 12% of the global cropped area under these crops in 2020 across 29 countries. Another 43 countries are importing foods produced from GM crops (ISAAA 2019). The farming community gained a total of $261 billion and reduced pesticide usage by 7% from growing these crops, with around 55% of these gains accruing to developing countries (Brookes 2022a, 2022b). Billions of people have consumed food from GM crops since 1996 without any verifiable adverse effects (Nicolia et al 2014; Smyth et al 2015).

GM crops are also not riskier than their conventionally bred counterparts, as has been confirmed by leading international bodies and science organisations, including, among others, the World Health Organization (WHO 2014), the US National Academy of Sciences (NASEM 2016), the American Association for the Advancement of Science, the UK Royal Society (2016), the European Academies' Science Advisory Council (EASAC 2013), the European Commission (EU 2010), the German Academy of Sciences (GNAS 2019), and the African Academy of Science (AMASA-9 2013). In 2016, more than a hundred Nobel laureates gave a call to end the opposition to GM crops to better enable humankind to fight against poverty and malnutrition (Roberts 2018).

Going beyond the four crops of soybean, maize, cotton, and canola, commercialised GM crops have extended to several other crops and traits like drought-tolerant (DT) maize in the US, golden rice in the Philippines, DT soybean in Brazil and the US, DT sugar cane in Indonesia, water-efficient maize in Kenya, virus-resistant beans in Argentina, Bt brinjal in Bangladesh, non-browning apple in the US, pod borer-resistant chickpea in Nigeria and Ghana and in other countries (Nuthalapati 2020). Certain new biotech crops may not even depend on foreign gene insertion, as a few desirable traits can also be achieved through gene editing without foreign DNA (Qaim 2020; FAO 2022). One needs to appreciate that the tools of modern science are warranted even to protect yields at the current levels against soil degradation, rising temperatures, adverse weather phenomena, and biotic and abiotic stressors (Zilberman et al 2018; Kovak et al 2022). These tools can also aid in ramping up the crop diversity that has shrunk with domestication and intensive selection for human-desired traits (Fernie and Yan 2019; Hickey et al 2019).

Addressing pests and diseases, meeting the challenges of food security and climate change, and increasing population require continuous technological upgrading and utilisation of advanced science. The discovery of DNA and the technologies it has spawned have revolutionised life sciences. Modern biotech has led to medical breakthroughs, including the development of effective vaccines against COVID-19. In agriculture, modern biotech has led to new, safe, and productive applications and can lead to even more interesting innovations needed to deal with the challenges of sustainable food security (Qaim 2020). Two decades of regulatory uncertainty around GM crops and inaction has exerted huge damage to breeding efforts for continuous yield growth and addressing pest resurgence, with poor developing countries bearing much of the costs (Bennett et al 2013). The conditional approval for the release of GM mustard signals a new opening that will benefit Indian and global agriculture and society.

Summary and Conclusions

The tools of biotechnology present an opportunity to produce sufficient quantities and desirable qualities of food and overcome the ominous portends of climate change. Harnessing biotechnology assumes significance given the tardy pace in achieving zero hunger and food and nutritional security under the SDGs. Despite significant income and welfare gains to farmers with Bt cotton, policymaking for further commercialisation of GM crops was in limbo in India for the last two decades. Policy inaction has already denied the farmers and consumers the benefits of the technology. The foregone losses due to the delay in allowing University of Delhi's GM mustard in farmers' fields between 2016 and 2024 amounted to a staggering ₹1,24,000 crore, apart from the costs to vegetable oil consumers due to higher prices.

Conditional approval for GM mustard can reinvigorate mustard production, and also the food system in general, if decision-making processes are not unreasonably hindered. The regulatory decision for the environmental release of the GM mustard hybrid system and DMH-11 has the potential to drive up farmer incomes and reduce import dependence. The second-generation hybrids harnessing the parental events, bn3.6 and modbs2.99, can ratchet up yields to global levels, develop mustard with low erucic acid and glucosinolates, and bring in the much-desired turnaround for edible-oil *atmanirbharata*. The six million mustard farmers in India stand to benefit directly through higher yields and incomes and many more million edible oil consumers stand to benefit indirectly through lower edible oil prices.

Breeders from domestic and public-funded universities developed the DMH-11 hybrid. The hybrid as well as its parental events have been declared as safe for food, feed, and the environment by the government after a plethora of tests over the last 20 years by the robust and multilayered regulatory system. This regulatory system comprises several committees working in compliance with domestic laws under the Environment (Protection) Act, 1986 and internationally as per the Cartagena Protocol on Biosafety (CPB). The GM hybrid seed production system was approved in the sister crop rapeseed (*brassica napus*) for cultivation in Canada, the US, Australia, and the Philippines; and for food and feed in several countries, including China, Japan, European Union, Mexico, South Korea, and Taiwan. It has been in use since 1996 and the oil and meal coming from the crop using this technology were consumed by billions of people without any known and verifiable case of adverse effects.

The widespread acceptance across different parts of the globe, including advanced economies such as Canada, the US, and Australia, indicates the safety of GM mustard. Any assertion on the contrary, devoid of any evidence, does not hold any ground.

Achieving improved self-sufficiency in oilseed production through yield-enhancing and price-reducing genetic modification crop technologies can no longer be overlooked in view of several welfare-optimising considerations. Evidence shows the inadequacy of promotional efforts like the National Oilseeds Mission, slashing import duties to as low as 5% and enhancing the area under mustard irrigation to 83% in 2019–20 from 66% in 2000–01 in propping up mustard yields and production. Moreover, edible oil consumption is crucial for essential and healthy plant-based fatty acids in rural areas (Mani and Kurpad 2016).

The alarming deceleration of income growth from crop cultivation, as borne by data from the recent Situation Assessment Survey (SAS) of the National Sample Survey Office's 77th round, makes it imperative to boost farm profitability. Our analysis from SAS data shows that the income from crop cultivation fell in real terms at the rate of 1.29% per annum between 2013–14 and 2018–19, following a rather subdued growth at 3.81% between 2002–03 and 2012–13. Evidence shows that farmers cultivating "orphan crops" like oilseeds, pulses, and millets bear the brunt of these falling farm incomes (Sharma 2018; Narayanamoorthy 2021). Technological breakthroughs in these crops will go a long way in reversing the slide in incomes of these crops. Several other studies concluded that policy focus should broaden in the development of all crops beyond rice and wheat to move towards achieving nutritional security (Pingali et al 2017).

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Dampening Sustainability

A Critical Review of the 'Alternative' Approaches to Sustainable Agriculture

SANDIPAN BAKSI

The sustainable development framework of the United Nations presents the possibility to orient and expand the ends and means of sustainable agriculture and build consensus around it. The approach of alternative agriculture that has grown in the last few decades prevents this consensus building. A few fundamental features of the paradigm—undermining the importance of agricultural productivity, lacking in appreciation for the critical role of agricultural science and technology, and romanticising the traditional systems of knowledge and organisation of production—harm the cause of sustainable agriculture. They appear to threaten the foundational understanding of sustainability defined in anthropocentric terms, one that strives for integrating intra- and inter-generational development and justice.

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The idea of sustainable agriculture, though not novel, has grown in scope and prominence in the contemporary context. On the one hand, parts of the world are marked by the persistence of widespread hunger despite the remarkable developments in agricultural production. On the other hand, there is a growing concern around anthropogenic global warming or climate change. Consequently, there is a felt need to develop climate-resilient, sustainable farming systems for the future that can ensure food and nutrition security. The increasing number and growing reach of the new discourses on sustainable agriculture reflect this context. These discourses arising from different parts of the world are voiced by social activists, agricultural scientists, environmentalists, social scientists, bureaucrats, political parties, multilateral institutions, and civil society at large.

Nevertheless, the meanings associated with sustainable agriculture are often different and, at times, conflicting too. The sustainable development framework of the United Nations (2015), as amplified in Goal 2 of the Sustainable Development Goals (SDGs), is a reasonable attempt to draw a consensus. Goal 2 essentially understands agriculture as a productive activity that must provide food and nutrition security for all, and income support for all producers, in a manner that is resilient to climatic shocks and environmentally sustainable. The dimension of environmental sustainability is, evidently, seen in conjunction with the productive dimension of agriculture.

Against this background, a few approaches, such as alternative farming, natural farming, and agroecology, have emerged that appear to disrupt the consensus around sustainable agriculture as understood in the SDG framework.[1] Notwithstanding the differences in nomenclature, their evolution and prescriptions reflect an influence of specific theoretical frameworks like "post-development" and "postmodernism." This paper is an attempt to critically discuss some defining features of these alternative approaches that are disruptive to the much-needed consensus on sustainable agriculture.

The origin of the idea of sustainable agriculture goes back to the early decades of the 20th century. Its evolution followed a trajectory that ran parallel to the development of modern scientific agriculture. While the development of modern agricultural science and technology in production was driven by the need for expanding the production of food, fibre and fodder using lesser resources like land, the proposed alternatives

were shaped by world views like "holism," "ecosystems," and "learning from nature," giving rise to practices such as biodynamic agriculture and organic farming (Harwood 1990).

The remarkable successes in production achieved by scientific agriculture during the 1960s and 1970s increased the fissure between these two paradigms in agriculture. On their part, members of the scientific community recognised, notwithstanding their successes, the limitations of scientific agriculture in distributing economic gains, and its potential adverse impacts on environmental health. Such a recognition led to attempts to incorporate themes like soil conservation in the agenda of scientific agriculture.[2] This recognition, perhaps, marked the beginning of a long-drawn effort (that continues) to develop a consensus understanding on sustainable agriculture. These efforts gained in strength in the 1980s, with a concerted attempt to define sustainability in anthropocentric terms and expanding the scope of developmental concerns to the future generations (United Nations 1987).[3]

Following the basic framework of sustainable development, as defined by the Brundtland Commission (United Nations 1987), sustainable agriculture was defined as a system of agriculture production that could satisfy the food, nutrition, fodder, and fibre needs of all human beings, and provide adequate livelihood to all those involved in it in the current generation, without harming its capacity to do so for the future generations. Goal 2 of the SDG framework—"end hunger, achieve food security and improved nutrition, and promote sustainable agriculture"—was a concrete expression of such an understanding (United Nations 2015).

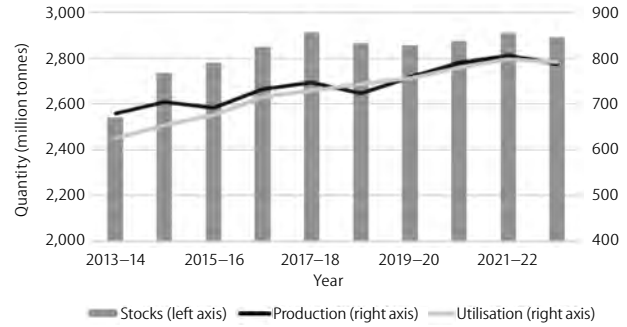
Since 1987, the idea of sustainable agriculture has grown in prominence and evolved in myriad directions, and even more so in the context of climate change. Today, there are a multitude of strategies, approaches, and action items proposed to achieve the objectives of sustainable agriculture. While varying in nuances, many of these interpretations appear to draw on the framework of sustainable development, reflecting thereby the gradual emergence of a consensus around the UN's SDG framework.

The alternative agricultural approaches, however, have continued to survive under various names. More recently, these approaches have gained importance and begun influencing popular discourses on sustainable agriculture, particularly in the context of anthropogenic climate change. While intentions and concerns may often be genuine, many prescriptions of these alternative approaches militate against some of the most fundamental understandings of sustainability as summarised in the SDG framework.

Centrality of Agricultural Productivity in Sustainability

The approaches on alternative agriculture betray a peculiar disdain towards agricultural productivity (Rivera-Ferre 2012; Patel 2013; Raina 2015). There is an evident lack of appreciation for the crucial role played by the gains in agricultural productivity in achieving a more food-secure and environmentally sustainable world than in the past.[4] The focus on land productivity is regarded as a modern technocratic fetish that treats production as an end in itself. The green revolution of the 20th century is perceived as "an environmentally unsustainable and socially exclusive agricultural model" that was derived from a "productivist philosophy" (Sarandon and Marasas 2017; Zabala and Panagiotopoulos 2021).[5]

Figure 1: Cereal Production, Utilisation and Stocks



Source: https://www.fao.org/worldfoodsituation/csdb/en/.

The disregard for productivity seems to draw from two separate strands of arguments.

Higher productivity for a food-secure future: The first strand claims that the contemporary world is already food, or calorie, abundant; therefore, the problem of food insecurity is essentially a case of hunger amid plenty. Concerns regarding shortages in the overall supply of food are invalid, and global food insecurity is essentially a problem of distribution, not production.[6] The problem of hunger can be resolved by better redistribution of food and reduction of food wastage.[7] It is also implied that the maintenance of an adequate stock of food did not (and does not) require advances in productivity.

The system of agricultural production across the globe underwent a remarkable and irrevocable change by the mid-20th century. With the large-scale adoption of modern science and technology, productivity in agriculture experienced a quantum jump. These developments led to a growth in agricultural output. They also spared large areas of land from being converted to farmland. Blomqvist et al (2020) report that "since the 1960s, new technologies and practices associated with the 'Green Revolution' raised yields to such a degree that crop production was increased by 250% even as cropland area only expanded by about 15%." The widespread hunger that continues to haunt humankind (and that has, in fact, worsened in the recent years [FAO 2021]) does not diminish the achievements in the availability of, and access to, food made possible due to the quantum jumps in productivity. The continuing problem of hunger is, in fact, an outcome of inequities in the distribution of the gains in production and productivity—a concern that assumes importance only when there is enough to distribute.

Notwithstanding the global expansion in stocks, it would be naive to imagine that humankind has achieved a state of global food abundance maintainable in the future without increases in productivity even if the population is growing and more land is diverted to non-agricultural uses. This is even more true in the face of the fact that the productivity in many major

crops, such as maize, rice, wheat, soybeans, and sugar cane, have experienced minimal growth in the last couple of decades, and are predicted to decline in the future with global warming (FAO 2017). The FAO estimates show that the annual cereal stocks have been stagnant, in the range of 600–850 MT, over the last decade (Figure 1, p 56). The cereal utilisation levels have on occasions been higher than the production levels, leading to a depletion of the stocks. The annual cereal utilisation levels, as per FAO estimates, hover around 2,800 MT, which means that the stock levels are sufficient to sustain the cereal needs for just about four months.

Unsurprisingly, the availability of food is not evenly distributed across the globe. Many less developed economies, particularly in Africa, suffer from low yields and are not abundant in terms of domestic food production and supply. Average cereal productivity in Africa is "half that of India and one-fifth of the yields in the US" (Ritchie 2022). They continue to depend heavily on cereal imports from the developed countries for domestic food security.

Self-reliance in food production at the national level continues to be a critical goal, even in a world defined by international trade in agricultural commodities. The risk of food insecurity faced currently by many African countries due to the disruptions in food supply (particularly in wheat and maize) is evidence of the risks of overdependence on international trade for food security (Smith 2022). Even a single knee-jerk reaction by a grain-exporting country, driven by compulsions of domestic politics, can push many poor import-dependent countries to the brink of food insecurity.[8] The evident lack of self-reliance in production in countries with low productivity shows the need, and scope, for expanding productivity in such countries. Remarkably, some studies suggest that in the last few decades, there has been a general shift of crop production to countries with lower productivity, which in turn has had a negative impact on global food output (Blomqvist et al 2020).

The need for higher productivity becomes even more stark when one considers the future challenges to agricultural production. The FAO (2017) estimates that by 2050, the world will need to produce almost 50% more food, feed, and biofuel than it did in 2012. It projects that feeding a world population of 9.1 billion people in 2050 implies that food production in developing countries must double from that in 2005–07. It elucidates further that:

> this implies significant increases in the production of several key commodities. Annual cereal production, for instance, would have to grow by almost one billion tonnes, meat production by over 200 million tonnes to a total of 470 million tonnes in 2050, 72% of which in the developing countries, up from the 58% today [2005–07]. Feeding the world population adequately would also mean producing the kinds of foods that are lacking to ensure nutrition security. (FAO 2009)

These projections are, of course, far from accurate as they are based on several assumptions. Nonetheless, they point to the need for a consistent expansion in food output. This need for a growing population must also consider the greater pressures on resources like land and water available for agriculture, which are likely to result from growing urbanisation and industrialisation (Bren d'Amour et al 2017). Climate change may also add significantly to the pressure on natural resources available for farming. The effect of climate change on productivity across crops and regions adds yet another level of uncertainty to the future of food output (Jayaraman 2011). The current trends of productivity in major global crops may prove to be insufficient to address the food needs of the future, given these considerations (Ray et al 2013). Future food production also needs to account for the fact that with growing incomes, countries tend to shift their composition towards crops that are relatively lower yielding.[9] These shifts in diet would naturally imply the need for increasing the output and productivity of other non-cereal crops.

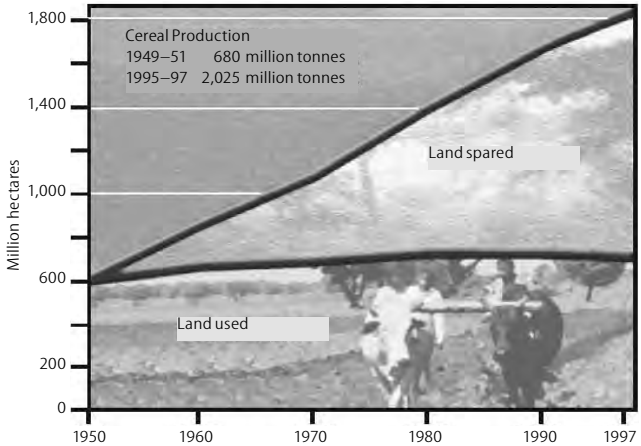
We need, among other things, higher agricultural productivity to produce more food for an increasing population, with lesser natural resources.[10] No doubt, food security requires better food distribution and equitable access to food than what corporate agriculture and government policies shaped by neoliberalism have allowed for. But better distribution, by itself, cannot fulfil the need for more food output. The inability of capitalist food systems to ensure fair and just distribution of available food cannot be an argument against the need for higher agricultural productivity.

Higher productivity for environmental sustainability: The second strand of argument is one that resolutely ignores the complexities in the interactions between agricultural productivity and environmental sustainability (Balmford et al 2018; Smith et al 2019). A priori, it appears to pitch productivity against environmental sustainability. Productivity is seen as intrinsically opposed to, or, at best, in competition with sustainability, or one that must be sacrificed at the altar of the latter.

The possibilities of convergence between higher productivity and environmental sustainability are completely ignored in this approach. The most evident positive impact of boosting productivity on environmental sustainability is in terms of sparing natural habitats from being converted into cropland. The tenet of environmental sustainability inevitably necessitates the need for ensuring higher levels of food production without expansion in cropland through deforestation. The "land-sparing" effect of higher productivity continues to invoke meaningful debates (Mathu and Smith 2023). Notwithstanding one's position in the debate, it is undoubtedly clear that greater productivity plays an important role in dealing with the dual challenge of achieving higher food production while preserving biodiversity. Without consistent improvements in resource-use efficiency in general, and crop productivity in particular, it will be logically impossible to attain food and nutrition security for a growing human population with a sustainable footprint.

A significant extent of land was, in fact, spared from being used for cereal production in the second half of the 20th century due to higher productivity attained through improved technology (Figure 2, p 58). Just about 11% of the overall increase in crop production in the last half a century or so can be attributed to the expansion of cropland area (Blomqvist 2022). Recent

Figure 2: World Cereal Production—Area Saved through Improved Technology, 1950–98



Source: N E Borlaug, Special 30th Anniversary Lecture, Norwegian Nobel Institute, Oslo, 8 September 2000.

studies argue that the world may have passed the "peak agricultural land," leading thereby to a decline in global land use for agriculture, even though the total food production is higher than ever in history (Ritchie 2021, 2021a).

Higher productivity can also be a possible pathway to enhance incomes from agricultural production. Agricultural productivity is an important driver of structural change in an economy (McArthur and McCord 2017; Pingali 2012). Countries like Vietnam have seen recent successes in this direction (Johnson 2022). Investment in appropriate seed and irrigation technology by the government helped Vietnamese farmers to produce more, and sell more through a controlled market mechanism, which has, in turn, led to higher incomes (Johnson 2022). Notably, a stable economic environment for the farming population may help advancing the cause of sustainable agriculture in many ways.[11] This is an aspect that certainly awaits further exploration.

Disapproval of Science and Technology

Apart from a disdain towards productivity, proponents of alternative agriculture dismiss the role of modern science and technology in bringing about more sustainable agricultural production.[12] This tendency, arguably, emanates from a reductionist understanding of the nature of the interplay between the functioning and evolution of science and technology, and the overarching structure of capitalism under which it operates. Modern science is often perceived by these resurgent discourses as one of the many systems of knowledge, one that operates as a handmaiden of capitalism—and nothing more—and, therefore, enjoys a status of privilege.[13]

The emergence of agricultural science and technology: The beginning of the application of science and technology to agricultural production goes back to the systematic crop experiments in the Rothamsted experimental station, in mid-19th century England (Blaxter and Robertson 2007). This was followed by the application of the burgeoning science of statistics on the data generated through these experiments. These developments gradually introduced the idea of precision in farming practices, thereby reducing the level of uncertainty associated with agriculture. This was perhaps the beginning of the transition of agriculture from an empirical craft to a productive activity informed by scientific principles and methods—principles that often built upon the empirical knowledge of the craft.

The science of chemistry was also gradually beginning to be applied to different aspects of agriculture by the mid-19th century (Blaxter and Robertson 2007). It was established that plants absorb their nutrition from soil, and that nitrogen was one of the essential elements for plant growth. Soil science evolved further with attempts to prepare taxonomies of soils, leading eventually to soil surveys and preparation of soil maps. These initial endeavours gradually led to a leap in the knowledge of soil and plant nutrition. The need for maintaining the fertility of soil through the application of external inputs, such as manures, was also established by the mid-19th century. Rothamsted experiments were once again instrumental in providing evidence for the yield-enhancing effects of nitrogenous fertilisers, as well as crop rotation with nitrogen-supplying legumes. The Haeber–Bosch process of converting atmospheric nitrogen into ammonia provided an unprecedented scale to the production of fertilisers, and subsequently their application to crop production from the early-20th century, leading eventually to a great leap in agricultural productivity and food production (Ritchie 2017; Ramachandran et al 2023).

In the early 20th century, the science of biology, particularly the Mendelian principles of inheritance, began to be consistently applied to plant production (Kingsbury 2009). This eventually led to the development of scientific knowledge and capacity to manipulate the genetic make-up and capabilities of plants, and have thereafter been used for selective breeding, development of high-yielding varieties and hybrids and genetic engineering, allowing the selection and amplification of specific traits with much greater precision.

The large-scale adoption of these scientific and technological developments in the process of agricultural production began in the second half of the 20th century. Both chemical and biological agents were increasingly used for plant protection—control of weeds, pests, and diseases of crops since the mid-20th century (Blaxter and Robertson 2007). Mechanisation of different farm operations is yet another instance of the application of science and technology to agricultural production, one that has allowed scaling up of production processes to levels that were unimaginable until a century ago (Blaxter and Robertson 2007). The immediate, and the most evident, result of the large-scale application of science and technology was, of course, the quantum jump in crop productivity.

The dialectical evolution: Interestingly, the growing application of science and technology in agricultural production also led to newer problems and research questions, which, in turn, encouraged further research and developments in agricultural science. Many such instances of this dialectical evolution of science and technology were evident in the process of development of new crop varieties, and their acclimatisation in different agroclimatic environments in the mid-20th century.

The initial research in rice breeding by the International Rice Research Institute in the Philippines in the early 1960s, for instance, led to the development of plant types that were more responsive to fertiliser use, resistant to lodging, and better efficient in the use of solar energy (Barker et al 1985). However, during their application in different regions, it was understood that their successful adoption required better water management, which was, of course, not possible in unirrigated areas (Barker et al 1985; Swaminathan 1969). Many of these varieties were also found to be susceptible to virus and bacterial diseases. These realisations, in turn, led to greater attention to such diseases as part of the rice research programme, and eventually led to dedicated research effort to develop insect and disease resistant varieties. In a similar vein, the continued lodging in single- and two-gene dwarf strains of wheat in the Indo-Gangetic alluvial soils led to development of triple dwarfs—varieties with three genes for dwarfing (Swaminathan 1969).

More recent instances of this dialectical nature of development of agricultural science and technology can be found in the field of biotechnological research. The early application of biotechnology, in terms of transgenic technology, was to breed crops with higher productivity and better resistance to biotic and abiotic stresses and shocks. In the process, its potential to deliver human health benefits was also understood. While the technology of genetics itself was evolving in various directions, such as in gene editing, research questions raised by concerns pertaining to environmental sustainability and climate change gave new directions to the trajectory of its development. Developments in biotechnology today are increasingly being seen as essential to the cause of environmental sustainability—be it in terms of climate change mitigation (Kovak 2022; Kovak et al 2022), or the reduction of the use of nitrogenous fertilisers in growing cereal crops (Dooley 2022). It is evident that the potential of the technology, and therefore the different possibilities of its utilisation, are being realised as part of its development, and its application in production.

Misreading science and technology: The appreciation of the contributions of the developments in agricultural science and technology is conspicuously absent among the approaches drawing on alternative agriculture. The different components of science and technology are, in fact, often targets of persistent and widespread attacks by proponents of these approaches (see Shiva [1991] as a representative example). It is true that certain agricultural developments in the last century have been accompanied by detrimental impacts on natural environment, including the overuse of chemical inputs leading to soil and water pollution, over-extraction of groundwater, and promotion of monocultures that may, at times, lead to erosion of biodiversity and potential ecological harm.[14] At the same time, however, it also led to an increased understanding of the laws of nature, including a growing awareness of their detrimental impacts on the environment. This growing awareness has, in turn, led to scientific efforts to prevent and mitigate these ill-effects. In a sense, this trajectory of self-correction reflects the nature of development of science and technology. Uncertainty associated with its use and effect is fundamental to any technology. This uncertainty, however, reduces with greater experimentation and use.

Evidently, the ill-effects attributed to modern agricultural science and technology are often the outcome of the fact that agricultural development under capitalism is driven by a profit motive. The logic of capitalism does not allow a planned approach to production considering the goals of human development and environmental sustainability. The inability to differentiate between the trajectory of development of science and technology and the question of its ownership appears to be a characteristic tendency among the alternative approaches. This leads them to underplay, if not outrightly oppose, the past and the future role of science and technology to advance the cause of agricultural advancement along with environmental sustainability.

Historically, science achieved a revolutionary edge when it became a force of production under capitalism. However, having nurtured and harnessed the potential of science and technology to transform production and society, profit-driven capitalism then limits its reach and pace, and steers the direction of its development and realisation. In the field of agricultural science, this is reflected by the fact that research and ownership in biotechnological innovations are appropriated by agribusiness corporations. By contrast, green revolution technologies of the mid-20th century were driven by national agricultural research systems and international public-access institutions. The marked withdrawal of the state in many countries from the sphere of agricultural research and development and extension services is a clear instance of the functioning of the capitalist relations of production.[15] These shifts have prevented income-poor cultivators in different parts of the world from realising the full potential and benefits of modern biotechnology.

Another fundamental aspect of scientific development ignored by approaches of alternative agriculture is the autonomy that its trajectory retains despite being controlled by the motives of capitalism. There is an underlying necessity associated with the nature and direction of technological development, but this necessity itself is eventually realised through contingencies that are social and cultural. The ultimate development of technology is an outcome of the interplay of this necessity and contingency. The development of science and technology, therefore, is never an absolute construction of the overarching social structure—capitalism, in this case. In other words, the fact that technological advancements under capitalism are driven by profit motives does not make these advancements and the efficiencies emanating from their application any less real. Even under capitalism, technological developments have great potential for progressive transformation.

The object of sustainable agriculture can be achieved by appropriate developments in science and technology and its rational application. But the current food production regimes will allow more investment towards addressing food security and sustainability only when it has an associated profit motive. The need, therefore, is to unshackle the inherent potential of science and technology from private ownership and the profit

motive. However, the opposition to private profiteering in scientific research should not translate into an opposition to the technology itself. The approach of alternative agriculture, unfortunately, often does not appreciate this perspective.

Romanticising the Local

A third characteristic feature of the approaches on alternative agriculture is an unqualified glorification of local (used interchangeably with "traditional" or "indigenous") methods of cultivation, and the attendant ways of organising production and society (see Wise [2018] as a representative example). The tendency perhaps is best expressed by the concept of "food sovereignty," broadly defined as the right of "local producers" of food to determine what and how to produce, distribute, and consume.[16] It has been supported by organisations such as La Via Campesina as an approach to solve the world's food problem in an environmentally sustainable fashion based on "local autonomy, local markets, local production-consumption cycles, energy and technological sovereignty, and farmer-to-farmer networks" (Altieri 2009). The smallholding peasant is seen as the central figure in this approach, having the capacity and the responsibility to ensure sustainable agricultural growth and a food-secure world (Altieri 2009; Ploeg 2014). Such an approach, it is proclaimed, can also be an alternative to the neo-liberal framework on food security focusing on international food trade (McMichael 2014).

Indigenous knowledge and practices: The first dimension of the tendency to glorify the local pertains to the methods and techniques of cultivation. Agricultural production based on traditional practices and indigenous knowledge—in place of integrative science—is argued to be the pathway for realising sustainable agriculture and a food-secure world (Jansen 2015).[17] Local ways of understanding and acting upon nature are presented as better placed to maintain a non-exploitative and harmonious relationship with nature, as they are historically situated in the specific agroecological contexts.

This line of argument points to a lack of understanding of the nature and limitations of local ways and practices of agricultural production, as well as a lack of appreciation of the nature of interplay between experiential knowledge and modern science.

At the outset, subsistence production by small peasants using local methods was not instrumental in achieving surplus food production. It will also not be able to provide the basis for a food-secure and sustainable agriculture in the future. Expecting a consistent advance in efficiency, that is, higher levels of food production at lower levels of resource use, from subsistence-based peasant production is illusory. The outcome of this illusion played out in Sri Lanka in 2021 when a ban on chemicals in pursuit of a 100% organic food policy led to a terrible aggravation of a food crisis (Nordhaus and Shah 2022; Ramakumar 2021). Sri Lanka was pushed to the brink of becoming food-insecure, and was forced to import rice in huge volumes, as domestic production plummeted. The ban also destroyed the tea economy of the country, a major export and source of foreign exchange. The decision was carried out against the recommendation of agricultural scientists (Nordhaus and Shah 2022; Ramakumar 2021).

Subsistence production under traditional peasant agriculture has low productivity and is therefore land-intensive (Seufert et al 2012; Kirchmann 2019). Evidence from intensive village studies in more than 17 villages located in different agroecological zones of India shows that small farmers are as equally efficient (or inefficient) as large farmers in terms of choice of crops, fertiliser use or efficiency of fertiliser use (Murari and Jayaraman 2017). That peasants and small farmers necessarily use local knowledge and practices and indulge in more "environmentally sustainable" ways of cultivation is evidently a myth.

Traditional knowledge is generally based on practical experiences and observations that are passed on through generations. In the absence of any rigorous scientific scrutiny, such knowledge has limited validity. This is not to discount traditional knowledge, but such knowledge must be assessed in its specific experiential, natural, and socio-economic context. Traditional knowledge cannot be replicated on any large scale. An objective investigation may also reveal that many local practices are often inefficient and exploitative of nature and natural resources. An uncritical promotion of all local knowledge will undoubtedly prove contradictory to the foundations of sustainability itself.[18]

Local knowledge specific to a particular agroecological (and/or socio-economic) context can certainly be the starting point for a scientific enquiry. In fact, modern science has often developed by learning from prevalent material practices, by abstracting their essence as theoretical knowledge that subsequently allows for its widespread application. Science, particularly genetic engineering, can also be instrumental in preserving some select local practices, and making them more resource efficient and productive.[19] In this sense, modern science is a dialectical negation, and not a mechanical opposition of indigenous knowledge as is often understood by the approaches to alternative agriculture. The former negates the latter, but also absorbs its scientific essence and builds upon it.

Differentiation of rural society: The other dimension of the tendency to romanticise the local pertains to the organisation of production and society. The local in many of the alternative agriculture approaches is conceived as one homogeneous community living together in harmony with each other and with nature, with no contradictory interests whatsoever (Wise 2018). The community is seen as united in its fight against corporate agriculture (McMichael 2014; Ploeg 2014). Here, there is a clear tendency to paper over the structural differences and contradictions among different socio-economic classes involved in agricultural production (Bernstein 2014; Jensen 2015).[20] It also ignores the structural divides of gender and caste that are fundamental to the rural society in a country like India (Ramachandran and Swaminathan 2014; Swaminathan et al 2020).[21]

A strategy of sustainable rural change and development must consider the existing differentiation and contradictions in the countryside. An inability to do so will imply a vision of

sustainable agriculture that is laced with the hegemony of the rich and the dominant sections in the countryside. Any discussion around local sovereignty that does not recognise and seek to weaken local power structures essentially reaffirms the sovereignty of the rural rich and the powerful.

Concluding Remarks

Agricultural production in the contemporary era faces several challenges. Food and nutrition insecurity continues to prevail despite the many great technological achievements and institutional innovations in the field of food production since the mid-20th century. Changing land use patterns and growing urbanisation add to the pressure on land for agriculture. The phenomenon of climate change is another challenge to crop production, and its impact on agricultural productivity, and the quantity of land available for farming is still very uncertain. A separate but closely interlinked concern is that of the persistent crisis of farm profitability. Incomes from agriculture have been declining in many parts of the globe, especially in most of the developing countries.

Surmounting the challenge of global hunger would, of course, require establishing equitable systems for distribution of food, and changing consumption patterns. But these efforts must proceed in tandem with a consistent expansion in food production. There is a strong felt need to imagine new systems of agricultural production that can provide better food and nutrition security to the global population and reasonable incomes to those engaged in cultivation, while maintaining a sustainable footprint. Such systems of agricultural production must bring together the possibilities of high-yielding intensive agriculture, and the tenets of environmental sustainability through the means of appropriate developments in science and technology.

The UN sustainable development framework, among others, was a concrete step towards realising this felt need within the rubric of capitalism. It also tried to define the concrete steps to achieve the objective of sustainable agriculture through enhanced and prioritised investments on the development of appropriate technologies and its adoption in agricultural production. The framework was not without flaws and limitations. However, it provided the possibility to orient and expand the ends and means of sustainable agriculture and build a consensus around it.

The approach of alternative agriculture that has grown in the last few decades disrupts this consensus-building exercise. A few salient features of the approach threaten the foundational understanding of sustainability defined in anthropocentric terms, one that strives for integrating intra- and inter-generational development and justice.

This paper attempted to discuss three features of the alternative agriculture approach. First, there is the tendency to undermine the importance of agricultural productivity for a food and nutrition secure and environmentally sustainable future. Second, the approach displays a very one-sided understanding of modern science and technology being a handmaiden of capitalism, with no autonomy and emancipatory potential whatsoever. Finally, it betrays a peculiar romanticisation of the local and traditional systems knowledge and practices, turning a blind eye to the limitations and hierarchies embedded in such systems.

At the most essential level, the approach of alternative agriculture appraises environmental sustainability from the lens of conserving a traditional system of life and production, as opposed to the SDG framework, which, despite its many limitations, tries to integrate environmental sustainability as part of the efforts to enhance human development.

NOTES

1 This paper will use the term "alternative agriculture" to denote these different approaches.

2 M S Swaminathan's (2009) address to the Indian Science Congress in Varanasi in 1968, for instance, clearly reflected an early recognition of the dangers of "exploitative agriculture," if "carried out with only an immediate profit or production motive." The need for a scientific approach to sustainability in agricultural production is evident in these remarks.

3 In the words of the Brundtland Commission, sustainable development is a notion of "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations 1987). Many others, like Sen (2013), have expanded on this framework without disturbing the core, and tried to strike a balance between intra- and inter-generational development and justice.

4 See Ritchie (2017a) for a data-based discussion on the impact of growth in agricultural yields since the second half of the 20th century on global cereal production, and land available for non-agricultural use.

5 The ideology of "productionism," or the broader idea of "productivism," as used by eco-socialists, is discussed in the literature (Thompson 2005; Wolf 2019; Lowy 2018; Berard 2019).

6 Kumar (2019), for instance, makes this argument in the context of green revolution in India. She claims that "There is inadequate evidence to support the claim that India was food-insecure in the 1960s."

7 See Tricontinental (2023) as a representative example of this line of argument. Denning (2023) terms this line of argument as "an alternative view, more often than not, inducing nods of approval in nonpartisan, lay audiences."

8 See, for instance, Munjal (2023) on the effect of a sudden decision by India to curb rice exports.

9 FAO (2017), for instance, highlights that "income growth in low- and middle-income countries would hasten a dietary transition towards higher consumption of meat, fruits and vegetables, relative to that of cereals, requiring commensurate shifts in output and adding pressure on natural resources."

10 To quote Denning (2023), "there is no clear consensus on the amount of additional food required by 2050. But it is important to note that none of the science-based estimates of future food needs suggests that we can satisfy demand with current production levels."

11 For instance, one of the conclusions of Mellor (2002: 20) was that "agricultural development, based on intensification, globalisation, and rapidly improving technology, is a primary factor in poverty reduction and enlarging biodiversity conservation areas."

12 For discussion on the crucial role of science and technology in raising productivity and incomes in a sustainable fashion, see Brookes and Barfoot (2020); Kovak (2022); and Qaim (2020).

13 Ploeg (2014) for instance, uses the term "imperial science" pitching it against peasants' knowledge that, according to him, drove organic farming.

14 The interplay of plant diversity, biodiversity, and ecology is extremely complex with many different aspects that are still being studied (see Florence and McGuire 2020 and McGuire 2020).

15 See FAS (2022), for the trends, patterns, and composition of public spending in agriculture (and rural development) in India during the last decade (2010–11 to 2019–20). It concludes that public spending in agriculture in India is low, particularly when compared with the size of the sector in the overall economy. Further, public expenditure in agriculture as a share of overall public expenditure is also falling.

16 See McMichael (2014) for a sympathetic take on what he terms "the food sovereignty countermovement." Bernstein (2014), in his critique, succinctly defines the elements of the concept.

17 Wise (2018) exemplifies this point of view. Also see Martínez-Torres and Rosset (2014) and Swiderska and Ryan (2010).

18 Jansen (2015) gives the example of the practice of "burning to clear fields—based on knowledge of local realities, passed from generation to generation" to make this point.

19 A recent study led by Rothamstead Research, for instance, claims that "Global wheat production could be doubled by the genetic improvement of local wheat cultivars—without increasing global wheat area" (Senapati et al 2022).

20 Bernstein (2014) identifies this tendency "as the restatement and extension, in conditions of contemporary globalisation, of that foundational trope of agrarian populism: the social and moral superiority of 'peasant' (or 'small scale') farming, and now centrestage its ecological superiority too."

21 A series of village studies conducted by the Foundation for Agrarian Studies (FAS) spanning different agroecological and socio-economic regions in India, during more than a decade and a half strikingly highlights the differentiated nature of the Indian countryside and underline the structural inequalities in terms of land and other assets, incomes, and living standards (Swaminathan and Baksi 2017).

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The Changing Role of Agriculture in the Global Climate Policy Regime

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The UNFCCC treaty of 1992 conceived of the agriculture sector primarily as a site of adaptation. However, there has been increasing pressure in the global climate regime to reconfigure agriculture into a site of deep emission cuts to meet the Paris temperature targets. Land-based mitigation measures—as opposed to adaptation measures—are prioritised and promoted by influential sections, including developed countries and international development and climate organisations. The emphasis on mitigation is an extension of the strategy of developed countries to transfer the responsibility of deep emission reductions to developing countries in the context of the failure of the former to undertake deep emission reductions in the decades following the establishment of the UNFCCC.

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Agricultural emissions constituted only 12.42% of the total global greenhouse gas (GHG) emissions in 2021. In contrast, emissions from the energy sector were significantly higher at 73.31% of the global GHG emissions. If the livestock sector was excluded, the share of agricultural emissions would drop to 6.1%. If one considered only the least developed countries (LDCs), their share of agricultural emissions in global emissions was less than 2% (Table 1). In other words, the usually cited figures (Crippa et al 2021; Vermeulen et al 2012) on the contribution of agricultural emissions to global emissions are misleading. These figures include both input and output supply chain emissions, which are not included when emissions from industrial sources are estimated and cited.

Yet, climate change is a threat multiplier that amplifies the existing abiotic and biotic stressors and structural challenges faced by agriculture and allied activities. In developing countries, where small and marginal farmers dominate the rural areas, climate shocks are likely to have a direct negative impact on food and nutrition security, poverty eradication, and rural development. While the impacts of climate change are likely to be large in the developing world, their emissions are best termed "survival emissions." In contrast, emissions from the economically advanced countries are "luxury emissions" arising from profligate resource consumption (Climate Equity Monitor 2023).

The documented and realised impacts of climate change on agriculture—varying across regions and in intensity—are lower crop yields and livestock yields due to extreme weather events like droughts, floods, and heatwaves, changes in the timing and duration of seasons, water shortages and increased soil erosion and degradation. The impacts are harsher on regions with development deficits and dependence on climate-sensitive livelihoods, such as South Asia, West, Central and East Africa (IPCC 2022a). Given the correlations between climate risks and vulnerabilities and the prevailing developmental patterns—rather than differences between emission scenarios—the Working Group II (WG II) of the IPCC Sixth Assessment Report (AR6) noted the urgency to pursue socio-economic

Table 1: Emissions from Agriculture as a Share of Annual Global GHG Emissions, 2021 (in %)

Region	Share of Emissions from (%)	
	Agriculture Including Livestock	Agriculture Excluding Livestock
World	12.42	6.10
Non-annex-I countries	9.32	4.56
Least developed countries	1.91	0.96
Annex-I countries	3.04	1.52

Source: Authors' calculations based on PRIMAP V2.4.2 database and Gütschow and Pflüger (2023).

development and enhancement of adaptative capacity in these regions (IPCC 2022a). For example, there is an urgent need to implement robust science-based adaptation measures in the agricultural sector that are aligned to the needs of raising productivity and farmers' incomes and bolstering food security.[1]

However, land-based mitigation measures in agriculture—as opposed to adaptation measures—have been prioritised by international development and non-profit organisations, a section of climate scientists, global civil society and media, and in some recent IPCC reports. This paper would argue that an emphasis on mitigation is an extension of the strategy of developed countries to transfer the responsibility of deep emission reductions to the developing countries, particularly in the context of historical inactions by the former. Thus, a package of policy shifts has been advocated, parts of which contradict erstwhile priorities for agriculture in the global climate policy regime.

We begin with an overview of the history of agriculture within the global climate regime. Subsequently, the characteristics of the recent policy shifts in agriculture vis-à-vis climate change are traced. Further, the possible motivations for this policy shift are described. Finally, the potential implications of these policy shifts on the global South are discussed.

Agriculture in the Global Climate Policy Regime

The United Nations Framework Convention on Climate Change (UNFCCC), which came into effect in 1992, calls for climate action based on equity and in accordance with countries' common but differentiated responsibilities and respective capabilities (CBDR&RC). The UNFCCC considered the vulnerabilities and developmental needs of developing countries and accorded them flexibility in carrying out emission cuts. It mandated developed countries to undertake emissions cuts and provide new and additional financial resources to meet the needs of climate action in developing countries. This was a critical foundation on which the global climate governance regime was established and evolved.

Reflecting the spirit of equity and differentiation in the UNFCCC, "Agriculture, Forestry and Other Land Use" (AFOLU) was envisaged as a site of adaptation and not a carbon sink. As per Article 2 of UNFCCC, its ultimate objective was the stabilisation of GHG concentrations at a level that would prevent dangerous anthropogenic interference in the climate system. This stabilisation was to be achieved within a time frame to "allow ecosystems to *adapt* naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner" (UNFCCC 1992: 9).

Since the establishment of the UNFCCC, developed countries have attempted to extend the burden of deep emission cuts to the global South. This trend began during the negotiations towards the Kyoto Protocol, where many developed countries proposed, relatively successfully, to incorporate land-based carbon sinks and negative emissions into international climate policy discussions. The aim was to provide flexibility and cheaper alternatives for the deep decarbonisation of the economies of the global North (Carton et al 2020). Jung (2004) showed that countries that were the most opposed to strong international climate action, such as the United States, were also the staunchest advocates of land-based carbon sinks in the Kyoto Protocol negotiations. But although land-based sinks were discussed, emissions from agricultural production were not under focus in the global climate policy and negotiations in the two decades after 1992.

The focus on agriculture in the UNFCCC began to gain traction at the 17th Conference of Parties to the UNFCCC (COP-17) held in 2011 in Durban. For the first time, parties allowed the Subsidiary Body for Scientific and Technological Advice (SBSTA) to consider agriculture as an agenda item at its 36th session (SBSTA 36).[2] Agriculture has since then been a part of SBSTA agenda items. From SBSTA 36 in 2011 till SBSTA 46 in 2017, discussions on agriculture were framed in terms of themes like enhancing adaptation, increasing productivity, rural development, food security, finance, technology transfer and a recognition of the diversity of agricultural production systems. SBSTA 47 continued the exchange of views on issues relating to agriculture, considering the outcomes of the past in-session workshops and parties' deliberations and the progress made at SBSTA 46. At the end of SBSTA 47, a draft decision titled "Koronivia Joint Work on Agriculture" (KJWA) was recommended to COP-23 and adopted as a decision (UNFCCC 2017).

The COP-23 decision establishing the KJWA requested countries to submit their views on climate action in agriculture through six "Koronivia workshops." It, however, made no reference to the question of differentiation across countries despite demands from the developing countries. Subsequent negotiations witnessed the deepening of fault lines between developed and developing countries. Developed countries began to prioritise reductions in agricultural emissions in addition to their earlier focus on forest carbon stocks and other land-based negative emissions in the AFOLU sector. Additionally, they refused to acknowledge the vastly different circumstances under which agriculture, as a productive economic activity, is undertaken in the global South as compared to the global North.

In response, developing countries were resolute that discussions must focus only on adaptation if differentiation was not explicitly addressed in climate action in agriculture (Urrutia and Siemons 2020). During their Koronivia negotiations and submissions made to the UNFCCC, developing countries from Asia and Africa highlighted the challenges faced by agriculture in the global South, including low yields and low use of external inputs, prevalence of subsistence modes of production, underdeveloped infrastructure, high vulnerability to climate extremes, relatively high contribution of agriculture to GDP and employment, and the need to increase productivity. They also demanded vastly enhanced international cooperation and support with respect to financial resources and capacity building, technology transfer, enhancing adaptive capacities, and securing food security (UNFCCC 2023).

While these fault lines were deepening, during the COP-27 held at Sharm el-Sheikh in 2022, developed countries once again pushed for targeted action to reduce agricultural emissions. It even appeared in the final decision text as a key area of focus. However, the persistent opposition from developing

countries resulted in the addition of a caveat that solutions were "context-specific" and regional, local, and national circumstances were to be taken into consideration while addressing issues in agriculture.

The Turn to Mitigation

Following COP-23 in 2017, climate policy discussions led by the developed nations and organisations based in the global North shifted markedly. There was a definitive shift towards using agriculture as a key means of reducing global emissions to meet temperature targets. This was in sharp contrast to the earlier view of crop production as primarily a site of adaptation.

In an important review of the reports of the High-Level Panel of Experts (HLPE) on Food Security and Nutrition, Jayaraman (2021) outlined the defining features of the policy shift in agriculture (FAO 2019, 2020). The first related to how agriculture was conceived in the discussions led by developed countries. With mitigation as the focus, agriculture came to be conceptualised in terms of ecological conservation rather than as a productive activity. For example, the COP-27 decision text described farmers, including smallholders and pastoralists, as "stewards of the land" who were "inclined to apply sustainable land management approaches" and vulnerability to climate change as "a challenge in fulfilling this important goal" (UNFCCC 2022b). Theories on natural resource conservation were privileged over agricultural science in directing policy.

Second, the aim of productivity growth was dismissed or relegated as a lower policy priority. Policy recommendations favoured low-input, low-productivity and low-profitability agriculture using languages appropriated from mainstream agricultural sciences. For example, irrigation was denounced as detrimental for environment and climate adaptation; the use of chemical fertilisers was decried; food supply was to focus on "local" production; livestock production was disapproved of; and the replacement of rice and wheat by millets was advocated without acknowledging the technical and socio-economic barriers to increasing millet production and consumption.

Third, certain points of view that were historically marginal in their policy impact began to attain a mainstream status. For example, there has been increasing importance accorded to degrowth and associated concepts as a theoretically reasonable response to the complex challenge of improving human welfare in the era of global warming (Gerber 2020; Guerrero Lara et al 2023; Hickel 2020; Kallis 2011).

Fourth, prominent multilateral institutions, such as the FAO (nd, 2019, 2022a, 2022b) but also others, began to advocate for the conservation agenda in policy discussions. Previously, the FAO was an important source of information and technological knowhow on the need for increasing productivity in agriculture even if they overlooked the social, political, and institutional barriers to agricultural production. But more recently, the FAO and other international organisations have begun to share a deep scepticism towards modern agricultural practices on grounds falsely attributed to the green revolution and not validated by agricultural science (see papers by Ramakumar and Sandipan Baksi in this issue). As a result, many smaller developing nations were deprived of the right kind of technical advice, information, and inputs to participate effectively in negotiations and framing appropriate domestic policies in agriculture.

In another curious development in emissions accounting, emissions from crop production were sought to be labelled under "food systems." The Special Report on Climate Change and Land (SRCCL) of the IPSS defined food systems as "all the activities and actors involved in the production, transport, manufacturing, retailing, consumption, and waste of food, including production, transport, processing, packaging, storage, retail, consumption, loss, and waste" (Mbow et al 2019). Instead of accounting for emissions from different sectors on a direct basis, as in the standard IPCC emissions accounting procedure, emission accounting in agriculture was modified to also include indirect emissions from all sectors and activities indirectly associated with it. Consequently, emissions from activities like fertiliser production or transportation, which were previously accounted for under industry and transportation sectors, were now included under agrcultural emissions.

Having inflated agricultural emissions with such a methodological change, "food systems" were then identified as one of the crucial sites of mitigation to achieve emission reduction targets in the global South. Similar inclusion of indirect emissions was not undertaken for other sectors that contributed a larger share of global emissions. For instance, emissions accounting in the energy sector, the most important source of GHG emissions globally, does not include emissions associated with the manufacturing of power production machinery like turbines or generators.

It must be mentioned that the pressure to shift policies as described earlier had begun much before 2017 from various quarters of the scientific and policy community. But it was after 2017 that they came together into a unified mass of policy appeals with considerable political, financial and institutional backing, culminating in the KJWA at COP-23. One of the products of this convergence of views was the emergence of new concepts, such as Nature-based Solutions (NbS) and agroecology, which have currently become pervasive in the academic and policy circles.

Nature-based solutions and agroecology: NbS, which was first mentioned by the World Bank (2008), has had no single definition or standards (Sowińska-Świerkosz and García 2022). To date, scholarly research on NbS has remained largely conceptual, either offering principles and frameworks for implementation and/or assessment or reviewing the concept's origins and use. Despite the concept's policy relevance and ramifications for people and the environment, little empirical research is currently available. Even the limited empirical studies, available mostly from the developed countries, focus narrowly on the environmental benefits of NbS, and no study has comprehensively evaluated its social, economic, and environmental benefits (Hanson et al 2020).

Closely related to NbS, and often presented as a part of NbS, is the concept of agroecology. According to FAO, agroecology is a "holistic and integrated" approach that simultaneously applies "ecological and social concepts and principles to the design and management of sustainable agriculture and food systems."

Adherents assert that agroecology is concurrently a science, a set of practices, and a social movement. It is argued to be optimising the interactions between plants, animals, humans, and the environment while also addressing the need for socially equitable food systems within which people can exercise choice over what they eat and how and where it is produced (FAO 2019, nd). It claims to endorse diversification, mixed cultivation, intercropping, cultivar mixtures, habitat management techniques, biological pest control, improvement of soil structure and health, biological nitrogen fixation, and recycling of nutrients, energy and waste.

These are indeed desirable outcomes but, as Jayaraman (2021) points out, each of the practices mentioned lacks a distinctive characteristic that sets it apart as "agroecological" compared to other approaches. Additionally, each practice seems to have originated independently of this seemingly novel concept. Agroecological approaches strive to eliminate all external inputs using closed local resource loops, endorsing local knowledge and direct exchange between farmers, promoting labour intensification, and relying on local markets (FAO 2019). They challenge the notion of economies of scale and advocate farm-level self-sufficiency employing labour-intensive techniques. While it does not prioritise science to boost productivity and output, it may utilise scientific advancements to bolster sustainable and low-input practices at the local level. Like for NbS, empirical studies examining the agronomic and socio-economic performance of agroecology practices are not yet available.

Despite the lack of conceptual clarity around the terms, what is common to almost all framings of NbS and agroecology is that they are presented as "cost-effective" measures that deliver a "triple win" for climate, biodiversity, and society (Jaiswal et al 2023). This framing appears to address multiple objectives, including cheap mitigation (since these "solutions" require far fewer financial resources compared to similar efforts in industry, energy, and transportation sectors in the global North), slows down the pace of industrial and infrastructure growth, and successfully draws developing countries into adopting mitigation policies on par with developed countries. It also leverages the general reverence for nature in developing societies to actively promote the idea.

In the Indian context too, the promotion of agroecological techniques like no-till and regenerative agriculture, and a broader policy shift towards emphasising conservation and mitigation in agriculture, can be observed. This includes the endorsement, under the garb of agroecology, of not-validated concepts like zero budget natural farming (ZBNF), which sideline or ignore established agricultural science. The currently popular version of ZBNF, or natural farming, has no significant benefit over conventional agriculture (Ramakumar and Arjun 2019; NAAS 2019), except in situations where smallholders apply no inputs at all, and hence any extension advice provides opportunities for some improvement.

Leveraging Modelling Studies and Climate Finance

Modelling studies: Different modelling exercises are used to lend a semblance of scientific validity and justify the advocacy of mitigation in the AFOLU sector, especially in the global South. The first are a set of modelling studies, almost all conducted in the global North, that estimate the mitigation potential of land-based mitigation measures (Roe et al 2019, 2021). These models, driven purely by the cost-minimisation logic, declare that more than 80% of the cost-effective mitigation potential is in developing and LDCs (Nabuurs et al 2022; Roe et al 2021). By their own admission, these modelled mitigation pathways do not make "assumptions about global equity, environmental justice or intra-regional income distribution" (IPCC 2022b), but rather explore cost-effective pathways to limit temperature rise, thereby allocating emission reductions wherever it is cheaper. To be more specific, cheap mitigation measures in developing countries translate to protecting, restoring, and managing forests, carbon sequestration and reduction in emissions from agriculture (IPCC 2022b).

Despite the highly iniquitous nature of prevailing modelling studies, it is possible to develop alternative models that allow different sectors and regions to share the mitigation burden based on fairness and equity (Kanitkar et al 2013; Baer et al 2012; Holz et al 2019). Therefore, statements about the unavailability of rapid mitigation led by the AFOLU sector in meeting 1.5°C or 2°C temperature targets (CCAFS-CGIAR 2016; Hole et al 2022; Lynch 2020) are an outcome of inequitable assumptions and normative choices made by the modelling studies.

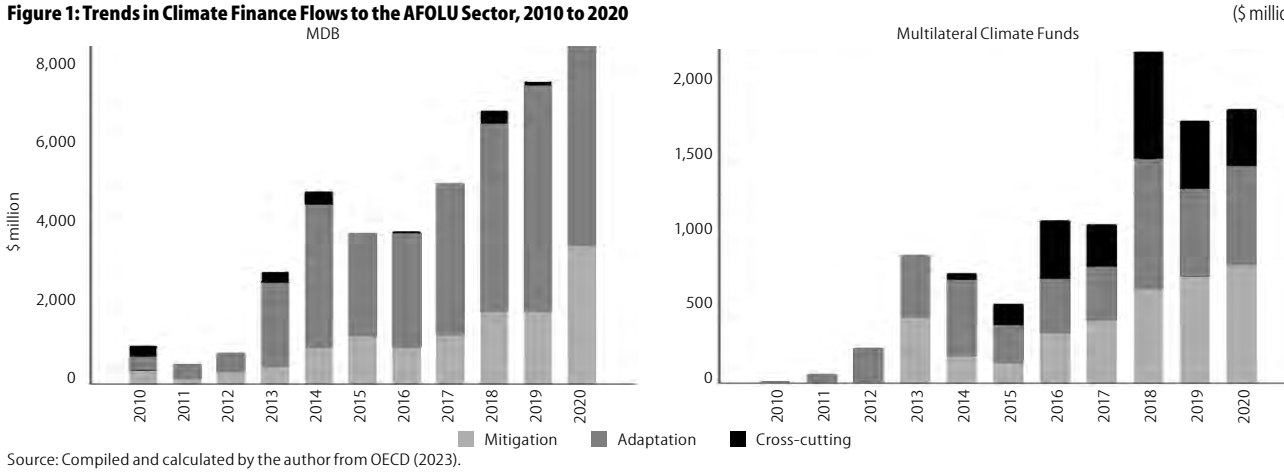
Climate finance: Another avenue to force the hand of developing countries in climate policy is the emerging international climate finance regime. Developing countries are facing mounting pressure from the climate finance institutions to prioritise land-based mitigation efforts. Based on the modelling studies discussed earlier, there has been a surge in global finance flows towards mitigation in the agriculture and forestry sector (Jaiswal et al 2023). According to OECD (2022) estimates, mitigation finance from developed to developing countries targeting the energy sector decreased between 2016 and 2020, both in relative terms (51% to 44%) and in absolute terms (by $0.8 billion). In contrast, mitigation finance steadily increased in agriculture, forestry, and fisheries, marking a shift away from adaptation finance (Jaiswal et al 2023).

Data in OECD (2023) details the shift in global climate finance flows towards mitigation in the AFOLU sector (Figure 1, p 68). Between 2010 and 2020, the AFOLU sector received $39.5 billion in climate finance from multilateral development banks (MDB), of which 69.4% went towards adaptation, 27.8% went toward mitigation, and 2.8% went towards cross-cutting goals (both mitigation and adaptation). Out of the $10 billion finance from multilateral climate funds, 41.8%, 35.2% and 23%, respectively, went to adaptation, mitigation and cross-cutting. While adaptation still dominates climate finance provided by MDBs to the AFOLU sector, the share of mitigation finance rose to 41% in 2020 from 15% to 32% between 2013 and 2019. There is a clear trend in finance from multilateral climate funds shifting towards cross-cutting and mitigation financing at the expense of adaptation.

Several multilateral organisations have called for aligning the AFOLU sector finance to pursue the Paris Agreement's 1.5°C global warming limit (FAO 2022b; IFAD 2022). The sectoral

Figure 1: Trends in Climate Finance Flows to the AFOLU Sector, 2010 to 2020

($ million)



Source: Compiled and calculated by the author from OECD (2023).

guidance and strategy documents of the multilateral climate funds and multilateral organisations are now framed around NbS, low-emission resilient agricultural systems, and ecosystem and forestry measures that integrate mitigation, adaptation, and biodiversity concerns (FAO 2022a, 2022b; GCF 2021, 2022a, 2022b; IFAD 2022).

The increasing efforts to redirect the flow of international climate finance towards mitigation need to be read alongside the observation by IPCC that the current global finance flows for adaptation are inadequate and hinder the implementation of adaptation options in developing countries (IPCC 2022a). Annual adaptation needs are projected to reach $160–$340 billion by 2030 and $315–$565 billion by 2050, with a significant portion in the AFOLU sector. Developing countries currently require five to 10 times more adaptation funding than they receive from international sources, and the gap has continued to grow (UNEP 2022). The UNFCCC Standing Committee on Finance estimated that the total adaptation finance in 2020 was only about 9% of the total global climate finance flows. Considering public finance flows from developed to developing countries, adaptation constituted only 23.3% of the total $72.7 billion mobilised (UNFCCC 2022a).

Therefore, the pressure from the global North to channel climate finance away from adaptation towards mitigation in agriculture, by altering the financing strategies of major multilateral donor organisations, would compel developing countries to undertake deeper emission reductions in agriculture, even at the cost of their food security and livelihoods.

Exploring the Motivations

There is irrefutable scientific evidence that the increase in global average temperatures over the pre-industrial levels is directly proportional to the cumulative emissions of carbon dioxide, primarily from the use of fossil fuels, for economic activities (IPCC 2021). Therefore, to limit the temperature increase to 1.5°C or 2°C, over pre-industrial levels, there is a limit to the cumulative emissions from all countries that can be emitted. This limit on the cumulative emissions is the global carbon budget. As per the latest estimates, the bulk of the global carbon budget has already been exhausted, primarily on account of the historical emissions by developed countries categorised as Annex-1 countries.

However, three decades since the Rio Conference, the developed countries have failed to undertake any meaningful emission reduction at a scale and pace commensurate with their historical responsibility, capabilities, or what is scientifically required to avoid overshooting the temperature targets. On the other hand, they continue to appropriate far more than their fair share of the remaining global carbon budget (Kanitkar and Jayaraman 2019). Annex-I countries, despite being home to less than one-fifth of the global population, contributed more than four-fifth of the cumulative emissions between 1850 to 1990 (Table 2).

The Table from the Summary for Policy Makers (SPM) of the IPCC's Sixth Assessment Report (AR6) (IPCC 2021), presented in a modified form in Table 3, gives the estimate of historical CO2 emissions (1850–2019) and remaining carbon budgets (2020 onwards), for different temperature limits and different probability levels. Two of them correspond to the Paris Agreement temperature goal of limiting global warming to well below 2°C and preferably to 1.5°C, compared to pre-industrial levels, and the third to an intermediate value of the temperature.

In short, only a small proportion of the global carbon budget is remaining for the world to stay below the temperature targets set by the Paris Agreement. The remaining carbon budget is particularly small for a 50% probability of staying below 1.5°C; at current rates, this is expected to be exhausted within a few years. Despite this scientifically established fact, developed countries have done little to ratchet up their mitigation actions. The

Table 2: Share of Cumulative Emissions between 1850–1990 and 1990–2019 by Major Annex-I and Non-annex-I Countries (%)

Regions	Share of Global Population 2019	Share in Global Cumulative Emissions, 1850–1990	Share in Global Cumulative Emissions, 1991–2019
Annex-I countries	18	81	49
US	4	29	31
Canada	0.50	2	2
Australia	0.33	1	1
Japan	2	4	4
Germany	1	8	3
UK	1	7	2
EU (27)	6	23	12
Russia	2	9	6
Non-annex-I countries	82	19	51
China	18	5	22
Brazil	3	1	1
South Africa	1	1	1
India	18	2	5

Source: Climate Equity Monitor (www.climateequitymonitor.in).

net-zero targets announced by all the major developing countries also fall short of the year required to stay within their fair share of the remaining carbon budget (Table 4).

Developed countries, confronted with the rapidly depleting carbon budget to stay within temperature targets, are using their inordinate levels of influence within the global policy regime to transfer the burden of emissions reduction onto the developing countries. In this context, as a strategy to delay and substitute deep emission reductions in fossil fuels, agriculture and allied land-based sectors in the developing countries are being painted as sites of cheap emission reductions and carbon sinks (Anderson and Peters 2016; Carton et al 2020).

Table 3: Remaining Carbon Budget for Different Probabilities of Staying Below 1.5°C, 1.7°C and 2°C Temperature Limits

Approximate Global Warming Relative to 1850–1900 until Temperature Limit (°C)	Additional Global Warming Relative to 2010–2019 until Temperature Limit (°C)	Estimated Remaining Carbon Budgets from the Beginning of 2020 ($GtCO_2$) Based on the Likelihood of Limiting Global Warming to the Temperature Limit				
		17%	33%	50%	67%	83%
1.5°C	0.43°C	900	650	500	400	300
1.7°C	0.63°C	1,450	1,050	850	700	550
2°C	0.93°C	2,300	1,700	1,350	1,150	900

Source: Summary for Policy Makers (SPM) of the IPCC AR6 WG I, Table SPM.2 (IPCC 2021).

Table 4: Declared Net Zero Target versus Required Year of Reaching Net Zero to Stay within the Fair Share of Their Remaining Carbon Budgets, Selected Countries

Country	Declared Year of Reaching Net Zero	Required Year of Reaching Net Zero to Stay within Fair Share of Remaining Carbon Budget	
		1.5°C (50% Probability)	2°C (67% Probability)
US	2050	2025	2032
Canada	2050	2025	2033
Australia	None	2024	2031
Japan	2050	2031	2046
Germany	2045	2030	2045
UK	2050	2035	2057
EU (27)	2050	2031	2047
Russia	Not declared	2026	2036
China	2060	2031	2047
World	Second half of century	2037	2062

Source: Compiled and calculated by the author and Sreeja Jaiswal from OECD (2022).

In Conclusion

If agriculture was previously seen as a site of climate adaptation, the focus in the recent years has shifted to reducing emissions in agriculture, especially in the developing countries. The policy shifts that enable new focus are characterised by a new framing of agriculture: as a site of environmental conservation rather than of production. Most modelling studies that used to advocate mitigation in the AFOLU sector in the developing world are based on cost minimisation assumptions that ignore inequalities across countries. New policy recommendations focus on low-input, low-productivity agriculture, and receive extensive climate finance and other economic supports from multilateral development and financial organisations.

The interface of agriculture and climate change needs to be studied in the context of the concerted attempts by the global North to shift the burden of global environmental conservation and climate action on to the global South. In this process, the productive capacities in the global South are being weakened. Prioritising mitigation measures in agriculture can also lead to a compounding of socio-economic vulnerabilities in the global South.

Developing countries, with their low historical contribution to cumulative emissions, must be able to independently determine the course of their low-carbon development pathways. These determinations must be based on their development priorities and capabilities, and their compatibility with critical goals related to food security and livelihoods. Fundamental principles of equity and differentiation, as explicated in the UNFCCC, entail that these countries should not be expected to take on heavy mitigation burdens in agriculture and allied sectors.

NOTES

1 Various studies have suggested that closing yield gaps by increasing productivity, rather than bringing more land under crop production, is the most sustainable path for achieving food security (Foley et al 2011; Godfray et al 2010; Mueller et al 2012; Phalan et al 2011). Yuan et al (2021) show that most paddy cropping systems have room for increasing yield, resource-use efficiency, or both with the potential for aggregate total rice production enhancement pegged at 32%. See also Isaac and Jayaraman (forthcoming).

2 The SBSTA is one of two permanent subsidiary bodies to the UNFCCC (along with Subsidiary Body for Implementation) which supports the work of the COP (Conference of Parties to the UNFCCC), the CMP (Conference of Parties to the Kyoto Protocol) and the CMA (Conference of Parties to the Paris Agreement) through the provision of timely information and advice on scientific and technological matters.

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Greenhouse Gas Mitigation and Carbon Markets in Indian Agriculture

An *Ex Ante* Critical Review

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The prospects and implications for continued and possibly rapid extension of the broader effort at greenhouse gas mitigation and the specific effort of carbon markets in India are assessed along four axes: (i) the global experience of mitigation and carbon markets in agriculture in the global North, who are expected to be leaders in such actions; (ii) the theoretical prospects of carbon markets and carbon offsets in agriculture, with special reference to welfare and distributional aspects; (iii) the key initiatives in GHG mitigation and carbon trading related to Indian agriculture; and (iv) considerations of the priority to be assigned to both mitigation and carbon trading in Indian agriculture both in the international and intra-national contexts.

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In the 30 years since the Rio Earth Summit, the fate of agriculture in the global climate regime has undergone something of a 180-degree turn. From being positioned as the pre-eminent arena of adaptation, agriculture is now increasingly positioned as the arena of mitigation, or as the arena of both mitigation and adaptation. This positioning is paradoxical, as the enthusiasm for positioning agriculture as the arena of mitigation is not matched by real world policy actions that seek to implement this view. Climate policy experts from the developed world have always focused on agriculture, forest and land use (AFOLU) as potent sources of greenhouse gas (GHG) emissions, especially in the developing countries. However, there has been a notable increase in the stridency of this call for mitigation in agriculture that has now found a much larger constituency, including multilateral institutions.

The shift in emphasis, however, does not merely promote mitigation action in agriculture. Together with mitigation action, carbon markets are seen as the predominant mode of promoting action. Promoting carbon markets is a specific way to introduce carbon prices. A strand in this new emphasis seeks to push for a specific form of carbon markets in agriculture in the form of carbon offsets, arguing that this would be a means of incentivising farmers to undertake mitigation activity, while adding to their income.

India and a substantial part of the global South were successful in resisting the pressures generated for mitigation in agriculture earlier. But increasingly, they appear to be on the defensive on this question. India, since the Paris Agreement, has attempted to meet head-on the challenge of being labelled a naysayer in climate action, achieving a significant degree of success in this regard. Most significantly, the scientific support to India's position that it has considerably lower historical and current responsibility for GHG emissions has significantly been strengthened by the Working Group III Report of the Intergovernmental Panel on Climate Change in its Sixth Assessment Cycle (IPCC 2022). Such an assessment was based on a perspective of fairness and equity, despite the wide variation in what this means in operational terms. Nevertheless, there has also been relentless pressure from several actors in the developed world who have focused on mitigation in agriculture.

In India, mitigation in the agricultural sector is not yet a stated policy. But there are several initiatives that are mitigation-centric or mitigation-oriented as co-benefits to input efficiency or

lowering of input costs. This is clearly in keeping with India's overall strategy of "low-carbon development," a general concept that has now been clearly articulated in official submissions to the United Nations Framework Convention on Climate Change (UNFCCC) (MOEF 2021, 2022). In this view, India cannot immediately decarbonise its economy on the grounds of its developmental needs as well as on grounds of equity; yet, it is committed to low-carbon development with a clear sustainability perspective, with the timing and pace dependent on the availability of means of implementation. This low-carbon development will also not involve emissions more than India's equitable share of the global carbon budget.

India's previous carbon trading experiment was with the Clean Development Mechanism (CDM) credits under the Kyoto Protocol. The CDM credits were dominated by non-AFOLU sectors and had little to do with the agricultural sector. After the Paris Agreement, and the push towards mitigation in agriculture, there has been renewed interest in developing carbon markets. A major enabling legislation—the Energy Conservation (Amendment) Bill, 2022—was passed in 2022, that inter alia provides the legal basis for the formation and institution of a carbon market through the issue of carbon credits (MOP 2022).

Under the new policy, sustainable agriculture is included in the Green Credit Programme Implementation Rules, 2023 issued by the Ministry of Environment, Forest and Climate Change in October 2023 (MOEFCC 2023). In these rules, a programme of "green credits" for promoting sustainability is proposed. These rules are to be further developed in detail by a steering committee whose composition was only noted in general terms. What is also not clear is how, and in what manner, these green credits will be traded.

At the same time, there is already a small, voluntary, and unregulated carbon market in agriculture. Typically, these initiatives are celebrated in the business media and business literature, such as in a recent account breathlessly titled "Rise of Carbon Farming in India: World's Large Agrarian Country Expected to Become the Leading Market for Carbon Farming Credits" (Nozaki 2023). While these initiatives are not insignificant, the prospects of a formal carbon trading and carbon pricing scheme in agriculture will depend on the actions and policy signals of Government of India. Studies of such voluntary carbon markets provide important indications of the challenges that might emerge when they are scaled up in the future.

This paper consists of four sections. The first section looks at the state of carbon pricing and carbon trading in agriculture in the developed countries. The second section deals with the existing evidence and theoretical considerations regarding the welfare and distributional consequences of carbon pricing and carbon trading in agriculture. The third section reviews the status of the key initiatives in GHG mitigation related to agriculture in India, mainly from the perspective of government schemes, programmes and initiatives at the central and state level. The fourth section concludes the discussions.

Mitigation and Carbon Markets in Agriculture in the Global North

We begin our discussion with Table 1, which shows the specific mitigation targets in the agricultural sectors of the Organisation for Economic Co-operation and Development (OECD) countries. These account for a major part of the developed countries in the Annex I classification of the UNFCCC, the rest being the so-called "Economies in Transition," namely the former Soviet bloc countries. As the table shows, very few

Table 1: Agriculture Emissions and Emission Trading Systems (ETS) of Select OECD Countries

	Agricultural Emissions and Targets		ETS and Agriculture			
Country/Region	Share of Agricultural Emissions in Total GHG Emissions (with LULUCF) (%)	Mitigation Target (with Base Year/ Level in Parentheses)	ETS	ETS Sectors Covered	ETS Coverage of Agricultural Emissions (Yes /No)	Plans to Include Agricultural Emissions
Austria	10.76	None	Austria ETS	Road transport, buildings (residential/service/public, industry and energy (non-EU ETS)	No	–
Canada	8.31	-30% fertiliser emissions by 2030 (2020)	Canada Federal OBPS	Industry (emission-intensive, >= 50 ktCO_2e per year) and trade exposed sectors	No	–
EU	11.68	No target at the EU level. Targets for member states for 2030 are: BEL: -25% (2005); DNK: -55% (1990); DEU: -31-34% (1990); FRA: -18% (2015); IRL: -22-30% (2018); PRT: -11% (2005)	EU ETS	Domestic aviation, industry, power, maritime	No	Discussions ongoing; no deadline set
Germany	7.37	None	Germany ETS	Transport, buildings	No	–
New Zealand	67.78	-24–47% reduction in biogenic methane by 2050	New Zealand ETS	Forestry, waste, domestic aviation, transport, buildings, industry, power	No	Yes, by 2025
Switzerland	13.63	-40% by 2050 (1990)	Switzerland ETS	Domestic aviation, industry, power	No	–
United Kingdom	10.01	-17–30% by 2030; -24–40% by 2035 (2019)	UK ETS	Domestic aviation, industry, power	No	–
US		None	California cap and trade system; regional greenhouse gas initiative			–

Source: Data compiled from UNFCCC GHG Data Interface; OECD (2022b); ICAP (2023).

OECD countries have set specific mitigation targets for their agricultural sectors. Most countries with agriculture-specific targets are in the European Union (EU).

Emission pricing and trading: Emissions pricing instruments are among the range of policy instruments available at the disposal of governments to mitigate agricultural emissions. Emissions pricing instruments either tax the emissions or establish tradable permits. While emissions taxes have been implemented on certain sectors by some countries, the agricultural sector remains largely exempt. Canada's carbon pollution pricing system, which has been in effect across all provinces since 2019, notably does not include the agricultural sector. Similarly, in Norway, the agricultural sector is mostly excluded from the national carbon tax, except for emissions arising from fossil fuel use in agriculture. Other GHG emissions from agriculture are not subject to taxation in Norway.

Another market-based emission pricing instrument to reduce greenhouse gas (GHG) emissions is the emissions trading system (ETS). The ETS operates on the "cap and trade" principle, where the government sets a maximum on the total emissions within one or more sectors of the economy. Firms and enterprises within these sectors are required to possess one permit for each tonne of emissions. These permits can be obtained through allocation or purchase, and companies have the option to engage in permit trading with other companies. ETS have been implemented across various developed nations, including the EU ETS at the regional-, national-level schemes like the New Zealand ETS and United Kingdom ETS, as well as subregional programmes like the United States's (US) California Cap-and-Trade Program and the Regional Greenhouse Gas Initiative (RGGI).

Nevertheless, it is important to note that, as of now, no ETS in any part of the world covers emissions originating from the agricultural sector. On pricing emissions from agriculture, developed countries are pursuing a cautious and phased approach deploying extensive public consultation, stakeholder engagement, feasibility studies, technological development, and capacity building of farmers.

In terms of sectoral coverage, the New Zealand ETS has the broadest coverage and is the only ETS to include the forestry sector (Neilson 2023). Agriculture contributes more than 50% of New Zealand's gross GHG emissions, representing by far the largest share among the OECD nations. Around 91% of its biogenic methane emissions are from agriculture. Consequently, it is one of the few countries with declared mitigation targets for agricultural emissions. New Zealand's 2019 Zero Carbon Amendment Act, by distinguishing between short- and long-lived gases, aims to reduce gross biogenic methane emissions by 10% below 2017 levels by 2030 and by 24%–47% by 2050. Other GHG emissions are to reach net zero by 2050.

New Zealand also proposes to levy a carbon price on agricultural emissions by 2025, either through the ETS or a separate pricing mechanism. To lay the groundwork, it conducted public consultations on the government's proposed agricultural emissions pricing system in 2022 and published a document on policy directions. The reporting of farm-level emissions will become mandatory by 2024. A final decision on the implementation of farm-level pricing on emissions will depend on the outcome of a government study into its feasibility. This transition period is supposed to allow farmers and government agencies to build capacity on the measurement, reporting and verification (MRV) of farm-level emissions prior to the introduction of carbon pricing (Henderson et al 2021).

However, the National Party, which has emerged as a strong contender to the ruling Labour Party in the October 2023 elections, has asserted that it will delay current plans to price agricultural emissions from 2025 to 2030 and restrict the conversion of farmland to carbon-based forestry purportedly to protect local communities and domestic food production, keep food prices down and ensure that farmers have the tools they need to reduce emissions before charging them for their on-farm emissions (Coughlan 2023; Mcclay 2023).

Similarly, agriculture is an important part of the European economy, and plays a significant role in social and political terms. In the EU, farmlands cover 38% of the EU's total land area, but agriculture accounts for only approximately 1.5% of the total value added. The sector accounts for 11% of the EU's GHG emissions. While the EU ETS has been in operation since 2005, covering industry, power and domestic aviation, there is no plan to extend it to the agricultural sector. According to the European Court of Auditors, EU law does not apply the polluter-pays-principle to agricultural emissions and recommended that the European Commission should "assess the potential of applying the … principle to agricultural emissions, and reward farmers for long-term carbon removals" (European Court of Auditors 2021). In response, the European Commission is exploring options for pricing agricultural GHG emissions along the food value chain as well as for rewarding farmers and other landowners for carbon farming. They have commissioned an exploratory study to investigate ways to put a price on agricultural emissions possibly via a new and separate ETS. There is currently no established timeline for when pricing of agricultural emissions will go into effect.

The EU's attempt to limit agricultural emissions through its Common Agricultural Policy (CAP) has also not been successful. Between 2014 and 2020, the CAP spent €100 billion to encourage farmers to apply climate-friendly practices and techniques through three different mechanisms: the cross-compliance mechanism, which refers to a set of requirements and standards that farmers and landowners must adhere to receive direct payments and other forms of financial assistance; direct payments; and subsidies for rural development.

However, the European Court of Auditors (2021) concluded that CAP had little impact on agricultural emissions. Further, most mitigation measures supported by the CAP have a low potential to mitigate climate change and CAP rarely finances measures with high climate mitigation potential. Livestock emissions represent around half of emissions from agriculture and have been stable since 2010. Emissions from chemical fertilisers and manure increased between 2010 and 2018.

There are several reasons why developed countries are reluctant to price agricultural emissions, include it in an ETS or

push non-market measures to reduce agricultural emissions. These range from concerns regarding food production, protecting consumers from food price rises, ensuring trade competitiveness of agricultural products and protecting rural community and rural way of life (Holligan 2022; Kerr nd). Additionally, the complexity of measuring emissions at the farm level poses a significant challenge. Not only are emissions spread across millions of small agents relative to industrial emissions, but farm emissions are also affected by multiple factors like animal diets, tillage practices, soil composition, and fertiliser application methods (Matthews 2023; Verschuuren 2022). Farm-level monitoring and reporting of emissions have very high transaction costs for farmers and authorities. Other factors include capability of farmers to apply recommended farming practices, uncertainty among scientists about the effectiveness, feasibility and cost of mitigation options, and limited current mitigation options within the livestock systems (Matthews 2023; Powlson et al 2014, 2016).

Carbon offsets: While agriculture is not required to reduce GHG emissions under compliance ETS programmes, it is in principle a permitted source of offsets in some of them. However, in practice, the use of agricultural offsets in compliance ETS schemes (compliance schemes are those where participation is mandated by the government with specific mitigation targets) is relatively limited and varies by region. While ETS systems are designed to be flexible, allowing companies to either reduce emissions directly or to purchase permits from others, the inclusion of offsets provide even greater flexibility. Offsets allow emission reductions from outside the scope of the ETS. In the US, some compliance markets accept offsets from reduced or avoided agricultural GHG emissions but do not allow offsets from soil carbon sequestration. For example, California's Cap-and-Trade Program permits the use of offsets to cover 4% of compliance obligations, including livestock manure management, mine methane capture, and US forests. However, the majority of offset credits come from forestry projects in California.

Canada has established the GHG Offset Credit System to incentivise various entities—including businesses, municipalities, Indigenous communities, foresters, and farmers—to undertake projects aimed at reducing GHG emissions or removing GHGs from the atmosphere.[1] Offset credits can be traded and used for compliance as well. Yet, these offset credits do not currently cover sectors like forestry, agriculture, and livestock feed management.

Starting in 2021, offset projects are no longer accepted as a compliance option within the EU ETS programme. Overall, carbon offsets from agricultural activities have played a relatively minor role in compliance carbon markets, with forestry projects having a substantial presence.

Among the reasons for the failure of offsets in agriculture are limited supply of funding to pay agricultural producers for emissions reductions and limited demand for offsets due to the upper limit set up by various compliance ETS schemes (Henderson et al 2021). Agricultural offsets also require strong transparency and integrity standards to ensure additionality (that is, emissions reduction would not have happened without market for offsets) and permanence (that is, sequestered carbon can return to the atmosphere if farming practices change), potentially limiting their scope and effectiveness.

To summarise, developed countries—that practise "industrial agriculture with significant carbon footprint—have shown limited progress both in pricing agricultural emissions and in trying to mitigate agricultural emissions through other measures. We shall discuss the implications of the experience of the global North for India in the concluding section.

Distributional Impacts of Carbon Pricing

There are broadly two forms of carbon pricing—either by allowing trade in emissions with a cap or through an imposition of carbon tax (Steinebach et al 2021). The theoretical foundation of the cap-and-trade systems for emission reduction can be traced back to Coase's Theorem (Coase 1960, 1988). On the other hand, a carbon tax can be theoretically traced back to the Pigouvian Tax, which can be imposed broadly in three ways based on the amount of carbon emitted; on the use of inputs with high carbon content; and on carbon content in the final output (Gandhi and Cuervo 1998).

On cap-and-trade or carbon taxes, most reviews have concentrated on understanding the impact of carbon pricing on efficiency, productivity, carbon emissions, land use change and carbon leakage (Ollikainen et al 2020; Malhi et al 2021; Rosenstock et al 2016; MacLeod et al 2015; Arvanitopoulos 2021). The distributional impact of these economic instruments does not seem to have received as much attention.

Most studies use rational expectations or structural or general equilibrium or partial equilibrium models to understand distributional impacts. Other studies use models accounting for farm-level heterogeneity to study the distributional impacts.

Jansson et al (2023) conducted an *ex ante* analysis of region-wise impacts on food security for 2030 with a baseline without carbon taxes. According to them, if a global carbon tax of EUR 120 per tonne of CO_2 (or CO_2 equivalent) is implemented, food security in certain parts of the world like Ethiopia and Vietnam will be severely hit. Frank et al (2017) estimated that a global carbon tax on agricultural GHG emissions would lead to a significant increase in agricultural commodity prices in regions with inefficient production systems like sub-Saharan Africa, South Asia, and Southeast Asia. However, land-rich developing countries like Brazil may be able to reduce emissions with limited adverse impact on food security. They argued that the implementation of a carbon price can lead to a global average fall in calorie availability in 2050. There will be a decline in calorie availability up to 285 kcal per capita per day in a 1.5°C scenario, which would render 500 million people (up from the current 200 million people now) chronically undernourished in 2050. Havlik et al (2014) suggested that a global carbon price of \$100/t CO_2 equivalent on agricultural and land-use change sectors will lead to a loss of 200 kcal per capita per day. Hasegawa et al (2015) estimated that if global uniform carbon taxes were imposed, India could experience a loss in calories of up to 170 kcal per capita per day.

Ifft et al (2018) argued that a carbon tax on fuel-intensive inputs was regressive for intermediate and commercial-sized farms in the US. The regressivity was statistically significant at a carbon tax of above $10 per tonne of carbon, which is lower than what is considered necessary for mitigation to achieve the Paris targets. On a federal greenhouse gas cap-and-trade (GHG CAT) programme, Jiang and Koo (2010, 2014) estimated the change in cost and net farm income using a simulation model based on surveys of farmers from North Dakota. With the fertiliser industry exempted from GHG cap-and-trade, in the short run, less than 10% of farms in North Dakota would suffer loss. But if the fertiliser industry is subjected to caps, 70% of farms in North Dakota will incur losses with carbon prices up to $65 per metric tonne CO_2 equivalent. The economic loss ranged between $0 and $30 (with the fertiliser industry exempted) and between $0 and $55 (with the fertiliser industry capped).

Gonzalez (2012) analysed the distributional impact of carbon tax on Mexico and US with the assumption that the revenue generated from carbon tax will be recycled through either a manufacturing tax-cut or a food subsidy. The recycling through manufacturing tax would lead to a regressive distribution of costs but recycling through food subsidy would be progressive. For corn, sorghum, soybeans, and wheat, Dumortier and Elobeid (2020) found that even though there were significant regional differences, there would be a decline in median net returns for farmers across different states of the US due to increase in input costs.

Using a large-scale global, comparative-static economic, multi-commodity, agricultural sector model, Felimann et al (2018) estimated that small and less competitive farmers in EU may be pushed out of farming. But those who would remain in farming may potentially benefit, as increase in prices is likely to offset the increase in input costs and decline in output. They, however, caution that their "aggregated EU result hides large differences between the regions in the member states" (p 461).

Partridge et al (2015) undertook an *ex ante* analysis of South Africa's 2016 carbon tax. They found that irrespective of whether agriculture was excluded or included in implementation of carbon tax in South Africa, the domestic agricultural activity output would fall by 7%. In fact, the indirect impact of carbon tax due to a rise in input prices constituted 93% of the overall impact on agriculture. If the tax was imposed on all sectors, including agriculture, total agricultural commodity output would fall. Corong and Strutt (2019) studied the possible impacts of change in fuel and carbon emission prices on agriculture in New Zealand. They found that output and exports of key agricultural sectors—beef, sheep meat and dairy products—would decline even with a moderate increase in carbon prices in New Zealand and would witness further decline with increase in carbon prices and imposition of worldwide carbon taxes. The concerns about loss of jobs and distributional impacts in agriculture have been central to the political debate around carbon pricing in New Zealand (Cooper et al 2013). Lu et al (2010), using a dynamic recursive general equilibrium model, estimated that household consumption demand for all sectors, including agriculture would decline after the imposition of a carbon tax in China. They suggested a reduction in indirect taxes and provision of subsidy to households as measures to cushion the negative impacts and stimulate household consumption demand (Lu et al 2010).

It is worth mentioning here that in the case of India, Chandel and Kumari (2022) found that profit from paddy cultivation, which contributes 27% of farmers' gross income, was "directly elastic to output price … and inversely elastic to variable input prices …" (p 9). *Ceteris paribus*, any tax led to an increase in consumer prices and decline in producer prices. If supply was more elastic than demand, then the decline in producer prices was less than the increase in consumer prices. Agriculture goods, except for meat and dairy products, are generally characterised by low elasticity of demand (Arvanitopoulos et al 2021) and hence there is a higher probability of tax being passed forward (Coxhead et al 2013). Therefore, any imposition of carbon tax, which leads to rise in both output prices as well as input prices, will most likely adversely affect farmers' income in India and higher prices of agricultural goods will adversely impact low-income households (Arvanitopoulos et al 2021).

At the level of the economy, there is clear evidence of the adverse distributional impact of cap-and-trade scheme and carbon tax on the poor (Boyce 2018). Most of the empirical literature suggests that imposition of carbon tax would have a regressive impact on not only farmers but also household consumption. Accordingly, scholars have tried to find an appropriate recycling method to at least neutralise the regressive impact on carbon tax (Combet et al 2010). However, the recycling of revenue generated either through "cap and distribute" or "tax and distribute" to the poor through cash transfers may not lead to the desired results in developing countries (Azad and Chakraborty 2020).

Another problem with recycling the revenue is that transfers to household in cash or other forms may not lead to creation of jobs, especially when there can be job losses due to the impact of carbon pricing (Coxhead et al 2013). Since poor and low-income groups contribute only a small percent of total emissions (Michael and Vakulabharanam 2016), a better move from the point of view of equity would be to avoid imposing carbon taxes on them (Grottera et al 2017). One should also bear in mind that revenues from carbon taxes merely counterbalance the increase in production cost due to imposition of carbon taxes. The revenue generated from carbon tax is not "free money," as the votaries of the double dividend hypothesis would suggest (Fullerton and Metcalf 1997). Alternative proposals of imposing carbon tax only beyond a certain threshold so that resources required to fulfil the basic needs of people do not get taxed, should be also taken seriously (Baranzini et al 2000).

In sum, the over-arching message from the bulk of the literature is that there is no evidence that carbon taxes or cap-and-trade schemes would be of any benefit to farmers. There is much evidence to the contrary, considered at the global scale, that the impact of large-scale carbon trading to promote

mitigation in agriculture would result in the tide turning in the fight for global food security.

Mitigation and Carbon Trading in Indian Agriculture

India has always maintained with the UNFCCC that its agricultural emissions are "survival" and not "luxury," given their crucial role in ensuring food and nutritional security. During negotiations on the final drafting of the decision on the "Sharm el-Sheikh joint work on implementation of climate action on agriculture and food security" at COP 27, India opposed the efforts of developed countries to extend the scope of mitigation to agriculture in the developing countries (Carboncopy 2022). Adaptation and adaptation-led mitigation have been the central strategy in India's agricultural sector (Rao et al 2019). Thus, the theme of India's initiatives in agriculture have mainly been on sustainable development in agriculture with a focus on adaptation with co-benefits of mitigation accompanying some of these initiatives (Table 2).

The initiatives in Table 2 are only exploratory in nature, despite the major investment of resources that they represent,

Table 2: Details of Selected Schemes That Focus on Sustainable Agriculture, Government of India

Sl No	Name of the Scheme	Year of Introduction	Scope of the Scheme	Mitigation Benefits/Co-benefits
1	National Mission for Sustainable Agriculture (NMSA)	Established in 2010; Operational in 2014–15	Primary focus is to boost agricultural productivity, particularly in rainfed regions. It plans to increase "water use efficiency," "nutrient management" and "livelihood diversification" by adopting environment-friendly technologies, energy-efficient agricultural equipment, judicious use of inputs and promoting integrated farming (PIB 2018). NMSA has many components, as below:	
1a	Rainfed Area Development	2014–15	Aims to develop an integrated farming system across diverse components like crops, horticulture, livestock, fisheries, and forestry, along with income-generating activities.[1]	Mitigation benefits are to come from sustainable agriculture practices, such as soil health management, land development, resource conservation, and crop selection.
1b	Sub-mission on Agroforestry (SMAF)	Launched in 2016–17 under the National Agroforestry Mission (2014)	Aims to encourage tree planting on farmlands alongside crops.	The programme achieved an estimated emission reduction of 0.1318 $MtCO_2$ in 2017–18 and 2018–19 (MoEFC 2021)
1c	National Bamboo Mission	Launched in 2008–09 and restructured in 2018 under NMSA	Aims to increase bamboo plantations in non-forest areas of the country. The scheme also intervenes in post-harvest processing, skill development and market development (MoEFC 2021).	NBM Dashboard shows that 7,611.15 hectares were planted with bamboo from 1,328 plantations and 0.1873 Mt CO_2 equivalents CO_2 was sequestered in 2018–19[2]
2	Agriculture Demand Side Management (AgDSM)	2015	Aims to reduce power consumption in agriculture by improving energy efficiency of pumps and other demand-side management measures. It seeks to replace old inefficient pumps with BEE star-rated energy-efficient pumps (PIB 2015).	AgDSM dashboard shows that 81,180 pumps were replaced till October 2023, leading to savings of 210.23 million units/year, 1,55,571 t CO_2 emissions reduction/year, and 38,932 kW peak load demand reduction.[3]
3	Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)	National Mission on Micro-irrigation started in 2010, relaunched as PMKSY in 2015–16	Within PMKSY, the Per Drop More Crop (PMKSY- PDMC) component aims to replace traditional flood irrigation in crops with micro-irrigation (drip irrigation and sprinklers).It aims to increase water use efficiency,with the mitigation co-benefit being a reduction in power consumption for irrigation. The scheme also aims to create micro-level water storage and water conservation and management activities (PIB 2023a).	Till 2022–23, a total of 11.02 lakh ha has been brought under micro-irrigation, of which drip irrigation accounted for 5.32 lakh ha and sprinkler irrigation accounted for 5.70 lakh ha. There was an estimated emissions reduction of 22.82 $MtCO_2$ between 2010 and 2016.[4]
4	Crop diversification programme	2014-15	Aims to diversify at least 5% of cultivation away from water-intensive paddy and tobacco through alternate crop demonstrations, farm mechanisation & value addition, site-specific activities and awareness, training, and monitoring (PIB 2020).	Led to emissions reduction of 0.0388 $MtCO_2e$ during 2017–18. A total 81,816 ha of area shifted from paddy to other crops in 2017–18 and 2018–19 (MoEFC 2021).
5	System of Rice Intensification (SRI) and Direct Seeded Rice (DSR) cultivation in paddy	NA	Aims to reduce methane emissions arising from paddy. A reduction in water usage also leads to reduction in energy consumption for irrigation.	In 2017–18 and 2018–19, SRI was introduced in 52,377 ha and 33,487 ha respectively. In 2017–18 and 2018–19, DSR was introduced in 58,438 ha and 41,526 ha (MoEFC 2021).
6	Mission for Integrated Development of Horticulture (MIDH)	2014	Aims to promote cultivation of fruits,vegetables,root and tuber crops, mushrooms, spices, flowers, aromatic plants, coconut, cashews, and cocoa (PIB 2022).	Amount of carbon sequestered was 108.96 MtCO2between 2017–18 and 2018–19.
7	Neem coated urea	2015	Aims to coat all urea with neem oil to reduce the release rate of nitrogen and reduce losses (PIB 2021a).	Total mitigation of 7.529 $MtCO_2$ was achieved between 2017 and 2019 (MoEFC 2021).
8	Agricultural power solarisation under Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan (PM-KUSUM)	2019	Aims to replace diesel-powered water pumps with small solar power pumps up to 2 MW on farmers' barren/fallow/pasture/marshy land (PIB 2021b).	Projected to reduce 32 $MtCO_2$ emissions annually across the country if fully implemented (PIB 2023b; MoEFC 2021).

(1) National Mission for Sustainable Agriculture (https://nmsa.dac.gov.in/frmComponents.aspx).
(2) National Bamboo Mission dashboard (https://nbm.nic.in/Dashboard).
(3) National AgDSM Dashboard (http://agdsm.in/).
(4) PMKSY, Department of Agriculture and Farmers Welfare, GOI website (https://pmksy.gov.in/Default.aspx).
Source: Documents of the Government of India.

as is evident from the acreage covered and the emissions reduction that have been achieved. It is doubtful whether they can, as yet, be considered as scalable opportunities. There is no case, therefore, to regard the current efforts as representing some take-off point for agricultural mitigation in India. Of course, it may be argued in theory that it is only a matter of investing the required resources, whatever be the scale. But unless the overall budget expands, this would mean lesser resources to deal with the urgent development deficits and challenges in agriculture. Without climate finance available in real terms, and not merely as promises or targets, such scaled up mitigation will not be possible.

Another critical issue is that of the price of carbon in a carbon pricing scheme. There are three situations to be considered here. The first is the imposition of a carbon price on agriculture through carbon taxes. Already, through the numerous duties and taxes on fossil fuel use, India has an effective carbon tax, which the OECD estimates at approximately €13 per tonne (OECD 2022b). Farmers' input costs are affected by these taxes, though the level of farm mechanisation may keep this contribution low. But given the overall crisis of farmer incomes in India, a further rise in input costs through a direct carbon tax in any form is hardly in the realm of possibility.

The second possibility is that of a cap-and-trade scheme in Indian agriculture. Given the huge number of landholdings and their relatively low average area, measurement and verification are unlikely to be cost-effective. Attempting to achieve the same through farmer producer organisations or cooperatives will only pass the burden down to the lowest level, which is least equipped to deal with the challenge. Given the considerable efforts that developed countries themselves have had to undertake to enable readiness for measurable and verifiable mitigation activity (that is still to be introduced), there is no urgent need for a cap-and-trade scheme in Indian agriculture.

The third approach is the provision of incentives to farmers for mitigation using carbon offsets. Carbon offsets arise when one party (enterprises or individuals) provides finance to reduce mitigation elsewhere. Such finance may be provided through the selling of certificates of emissions reduction or removal that are initially provided to those undertaking the mitigation action. These are then sold to buyers who may then account for it as their emissions reduction, even though carried out on their behalf by another. These certificates of emission reduction or removal are either provided by a multilateral agency or through certifying agencies set up by private players or non-governmental organisations, as in the case of the voluntary carbon market. This approach is commonly portrayed as a win-win idea that will also add to farmers' incomes.

The draft Green Credit Programme Implementation Rules is an initiative that seeks to set up a voluntary carbon offset mechanism in India. Though the scope of environmentally friendly actions that it covers is much broader (hence "green"), the only structured market available is the carbon market in the foreseeable future. However, questions like whether those receiving the credits must bear the transaction costs are not clarified in the draft rules. As the experience of the Pradhan Mantri Fasal Bima Yojana shows, implementing large-scale monitoring down to the farm level will not be easy, especially since carbon mitigation will be even harder to monitor than losses due to weather extremes.

The more complex issue is that the beneficiaries of incentives would have to accept stringent conditionalities to ensure that the emissions reduction is permanent and lasting. Without such conditionalities, carbon credits would lack credibility leading to a collapse in their price. The issue of the credibility of credits was partly responsible for the collapse of the CDM credits. Recently, the voluntary carbon market, especially in the AFOLU sector, has again come under scrutiny with allegations that the carbon credits issued are not credible in India and other developing countries (Dev and Krishnamurthy 2023; Narain et al 2023; Probst et al 2023). Partly, consequently, the price of voluntary carbon credits fell steeply in 2022–23 (Carboncredits.com 2023). At the same time, such mitigation-centric conditionalities could also have serious negative consequences for farmers' production and incomes by restricting their freedom of farm-level decision-making.

Even if the carbon market is regulated to ensure that the credits are trustworthy, it is not obvious that they would benefit farmers, since their earnings would depend on carbon prices. Especially in developing countries, markets do not benefit the poor, and small and marginal farmers are well known to be vulnerable to price shocks of both inputs and outputs. Nor do farmers, especially small and marginal farmers, get the full benefit of high commodity prices for several reasons. Hence, the expectation that carbon markets will provide stable incomes to the bulk of India's smallholders stands unsubstantiated.

But the more fundamental problem with carbon trading mechanisms is that they are not aligned to the concept of the global carbon budget and the need for countries to equitably have access to these global commons. India has articulated this principle of operationalising equity in terms of equitable and fair access to the global carbon budget in its long-term low-emissions development strategy submitted to the UNFCCC (MOEFCC 2022). Cap-and-trade schemes assume, following the Coase theorem, that there is some distribution of rights to emissions among the emitters before trading commences. The Coase theorem argues that the environmentally viable outcomes are obtained irrespective of how these rights are distributed. However, this does not guarantee equity.

In Conclusion

Mitigation in agriculture is expensive and difficult, including its impact on farmers and the cost of monitoring, and even developed countries are hesitant to launch such initiatives. Mitigation in the agriculture sector in India is a burden that will be borne largely by one of the most vulnerable sections, with little historical responsibility for climate change. Mitigation in Indian agriculture, especially through carbon trading in the cap-and-trade sense or carbon offsets, where developed countries are the predominant buyers, is a means by which they will further enable their appropriation of carbon space. While these arguments apply to all carbon trading, agriculture is a sector whose emissions must be considered a necessary

part of ensuring food security for the future. This must be considered so until decarbonisation of agriculture can be achieved without threat to productivity and food security.

There is no case for any rush to develop carbon markets in agriculture. There is also no compelling case for mitigation being part of the main agenda of Indian agriculture. India would be far better off with a focus on adaptation as the key issue in the matter of climate change and agriculture, with mitigation being a co-benefit that radically improves input efficiency in agriculture.

NOTE

1 https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/output-based-pricing-system/federal-greenhouse-gas-offset-system.html.

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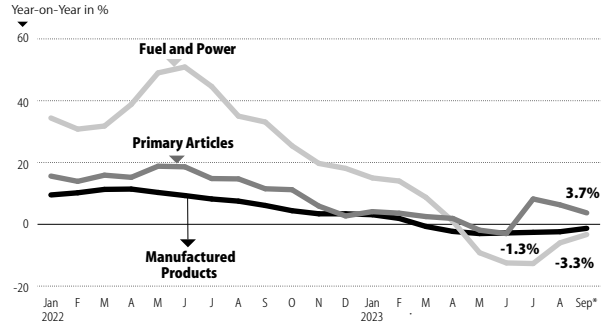
Wholesale Price Index

The year-on-year WPI-based inflation rate declined to -0.3% in September 2023 from 10.6% registered a year ago. The index for primary articles grew by 3.7% compared to 11.5% reported a year ago and 6.3% a month ago. The rate of inflation for food articles decreased to 3.3% from 11.0% a year ago and 10.6% a month ago. The index for fuel and power declined by (-)3.3% against 33.1% registered a year ago and that for manufactured products decreased by (-)1.3% compared to 6.1%.

Consumer Price Index

The CPI- inflation rate decreased to 5.0% in September 2023 from 7.4% reported a year ago and 6.8% a month ago. The consumer food price index grew by 6.6% compared to 8.6% a year ago and 9.9% a month ago. The CPI-rural inflation rate was down to 5.3% and the urban-inflation rate to 4.7% from 7.6% and 7.3%, respectively, reported a year ago. According to Labour Bureau data, the CPI for agricultural labourers (CPI–AL) stood at 6.7% in September 2023 compared to 7.7% a year ago and the CPI for industrial workers (CPI–IW) at 6.9% in August 2023 against 5.9%.

Movement of WPI-Inflation Rate January 2022–September 2023



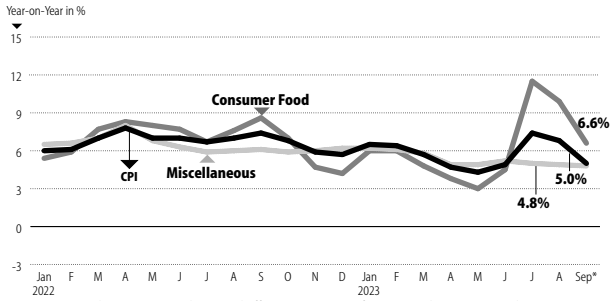
* Data is provisional; Base: 2011–12 = 100.

Trends in WPI and Its Components September 2023* (%)

	Weights	Over Month	Over Year	Financial Year (Averages) 2020–21	2021–22	2022–23
All commodities	100	-0.6	-0.3	1.3	13.0	9.4
Primary articles	22.6	-3.8	3.7	1.7	10.2	10.0
Food articles	15.3	-6.5	3.3	3.2	4.1	7.3
Fuel and power	13.2	2.3	-3.3	-8.0	32.5	28.1
Manufactured products	64.2	0.4	-1.3	2.8	11.1	5.6

*Data is provisional; Base: 2011–12=100. Source: Ministry of Commerce and Industry.

Movement of CPI Inflation January 2022–September 2023



* Data is provisional. Source: National Statistical Office (NSO), Ministry of Statistics and Programme Implementation, Base: 2012=100.

CPI: Rural and Urban September 2023* (%)

	Latest Month Index	Over Month	Over Year	Financial Year (Avgs) 2021–22	2022–23
CPI Combined	184.1	-1.1	5.0	5.5	6.7
Rural (2012 = 100)	185.8	-1.0	5.3	5.4	6.8
Urban (2012 = 100)	182.2	-1.2	4.7	5.6	6.4

CPI: Occupation-wise

Industrial workers (2016 = 100)#	139.2	-0.4	6.9	5.1	6.1
Agricultural labourers (1986-87 = 100)	1226	0.2	6.7	4.0	6.8

* Provisional; # August 2023; Source: NSO (rural and urban); Labour Bureau (IW and AL).

Foreign Trade

The foreign trade deficit stood at $19.4 bn in September 2023 compared to $28.0 bn reported a year ago. Exports contracted by (-)2.6% to $34.5 bn and imports by (-)15.0% to $53.8 bn from $35.4 bn and $63.4 bn, respectively, registered a year ago. Oil imports stood lower at $14.0 bn against $17.6 bn a year ago and non-oil imports at $39.9 bn compared to $45.8 bn. During April–September 2023–24, the cumulative exports declined by (-)8.8% to $211.4 bn and imports by (-)12.2% to $327.0 bn compared to $231.7 bn and $372.6 bn, respectively, registered during the same period last year.

Index of Eight Core Industries

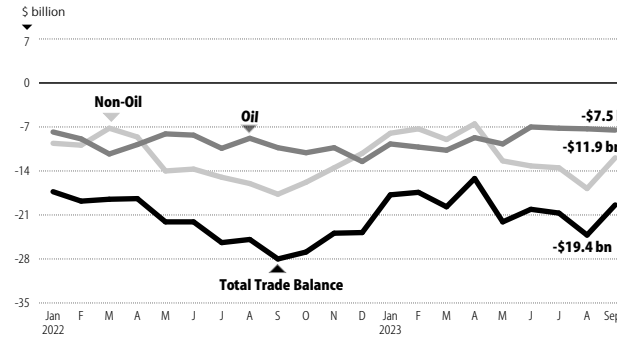
The ICI increased by 12.1% in August 2023 compared to 4.2% registered a year ago. Production of coal rose by 17.9%, refinery products by 9.5%, natural gas by 10% and crude oil by 2.1% against 7.7%, 7.0%, -0.9% and -3.3%, respectively, reported a year ago. Growth rate in the steel segment increased to 10.9%, cement to 18.9% and electricity generation to 14.9% from their respective growth rates of 5.8%, 2.1% and 1.4% a year ago. Production of fertiliser stood at 1.8% compared to 11.9% a year ago.

Merchandise Trade September 2023

	September 2023 ($ bn)	Over Month (%)	Over Year (%)	April–September (2023–24 over 2022–23) (%)
Exports	34.5	0.0	-2.6	-8.8
Imports	53.8	-8.2	-15.0	-12.2
Trade balance	-19.4	-19.8	-30.8	-17.9

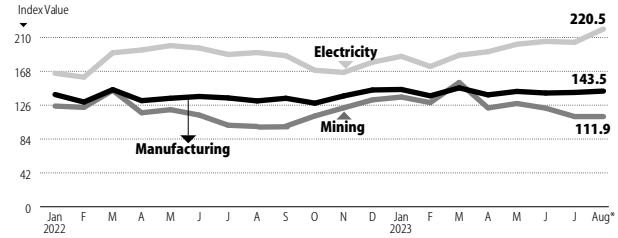
Data is provisional. Source: Ministry of Commerce and Industry.

Trade Balance January 2022–September 2023



Oil refers to crude petroleum and petroleum products, while non-oil refers to all other commodities.

Movement of Index Values of Components of IIP January 2022–August 2023



* August 2023 are quick estimates; Base: 2011–12=100.

Index for Eight Core Industries August 2023* (%)

	Weights	Over Month	Over Year	Financial Year (Avgs) in % 2021–22	2022–23
Infrastructure industries	40.27@	2.5	12.1	10.4	7.8
Coal	10.3	-1.5	17.9	8.5	14.8
Crude oil	9.0	-0.6	2.1	-2.6	-1.7
Natural gas	6.9	1.6	10.0	19.2	1.6
Petroleum refinery products	28.0	0.7	9.5	8.9	4.8
Fertilisers	2.6	1.1	1.8	0.7	11.3
Steel	17.9	-0.8	10.9	16.9	9.3
Cement	5.4	8.8	18.9	20.8	8.7
Electricity	19.9	7.8	14.9	8.0	8.9

(Base: 2011–12=100); *Data is provisional; @The revised eight core industries have a combined weight of 40.27% in the IIP. Source: Ministry of Commerce and Industry.

Comprehensive current economic statistics with regular weekly updates are available at: http://www.epwrf.in/currentstat.aspx.

India's Quarterly Estimates of Final Expenditures on GDP

₹ Crore | At 2011–12 Prices	2021–22 Q1		2021–22 Q2		2021–22 Q3		2021–22 Q4		2022–23 Q1		2022–23 Q2		2022–23 Q3		2022–23 Q4		2023–24 Q1	
Private final consumption expenditure	1822102	(17.6)	2121839	(14.2)	2426098	(10.8)	2333501	(4.7)	2182357	(19.8)	2298123	(8.3)	2478700	(2.2)	2399515	(2.8)	2312601	(6.0)
Government final consumption expenditure	403808	(-2.1)	346501	(11.7)	350565	(5.8)	474406	(11.8)	411243	(1.8)	332450	(-4.1)	348329	(-0.6)	485284	(2.3)	408300	(-0.7)
Gross fixed capital formation	1077836	(61.0)	1209609	(12.4)	1179221	(1.2)	1412108	(4.9)	1297588	(20.4)	1325580	(9.6)	1273453	(8.0)	1538071	(8.9)	1400832	(8.0)
Change in stocks	28895	(974.6)	31402	(655.9)	29902	(618.9)	33964	(613.8)	31050	(7.5)	30591	(-2.6)	29868	(-0.1)	35954	(5.9)	32256	(3.9)
Valuables	22035	(481.3)	134378	(156.6)	73595	(44.5)	48751	(-51.7)	34959	(58.7)	108206	(-19.5)	45595	(-38.0)	37330	(-23.4)	27633	(-21.0)
Net trade (Export–Import)	15631		-46285		-91258		-65580		-86460		-146624		-97506		-6264		-258496	
Exports	765031	(46.1)	826729	(25.1)	825929	(27.8)	888144	(22.4)	915111	(19.6)	927872	(12.2)	917492	(11.1)	994047	(11.9)	844252	(-7.7)
Less imports	749401	(44.8)	873014	(26.6)	917188	(19.7)	953723	(6.7)	1001571	(33.6)	1074495	(23.1)	1014998	(10.7)	1000311	(4.9)	1102748	(10.1)
Discrepancies	-59256	(-173.6)	-145787	(-293.2)	-117350	(-388.8)	-124790	(-758.1)	-126452	(113.4)	-70326	(-51.8)	-55812	(-52.4)	-128375	(2.9)	114019	(-190.2)
Gross domestic product (GDP)	3311050	(21.6)	3651659	(9.1)	3850772	(5.2)	4112360	(4.0)	3744285	(13.1)	3878000	(6.2)	4022625	(4.5)	4361515	(6.1)	4037144	(7.8)

India's Overall Balance of Payments (Net): Quarterly

Item	2022–23 ($ mn) Q1	Q2	Q3	Q4	2023–24 ($ mn) Q1	2022–23 (₹ bn) Q1		Q2		Q3		Q4		2023–24 (₹ bn) Q1	
Current account	-17964	-30902	-16832	-1356	-9214	-1387	[-2.1]	-2466	[-3.8]	-1384	[-2.0]	-111.6	[-0.2]	-757	[-1.1]
Merchandise	-63054	-78313	-71337	-52587	-56596	-4867		-6249		-5864		-4326.1		-4652	
Invisibles	45090	47411	54505	51231	47382	3480		3783		4481		4214.5		3895	
Services	31069	34426	38713	39075	35125	2398		2747		3182		3214.5		2887	
of which: Software services	30692	32681	33541	34370	33928	2369		2608		2757		2827.4		2789	
Transfers	22874	24773	28467	24762	22866	1766		1977		2340		2037.1		1880	
of which: Private	23065	24991	28641	25080	23073	1780		1994		2354		2063.2		1897	
Income	-8853	-11788	-12675	-12606	-10609	-683		-941		-1042		-1037.1		-872	
Capital account	22055	1461	28887	6540	34374	1702	[2.6]	117	[0.2]	2375	[3.4]	538.0	[0.7]	2826	[4.0]
of which: Foreign investment	-1238	12741	6641	4691	20812	-96		1017		546		385.9		1711	
Overall balance	4595	-30379	11069	5579	24432	355	[0.5]	-2424	[-3.7]	910	[1.3]	459.0	[0.6]	2008	[2.8]

Figures in square brackets are percentage to GDP.

Foreign Exchange Reserves

Excluding gold but including revaluation effects	13 October 2023	14 October 2022	31 March 2023	Variation: Month Ago	Year Ago	Financial Year So Far 2022–23	2023–24	Financial Year 2018–19	2019–20	2020–21	2021–22	2022–23
₹ crore	4474047	4003692	4340297	-50138	470356	-233925	133750	68050	668976	590416	302585	102680
$ mn	537346	486101	528083	-6661	51244	-73513	9262	-14168	56831	94535	21435	-31532

Monetary Aggregates

₹ Crore	Outstanding 2023	Variation: Over Month		Over Year		Financial Year So Far 2022–23		2023–24		Financial Year 2020–21		2021–22		2022–23	
Money supply (M_3) as on 6 October	23686111	208940	(0.9)	2350047	(11.0)	842335	(4.1)	1342351	(6.0)	2044615	(12.2)	1649151	(8.8)	1850031	(9.0)
Components															
Currency with public	3188095	-21137	(-0.7)	124749	(4.1)	27658	(0.9)	-88341	(-2.7)	402080	(17.1)	283859	(10.3)	240748	(7.9)
Demand deposits	2427930	93511	(4.0)	242284	(11.1)	-27346	(-1.2)	107332	(4.6)	257428	(14.8)	217872	(10.9)	107606	(4.9)
Time deposits	17996638	134919	(0.8)	1979335	(12.4)	830698	(5.5)	1327672	(8.0)	1376262	(10.9)	1136327	(8.1)	1482361	(9.8)
Other deposits with RBI	73449	1648	(2.3)	3679	(5.3)	11326	(19.4)	-4312	(-5.5)	8844	(23.0)	11093	(23.4)	19317	(33.1)
Sources															
Net bank credit to government	7369669	-47305	(-0.6)	810642	(12.4)	81398	(1.3)	204136	(2.8)	890012	(17.9)	627255	(10.7)	687904	(10.6)
Bank credit to commercial sector	15486805	309180	(2.0)	1894578	(13.9)	975707	(7.7)	1057168	(7.3)	629822	(5.7)	948054	(8.1)	1813117	(14.4)
Net foreign exchange assets	5028510	-57015	(-1.1)	545969	(12.2)	-371521	(-7.7)	116745	(2.4)	777810	(20.5)	275216	(6.0)	57703	(1.2)
Banking sector's net non-monetary liabilities	4230521	-3832	(-0.1)	903786	(27.2)	-155762	(-4.5)	37061	(0.9)	253594	(8.4)	202476	(6.2)	710963	(20.4)
Reserve Money as on 13 October	4361653	-134416	(-3.0)	252055	(6.1)	40711	(1.0)	-25106	(-0.6)	570276	(18.8)	468905	(13.0)	317872	(7.8)
Components															
Currency in circulation	3301582	-6791	(-0.2)	113837	(3.6)	54029	(1.7)	-76938	(-2.3)	406451	(16.6)	279953	(9.8)	244804	(7.8)
Bankers' deposits with RBI	986990	-128871	(-11.5)	134806	(15.8)	-24541	(-2.8)	56513	(6.1)	154979	(28.5)	177858	(25.4)	53752	(6.1)
Other deposits with RBI	73081	1245	(1.7)	3413	(4.9)	11224	(19.2)	-4681	(-6.0)	8844	(23.0)	11093	(23.4)	19318	(33.1)
Sources															
Net RBI credit to Government	1074456	-96204	(-8.2)	-48966	(-4.4)	-327174	(-22.6)	-376669	(-26.0)	107495	(10.8)	350910	(31.9)	529	(0.0)
of which: Centre	1054134	-99629	(-8.6)	-61494	(-5.5)	-333344	(-23.0)	-396242	(-27.3)	106606	(10.8)	352626	(32.2)	1404	(0.1)
RBI credit to banks & commercial sector	30461	-24896	(-45.0)	10682	(54.0)	563481	(-103.6)	124904	(-132.3)	-168464	(83.9)	-174345	(47.2)	449259	(-82.6)
Net foreign exchange assets of RBI	4714848	-52489	(-1.1)	521651	(12.4)	-249283	(-5.6)	127492	(2.8)	608998	(17.0)	243080	(5.8)	144876	(3.3)
Govt's currency liabilities to the public	31649	249	(0.8)	2645	(8.3)	991	(3.5)	1363	(4.5)	565	(2.1)	1100	(4.1)	2273	(8.1)
Net non-monetary liabilities of RBI	1489760	-38924	(-2.5)	233957	(18.6)	-52697	(-4.0)	-97804	(-6.2)	-21682	(-1.6)	-48160	(-3.5)	279064	(21.3)

Scheduled Commercial Banks' Indicators *(₹ Crore)*

(As on 6 October)	Outstanding 2023	Variation: Over Month		Over Year		Financial Year So Far 2022–23		2023–24		Financial Year 2020–21		2021–22		2022–23	
Aggregate deposits	19607329	224430	(1.2)	2343672	(13.6)	798344	(4.8)	1563416	(8.7)	1546019	(11.4)	1351801	(8.9)	1578600	(9.6)
Demand	2286057	91652	(4.2)	241329	(11.8)	-28018	(-1.4)	105627	(4.8)	244190	(15.1)	211553	(11.4)	107684	(5.2)
Time	17321272	132778	(0.8)	2102343	(13.8)	826362	(5.7)	1457789	(9.2)	1301831	(10.9)	1140247	(8.6)	1470916	(10.2)
Cash in hand	94070	-5214	(-5.3)	-16460	(-14.9)	24604	(28.6)	3807	(4.2)	3487	(4.0)	-4822	(-5.3)	4337	(5.0)
Balance with RBI	960612	-31934	(-3.2)	175722	(22.4)	101453	(14.8)	150705	(18.6)	6507	(1.2)	140744	(25.9)	126470	(18.5)
Investments	6061011	78150	(1.3)	956638	(18.7)	375425	(7.9)	645863	(11.9)	715177	(19.1)	266422	(6.0)	686200	(14.5)
of which: Government securities	6060315	78229	(1.3)	956776	(18.7)	375360	(7.9)	645993	(11.9)	722935	(19.3)	266547	(6.0)	686143	(14.5)
Bank credit	15342741	304576	(2.0)	2483935	(19.3)	967492	(8.1)	1667506	(12.2)	578649	(5.6)	1044026	(9.6)	1783921	(15.0)
of which: Non-food credit	15323461	304367	(2.0)	2485289	(19.4)	1001869	(8.5)	1668132	(12.2)	569159	(5.6)	1050269	(9.7)	1819026	(15.4)

Capital Markets

	20 October 2023		Month Ago	Year Ago	Financial Year So Far Trough	Peak	2022–23 Trough	Peak	End of Financial Year 2020–21		2021–22		2022–23	
S&P BSE SENSEX (Base: 1978-79 = 100)	65397.62	(10.5)	66800.84	59202.90	(-3.4)	59106.44	67838.63	51360.42	63284.19	49009	(63.7)	57362	(18.4)	58992	(0.7)
S&P BSE-100 (Base: 1983-84 = 100)	20006.36	(11.2)	20381.05	17983.77	(-2.9)	17644.91	20666.08	15562.65	19137.18	14689	(68.2)	17423	(20.1)	17602	(-0.7)
S&P BSE-200 (1989-90 = 100)	8549.13	(11.4)	8706.33	7677.70	(-2.6)	7406.09	8819.05	6602.62	8144.55	6211	(71.1)	7412	(20.9)	7389	(-2.0)
CNX Nifty-50 (Base: 3 November 1995 = 1000)	19542.65	(11.3)	19901.40	17563.95	(-3.8)	17398.05	20192.35	15293.50	18812.50	14507	(67.9)	17153	(19.7)	17360	(-0.6)
CNX Nifty-500	17208.75	(13.9)	17449.35	15112.10	(-2.9)	14601.95	17665.80	12950.75	16003.95	12149	(73.7)	14652	(22.2)	14558	(-2.3)

Figures in brackets are percentage variations over the specified or over the comparable period of the previous year. | (-) = not relevant | - = not available | NS = new series | PE = provisional estimates

■ Comprehensive current economic statistics with regular weekly updates are available at: http://www.epwrf.in/currentstat.aspx.

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