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Agriculture and Rural Economy Stock Taking Paper

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AGRICULTURE AND RURAL ECONOMY

TAKING STOCK

1. Changing Diets

In 2023, the share of food in the budgets of rural households fell below 50% for the first ever time (Tables 1 and 2). Compared to previous surveys, the food budget share was lower in both rural and urban households. Most of the decline is attributable to a sharp fall in the budget share of cereals. Less than 5% of all spending goes to cereals comprising rice, wheat and others such as maize, sorghum and millets – a commodity group that occupies a prime spot in our agricultural and food policies (Tables 1 and 2). In terms of sales value, milk, vegetables, fruits, and eggs, fish and meat are either as important or more.

These trends – in the share of food and its components – conform to empirical regularities that are so widely observed that they have the status of laws. Engel's law states that the budget share of food declines with income. A low budget share of food is an indicator of prosperity as it releases resources for households to spend on health, education, and consumer goods. The lesser known Bennett's law states that share of calories derived from staples declines with income. A low share of staples in total calories could indicate a healthy and diversified diet if the released resources are spent on nutritious foods such as those mentioned above. However, this may not happen if the declining relative importance of staples is accompanied by a rising share of processed foods. In the Indian data, processed foods account for about 10% of

household spending. The category includes foods that could be ‘junk’ offering minimal nutritional value or empty calories. Hence the implication of Bennett’s law for nutrition is ambiguous.

2. Health Outcomes and Diets

Nutritional outcomes are slowly improving but remain a cause for concern. Figure 1 shows that while there has been progress in reducing hunger (calorie deficiency), the problem has not vanished. We have not progressed much in reducing anemia among women (Figure 2). They remain among the highest in the world. Nutritional outcomes for children (stunting, anemia and Vitamin A deficiency) are also concerning (Figure 3). Paradoxically, even when we still have calorie and micronutrient deficiencies, obesity is on the rise comparatively among women (Figure 4). The improvement in economic conditions that have diminished hunger may also be responsible for the rise in obesity (Young et. al, 2020). There is a big role played by agricultural value chain transformation with rising incidence of food away from home and snacking including hunger snacking that transcends all regions and income groups. On the positive side, the coverage of nutritional interventions has been improving (Christopher, et. al, 2023).

Relative to inequality in income and expenditures, the consumption of cereals is relatively equal (Figure 5). The inequality in food consumption comes from other commodities – such as milk, eggs and pulses (see Figure 6). While households in the top deciles enjoy a diversified diet, the diet of the bottom deciles is dominated by cereals. The inequality in food consumption has, however, bridged over time (see Table 3). In this table, the percentage difference in consumption between the top decile and the bottom 3 deciles of different food items is normalized to 100 in 1993/94. Relative to

this level, we see that inequality has diminished in all commodities except salt and spices. This has happened despite an increase in inequality in total expenditures. These positive changes, notwithstanding, the trends in macro nutrient intake are disappointing (Figures 7, 8 and 9). Fats are the only nutrient with a discernible increasing trend.

A pressing research question is what changes in agricultural policy, production composition and social programs would lead poorer households to more nutritious diets.

A related question is whether existing agricultural policies and resultant specialization have influenced diets and nutrition. The foodgrain cultivating states in India have also observed a concurrent rise in several lifestyle diseases. These observations give rise to several important policy-relevant questions: (1) Has policy-supported specialization also resulted in a move from more nutritious calorie sources like coarse cereals to rice and wheat? Has it crowded out pulses and oilseeds leading in part to consumption of comparatively unhealthy oils and (2) Has this move contributed to a greater incidence of lifestyle and non-communicable diseases in the foodgrain belt of India where India is judged to be sitting on a volcano of diseases like diabetes? These questions are nontrivial, and the impacts are a priori not clear.

3. Food and Nutrition Subsidies

Rising incomes will slowly address the inequality in diets. In the immediate run, the question is how do food policies and safety nets matter here? And can these policies be refashioned or repurposed to have larger impacts on nutrition and health.

The PDS is the largest food subsidy transfer in the world reaching more than 800 million people. It offers 5 kg of cereals (principally rice and wheat) per person per month to its beneficiaries free of cost. The poorest among them are entitled to 35 kg per household per month. It is well known that per capita consumption of cereals is about 10 kg per month well more than the PDS transfer. It is hence an infra-marginal transfer. The practical implication is that the major effect of the subsidy is to displace the amount that would otherwise be bought from the market and to release household resources for spending on all goods (including cereals). By this logic, India's PDS is also the country's largest income transfer program. If so, would it not be less expensive to have a cash transfer program or if logistically possible a food stamp program instead?

The debate on cash Vs kind has been the subject of several RCTs (for a recent overview, see Banerjee et.al, 2024). Overall, just as economic theory predicts, the literature does not find large differences in the impacts of cash or in-kind food transfer. There are some minor differences – in-kind food subsidies have a larger impact on the consumption of subsidized goods while cash transfers seem to lead to more diversified diets. These differences notwithstanding, either of these programs or an intermediate hybrid (food vouchers), when implemented well, work to boost the consumption and welfare of target beneficiaries. These impacts are therefore not a reason to prefer one over the other. The evidence moreover is context specific depending on the state of supporting infrastructure and institutions that may not be assumed.

Administrative and logistic costs are usually much higher for in-kind programs. In 2023/24, a researcher estimated that more than one-fifth of all subsidized grain (22%) was illegally sold in the open market (Khera, 2024). In the past, these leakage rates were substantially higher. The previous literature also pointed to higher costs of the

Food Corporation of India (FCI) as another reason why all government spending on food subsidy does not reach households (Jha and Ramaswami, 2012).

As against this, in-kind programs offer greater protection against price rises – a danger with cash transfers to regions that have inelastic supplies. Access to payment systems may also be a problem in remote regions. Over the last decade, cash transfer programs have been seen in several domains – e.g., for books and uniforms in education, old age pensions, PM-Kisan (to small and marginal farmers). In Karnataka, the government expanded the food subsidy program – and the expansion took the form of cash transfers. These should be studied to understand the feasibility and efficiency of cash transfers.

It should be noted that cash transfers may not be appropriate for many kinds of social assistance – e.g., mid-day meals, nutritional support through Anganwadi and similar support to pregnant women. In these cases, the support may not be infra-marginal and hence their effects, in theory, need not be equivalent to a cash transfer. With cash transfer, the money may not be spent on nutrition for these groups. In these cases, in-kind transfers may have a better chance of achieving the goals.

4. Price Supports

The cereals supplied through the PDS are procured from farmers who are paid the minimum support price (MSP). The procurement system dovetails with the PDS. That makes it hard for a government to contemplate a move to substitute PDS with cash transfers unless farm supports are restructured in a similar manner.

In the early days of procurement (in the late 1960s and early 1970s), a distinction was made between support prices and procurement prices. Support prices were seen as floor prices and would be operative in exceptional years of glut that threatened to crash prices. To enforce support prices, government would procure all the quantity offered to it. In normal years, when market prices are greater than support prices, government would procure at the market price. Such procurement would be finite.

However, this distinction remained on paper. All government procurement took place at support prices and procurement was open-ended – whatever quantity was required to ensure market prices did not breach MSP. Because of the surpluses produced by the Green revolution, real prices trended downward. Till 1990, the procurement intervention stabilized supplies – in some years, the government propped up market prices by buying more than it sold. In other years, the reverse happened – the government sold more than it procured expanding supplies.

Since 1990, stabilization has been abandoned in favour of producer support. Procurement has exceeded distribution in all except the Covid years. The excess procurement has increased cereal prices. It has reversed the downward trend in cereal prices (Ramaswami (2019)). As a result, consumers bear a significant burden of price support. Further research can quantify these impacts using credible supply and demand elasticities. It is likely that the welfare losses because of support price are much greater than the welfare gains accruing to farmers. With NFSA, producers in some states could also be adversely affected if there is excess supply due to NFSA allocation in some states and crops.

Stocks management happens without a well-defined protocol. Since stocks management is bundled with procurement and distribution in the accounts of the Food

Corporation of India, there is no public scrutiny of the losses to the exchequer because of excess procurement.

Deficiency payments has been proposed as a reform for open-ended procurement. While it may lower the logistics costs associated with procurement, it continues to keep in place incentives to produce commodities that receive support. As a result, the problem of excess procurement will manifest itself in a different form: in depressed prices and in deficiency payments greater than expected. It is for this reason farm support policies in the rich countries have transitioned to direct cash transfers. While its efficiency advantages are undisputed, cash transfers may involve greater budgetary expenditures as the government will have to pay for the full extent of farm support unlike in the case of price supports where consumers shared the burden (Ramaswami, 2019). The pricing system has also not adequately addressed relative risk profile of crops and propensity to provide ecosystem services or health such as pulses and coarse cereals. An additional practical obstacle is that land records are imperfect. Resolving land titles and computerizing the records may have huge payoffs in permitting efficient support policies. This needs further research.

5. Supply Chains

The diversification of diets reflects demand and supply. In production, the share of fruits, vegetables and livestock products in agricultural GDP have increased. The demand for these foods is income elastic. As incomes grow, supply will have to keep pace with demand. Otherwise, their relative prices will rise choking demand and limiting diet diversification and its health benefits. This has been noticed in the past (Meenakshi, 2016).

Staples such as rice and wheat have a simple marketing structure. Wholesale markets are the fulcrum of their marketing chain. The marketing structure aggregates produce up to the wholesale markets after which the process reverses till the sale to consumers.

The limited infrastructure for transport, product preservation and information dissemination that is typical of traditional supply chains is ill-suited for marketing perishables (Byerlee et al., 2012, Pingali, 2015, Weinberger and Lumpkin, 2007). However, a ‘Catch-22’ situation prevents changes in marketing structures from happening automatically (Emran and Forhad, 2002, Tembo and Jayne, 2010). Trading in newer products requires specialized knowledge and information about the emerging market demand (often in distant centers) with respect to volumes, product preservation, acceptable quality levels and logistics. Investment in the associated physical infrastructure is also required. The high fixed costs of trading mean that creating new markets for non-staples is viable only if there are adequate volumes. But, farmers are inclined to create large volumes only if the markets to absorb them exist in the first place. Coordination may also fail when farmers fear hold up on the part of intermediaries because of lack of credible enforcement (Krishna and Sheveleva, 2017). There is a substantial literature that places innovations in agricultural supply chains central to agricultural development (Barrett et.al 2022)

Governments have attempted to break the impasse by promoting contract farming. Contract farming is an example of ‘modern’ food value chains consisting of short vertical links between sellers and buyers (Reardon and Minten, 2018). Such vertical links have been seen necessary to facilitate farmers access to the market for non-staples (Gulati et al., 2007). In this view, direct contracting can “cut transaction, coordination, and search costs and ensure greater control over quality and consistency

of supply” (Byerlee et al., 2012). The presumption is that assured demand from an intermediary (e.g., government, processor, trader) induces supply and breaks the low-level equilibrium trap. The resulting shift in cropping patterns increases farm incomes.

In successful supply chains, the marketing structure may no longer be atomistic and significant market power may be exercised by intermediaries. This is a long-standing issue in agricultural markets and sometimes captured by the statistic: how much of the consumer rupee is received by farmers. Considering the value added beyond the farm, the share of the consumer rupee is not necessarily the best metric to evaluate the competitiveness of the supply chain. If farmers are to receive remunerative prices and yet be sheltered from market risk, the intermediaries that are best placed to offer it may be large since they must be connected to large markets whether domestically or abroad.

India has had some success in promoting farmer cooperatives in the dairy sector. Replicating it to other sectors has been hard – it has not been clear what aspects of the cooperative experience in the dairy sector are replicable. In the last decade, there has been great deal of emphasis on farmer producer organizations. While they receive some support from the government, they are mostly starved of physical and human capital. The policies and practices that can help this sector may require experimentation and randomized trials. It may also require the understanding of structural issues in FPOs in terms of their size, composition and systems of promotion and financing. The big question is why with such strong emphasis on them, the majority of them have not delivered for farmer members in terms of higher and more stable incomes and have had short lives.

6. Agricultural Insurance

India has had a long experience with index crop insurance and is globally one of the pioneers in this field. Index (linked to area-yield) insurance was introduced in the country in the late 1970s as a subsidised scheme of the government. The take-up and the subsidy was, however, limited. In 2016, the government launched the Pradhan Mantri Fasal Bima Yojana (PMFBY) – a program of area-yield insurance. The program and the rate of subsidy were substantially scaled up. The Central government spends close to Rs. 15,000 crores annually. The program also involves equivalent expenditures by state governments. The program introduced several novel elements – in particular, the program implementation involved, for the first time, private insurance companies. The premiums are pegged to be very low – below the cost of providing insurance (actuarial cost plus administrative costs). The difference is the subsidy incurred by the central and state governments.

While the program coverage is much greater than the coverage in the earlier insurance programs, it is fair to say that the program has not expanded beyond the initial success. The budget allocations have stagnated. Why have farmers not responded more enthusiastically to the program? Such disappointing outcomes are not unique to India. Even so, this question needs urgent research.

7. Allocation of Resources across Sectors

It has been well recognized in development economics that Engel's law is a long-term constraint to agricultural growth. Agricultural exports offer an escape from this

constraint. Another escape is to produce more of crops that have industrial, or non-food uses (e.g., fibre, bio-fuels). In practice though, agriculture's share in GDP has declined with increases in GDP almost everywhere (Byerlee et. al, 2012). While agriculture's share in employment has also declined, it has remained well above its share in GDP (Byerlee et.al, 2012). As a result, output per worker in agriculture lags the output per worker in non-agriculture. This is a universal feature of the development experience. The sectoral productivities converge only in the high-income economies (Gollin, Lagakos and Waugh, 2014).

In India, the employment share exceeds the sector's GDP share by as much as 30 percentage points (Figure 10). This feature has been interpreted to mean 'too many' people are locked in agriculture. It should be noted that the scholarly literature has suggested another possibility – that the lower productivity in the farm sector is because low skilled people sort themselves into the farm sector. If that's the case, the gains from re-allocation will be limited.

The things that India must do to increase the absorption of agricultural labour in non-farm enterprises are not within the scope of this survey. However, it is relevant to understand the movements of agricultural wages. Till the early 2000s, this has largely been driven by agricultural productivity (Eswaran, Kotwal, Ramaswami and Wadhwa, 2009). It will be driven by non-farm productivity when the sector is able to take away enough workers from land.

The failure to add value commensurate to employment is not a problem of agriculture alone. Research has shown that the productivity difference between non-farm and farm sectors is primarily due to larger firms in the formal segment of the non-farm

sector (Jat and Ramaswami, 2024). Non-farm sectors where the informal sector dominates are at the same level of productivity as the farm sector.

Food enterprises comprise the sector with comparatively high growth and leveraging the agro-industrialization and food services sector in India might play a critical role in bridging the income gaps among leading and lagging states in India.

8. Allocation of Resources within Agriculture

The rising demand for non-staples should mean that returns to growing them would be higher than growing staples. Hence, in ideal circumstances, there would be a movement of resources (labour, land and capital) from staples to non-staples till the gap in returns is fixed.

However, despite the diversification in food expenditure against cereals, our cropping pattern is dominated by these crops. Many researchers and observers have attributed the cereal bias in production to price supports of these crops. R&D expenditures are also biased towards these crops. These arguments suggest that the profitability of cereal crops have been artificially propped up by government policies. And that is delaying production diversification.

Data from NSS's Situation Assessment Survey does indeed show that returns to cereals, pulses and oilseeds are the lowest among all crops – whether in rabi or kharif (Figures 11 and 12). Yet these crops account for 70-80% of area. While price support policies increase the returns to cereals, the data shows that their effect has not been so great as to elevate the profitability of cereal agriculture over other crops.

Therefore, the puzzle is all the greater. If it is not price supports, what stops the movement of resources out of cereals, pulses and oilseeds. A more disaggregated picture that triangulates these facts with other information would provide us with insights into this question. It might require a truer understanding of market access and its interface with policies to fully understand this pattern where relative risk distribution (both production and marketing risk) might play a critical role.

9. The Rabi Season, Seasonal Migration and Rain-fed Agriculture

The 2019 Situation Assessment Survey reveals that irrigated area is about the same between kharif and rabi. However, unirrigated area falls by 73% in rabi. This may be a reason why, according to the Indian Human Development Survey, a full-time worker in the non-farm sector (whether formal or informal) works 70% more work hours than a full-time worker in agriculture (Jat and Ramaswami, 2024). Agriculture's seasonality may not be the only reason since the disparity in work hours is seen in other countries as well where the seasonality may not be as marked as in India (Gollin, Lagakos and Waugh, 2014).

We saw earlier that agriculture is on parity with the informal non-farm sector in terms of productivity per worker. That calculation accounted for the differences in time input. This means that there is a considerable income gap between full time workers in agriculture and workers in the informal sector. This may well be the reason driving seasonal migration of workers from agriculture. We know from surveys that even agricultural households rely on non-farm sector as an income source as much as they do on the farm sector (Nabard, All India Rural Financial Inclusion Survey, 2016-17).

Thus, while structural transformation in the employment structure seems slow, we do see diversification in rural livelihoods. It will be important to study the sectoral income gaps because of lower work availability in agriculture and the role of seasonal migration and non-farm rural livelihoods in this regard. Seasonal migration has not received policy attention (except for NREGA). But if this is the primary form of structural transformation, then it must occupy that attention.

It would be good to know the differences between irrigated areas and rain-fed regions amid market access transitions in this regard. Is the diversification away from agriculture greater in rain-fed regions?

About 60% of pulses area and about 46% of oilseeds area are unirrigated. It should be noted that these are the two crops that account for bulk of India's food imports (oilseeds are imported in their processed form of edible oils). The lack of irrigation may be a source of comparative disadvantage for these two crops.¹ If subsidies were to be more equitably distributed across crops, these crops may not be so disadvantaged but if as a result the other crops were to be pushed to unirrigated areas, then they would also face a productivity penalty.

If the land in rainfed regions has lower value in agriculture, then this region may maximize its returns through alternative uses of land. Unlocking the value of land and ensuring its equitable distribution has been a thorny issue – administratively and politically. Arguably, it is one of the constraints to industrialization and urbanization.

10. Farm Income and Subsidies

¹ There may be other sources of disadvantage – notably the lack of R & D support.

In many ways, the relative productivity gap noted earlier is the central problem of not just Indian agriculture but of the entire economy. Relative to output, Indian agriculture contains 'too much' labour putting pressure on farm incomes and wages. What policies and investments can close the gap and increase incomes for about half of the work force? Clearly, a good part of the solution lies in creating productive non-farm jobs accessible to the farm labour force.

The rich countries put in place a variety of programs to support farm incomes. These programs have evolved from price supports, tariffs to direct supports. But as we have seen, the pain of structural transformation is felt even at much lower levels of income. As in other countries, the sectoral disparity in incomes is a point of social tension in India and fuels the political demand for farm income support so much so that farm subsidy is the most visible face of agricultural policy.

The rise of farm subsidies as a major component of agricultural policies has given rise to two major questions (among others). First, what ought to be the scale of subsidies? While the cost of support programs is a point of contention in rich countries as well, this question is naturally more salient in poor countries that have pressing demands on government expenditures from multiple under-funded priorities. In particular, policy makers have to be aware that subsidies may crowd out agricultural investments and delay the structural transformation processes. The trade-offs are between the short run and the long run.

The second question is about the form of subsidies. When income support operates through subsidies on inputs or through higher prices for outputs, it can lead to negative externalities that directly threaten the agricultural resource base. In addition, it may discourage the migration of resources from staple foods to other activities and choke

the income growth processes. The question is what investments and policies are necessary for the government to consider strategic approaches that would yield 'smarter' subsidies that offer more bang for the buck.

Ramaswami (2019) estimated farm subsidies to be at least Rs. 2,35,000 crores in 2017/18. This was evenly divided between the Central and the State government. The largest Central government subsidy is the fertilizer subsidy. The largest subsidy expenditures by State governments is because of the electricity subsidy to farm operations. Contrary to media impressions, subsidies because of output price support are not large relative to fertilizer and power subsidies.² Most of farm support subsidies are on account of input subsidies.

Earlier work from Krueger, Schiff and Valdes (1991) assessed agriculture as a net taxed sector. With the much-changed landscape of subsidies and economic policy (e.g. exchange rates), it is worthwhile to see contemporary situation and also to institute a dynamic toolkit to see protection to Indian agriculture, its constituents and their evolution.

Figure 12 shows that by 2013, all the input subsidies (fertilizer, power, credit and irrigation) put together exceed agricultural expenditure by a factor of 2. Figure 13 shows that input subsidies are about the same level as public investment in agriculture. As published by CSO, public investment in agriculture mainly measures investment in major irrigation schemes.

² Most of the food subsidy is received by consumers. The income gains to farmers because of price supports is greater than the expenditures by the government because consumers pay the difference through higher prices. For more on this point, see Ramaswami (2019).

These figures represent a critique of subsidies – that subsidies represent an opportunity cost of public spending and investment that are important to improve and sustain agricultural productivity. But to what extent do these input subsidies provide income support, which is arguably their major objective? Ramaswami (2019) estimates the farm subsidy expenditure amounts to as much as 21% of average farm income. This means that subsidies cannot be withdrawn without considerable hardship to the farm community.

The 2019 Situation Assessment Survey of Farmers (NSSO) estimates average monthly net income from crop and livestock production for farmers owning between 1-2 ha of land to be around Rs. 7000 per month.³ Inflating it to 2022/23 by the consumer price of rural labour makes this figure Rs. 8300-Rs.8500 per month. By the 2022/23 NSS consumer expenditure survey, the average monthly per capita expenditure of bottom 5-10 percentile fractile was Rs. 1782 or Rs 8000 for a family of 4.5. These back of the envelope calculations show that small and marginal farmers (accounting for close to 70% of cultivators) are likely to occupy the bottom end of the expenditure distribution. While they have an strong case for income support, doubling the subsidies will increase their income by only 10% - hardly sufficient for them to graduate to a decent standard of living.⁴ Subsidies are a band-aid but will not get small farmers out of poverty.

While subsidies are typically seen to compensate for low profitability in the farm sector, it is not clear that it is low profitability that is responsible for lagging farm incomes. Chand, Saxena and Rana (2015) show that farm income was as much as 70% higher than the cost of all variable inputs (including hired labour) in 2011/12. While such profitability was exceptional because of the unusually high farm prices that year, the profitability ratio was in the range of 40 to 50% in the 1990s and mid-2000s. The tiny

³ Including income from all sources raises the figure to about Rs. 11500 per month

⁴ This supposes that subsidies constitute 21% of their income as well.

asset base of much of the farming population is the fundamental constraint. For marginal and small farmers, the ownership of land is so limited that farm incomes would continue to be low in both absolute and relative terms even if subsidies increased substantially.

The literature suggests therefore that that even though farm subsidy expenditure by the government is a substantial component of farm income, even a large rise in subsidies will have (a) limited impacts on farm distress because our farmers own tiny plots of land and (b) little impact on the relative productivity gap because the gap is too large. Thus, while subsidies are too important for farm incomes for them to be curtailed, they do not represent viable future directions for sustainable increase in farm incomes. The structural transformation processes continue to be the primary mechanisms for rapid income growth.

These computations are rough and carry several caveats. It will be important for future research to deliver more precise estimates. It should also be remembered that for the 141 million workers in agriculture who own no land and for the majority of 118 million cultivators that own less than 1 hectare of land, incomes from farming will continue to be low and precarious, no matter how much we spend on subsidies. It would be wise, therefore, to consider farm subsidies in the wider context of safety nets that would be relevant universally.

11. Water

Groundwater is the dominant source of irrigation and it has expanded rapidly since the 1970s. Since electricity is used to pump water from underground aquifers, electricity use in agriculture and the number of electrified pump sets have also increased rapidly.

In 1979/80, the number of electrified pump sets was a little less than 4 million. By 2017/18, the number had jumped to more than 21 million. The share of agriculture in electricity supply was negligible in the early 1970s. By 2017, agriculture consumed 20% of all electricity supply.

By international standards, electricity consumption in Indian agriculture is quite exceptional. Figure 15 shows that consumption in India easily outstrips comparable countries such as China, USA, Russia, Brazil. Figure 16 shows that despite a lower GDP per capita (that lowers the demand for electricity in non-agricultural sectors), the share of agriculture in total electricity consumption in India is of many orders magnitude greater than in the richer countries (China, USA, Russia, Brazil). The high electricity consumption in India reflects a unique dependence on groundwater irrigation. According to the FAO Acquastat database, India is the largest user of groundwater at 251 billion cubic meters (2008-12). Groundwater withdrawals are 113 and 105 billion cubic meters in China and USA respectively.

If the level of groundwater extraction is high relative to recharge, it may be unsustainable. Figure 16 maps the 'unsafe' areas where extraction is more than 70% of annual recharge. It can be seen that except for the eastern part of the country, groundwater use is at unsustainable levels in the rest of the country.

Except for West Bengal, electricity use in agriculture is largely unmetered and farmers are charged flat tariffs (depending on Kwh connection). Second, these flat tariffs are low and do not cover the costs of supply. In three states, Punjab, Karnataka and Tamil Nadu, the flat tariffs are zero. Both of these features encourage the overexploitation of groundwater resources and promote the cultivation of water-intensive crops. Power subsidies imperil our already stretched groundwater resources and directly attack the sustainability of our natural resources.

Direct benefits transfer together with the separation of agricultural feeders and metering supplies seem like immediate policy imperatives. Unlike other subsidies that need to target direct benefits using some criteria such as land ownership, power subsidies have the advantage that they can be restructured to direct benefits on the basis of power connections.

12. Climate Change

There is now consensus that the agricultural sector is the most vulnerable economic activity to climate change. While agriculture is an inherently risky activity, unpredictable weather and frequent extreme events make agricultural incomes even more volatile. Given the large and disproportionate share of the population involved in agriculture in India, climate change threatens rural livelihoods and the country's overall growth trajectory. It is, therefore, imperative that we have a clearer idea of (1) What are the impacts of climate change on agriculture and the rural economy in India? and (2) What are the possible options to deal with such impacts? (3) how to minimize carbon and water footprint of agriculture in India?

Estimates from the Government of India suggest that if no measures are taken to mitigate the losses, yields of major staple foodgrains like rice, wheat and maize will reduce by 20 to 40 percent within the next 25 years. While these are the direct impacts of climate change on food productivity and are based on long-term average changes, they do not account for the greater likelihood of extreme events. Extreme climatic events are of greater consequence for multiple reasons. One, long-term trend changes are predictable, and farmers can accommodate such changes in their farming decisions. Greater uncertainty is harder to predict and, hence, is harder to accommodate in

farming decisions. An important research agenda is to understand the potential impacts of extreme climatic events on Indian agriculture. Such events are of greater consequence as they are harder to predict, can take farmers by surprise, and impart greater volatility to farm incomes, making it harder to save and invest in better technology.

It is also important to understand the interactions between existing agricultural policies and weather shocks. For example, providing highly subsidized grain via the Public Distribution System may help small and marginal farmers better deal with the consumption loss during an extreme weather shock. If so, then the PDS itself may be an important policy measure to deal with climate shocks. Likewise, a well-functioning crop insurance program may also provide farmers with significant protection against aggregate weather shocks and, hence, may become even more important going forward as the weather becomes more unpredictable. At the moment, several policies are in place to support the farm sector, and many of them may also be providing the additional benefit of income/consumption insurance from shocks. Investigating such benefits will be helpful in thinking about climate mitigation in the long run.

Farmers may also use crop diversification to deal with a more uncertain climate. Depending on suitability, farmers may diversify toward drought-resistant grains like millets and short-duration crops like vegetables as a measure to deal with uncertain weather. However, access to markets will be important for farmers to use crop and activity diversification as a measure to deal with climate change. Access to markets and the opportunity to trade may also help farmers smooth consumption, especially if the commodities in question are highly perishable and cannot be stored for long periods of time. How well these measures work to mitigate the welfare impacts of climate change remains an open question.

13. Agriculture and the Environment

While agriculture is affected by climate change and worsening environmental conditions, modern agriculture itself is a major contributor to environmental pollution. Studies suggest that agricultural intensification and slash-and-burn agriculture is a major contributor to greenhouse gas emissions. Moreover, there are hardly any policies in place to manage agricultural waste. For example, farmers in Northern India resort to burning crop residue as a cheap and easy way of dealing with residual biomass once paddy is harvested. While this may be a rational decision for the farmer, the resultant pollution externality has significant environment and health consequences. What are the health costs of this negative externality? How do current agricultural policies and the incentives they generate contribute to this externality? These questions are worth investigating in order to have the correct assessment of the true impacts of agricultural support policies.

Given the distorted nature of Indian agricultural markets, where the government procures surplus production at fixed price floors, upward movements in rice prices are matched with greater rice procurement. This procured foodgrain has found its way into the export markets in recent decades to the extent that India has now risen as the largest exporter of rice globally. This is ironic given that farmers in Northern India produce this rice with a slew of input subsidies and with immense environmental costs to the region.

The policy response to residue burning has mostly been in the form of bans and fines on such activities. Such policies, however, are poorly implemented and have been ineffective in curbing crop residue burning. Technological solutions like the use of machines that can plant the next crop without burning the leftover stubble have also

been unpopular with farmers. While one dimension of the problem may be the policy scenario and misaligned incentives, another could be farmers' perceptions about adopting new technologies. Could there also be behavioral reasons why farmers resort to polluting ways of dealing with residue? This makes a case for investigating farmers' beliefs and perceptions about the practice of stubble burning.

Along with weather-specific damages, farmers often report crop yield losses due to attacks by wild animals. Agricultural intensification has also come at the cost of shrinking habitats for wild animals. The result is a human-wildlife conflict where large hordes of wild animals often destroy valuable crops. Such incidents have become more frequent. The comprehensive economic assessment of such losses is, however, not available and is an important research agenda.

14. Agri-food trade

Contemporary understanding of trade implies that all forms of exchange, i.e., trade at all levels (domestic, international, and local), have to be considered together as a system with differences depending on trade costs, including due to policies. Though governments have tried to increase trade both internationally and domestically in agri-food products to much higher levels, India's share in global agricultural trade of less than 2.5% (comparable to comparatively small Thailand) highlight the significant room for growth given that she is the largest or second largest producer of many agricultural products and produces a diverse set of commodities. Domestic and international trade could lead to substantial benefits for India's economic growth and play a key role in reducing inter-regional disparity in India while mitigating the effects of shocks. There, however, are several policy-related challenges for economic integration in relation to agri-food products.

Traditionally in economic analysis, agriculture was treated as a sector producing homogeneous commodities. In trade with “homogeneous” agricultural products, the comparative advantage was defined at the aggregate product level and not at the level of segments of the value chain. With technological improvements and institutional changes, agri-food trade has fundamentally changed with a strong element of product differentiation. Evidence from the disaggregated trade data (8-digit) shows that agri-food trade increasingly has a substantial prevalence of intra-industry trade and is one of the primary sources of growth. Empirical analyses of trade liberalization at the firm level provide evidence for an additional source of welfare gains from extensive margins in terms of varieties. Not only countries but also firms are the appropriate unit of analysis for trade flows after the revolution in understanding international trade. It helps solve several paradoxes once the import and export firm heterogeneity are understood and accounted for. Value chain integration, like in manufactures, has become the core of agri-food trade where products are exported, processed, packaged, and exported after branding (e.g., edible oils, processed fruits, marine products). The success in trade for India’s agri-food sector would depend on participation and optimal positioning in globalized agri-value chains where India has been lagging behind countries such as Thailand and Vietnam.

Rising food prices have a significant impact on poverty and food security and nutrition. In the transformation towards a sustainable food system, agri-food trade (intra-national as well as international) must play a pivotal role. Yet, the agri-food trade at all levels is consistently below potential. There is an incomplete understanding in terms of methods and data that can be invoked to bridge the gap with the potential. An increase in food trade can help in reducing vulnerability to weather and price shocks, diversifying cropping patterns, thus making diet modifications less expensive

and raising the incomes of farmers by integrating them into the value chains. The research will try to bring in contemporary analytical methods employing extensive data, including geospatial information, in building the knowledge base for agri-food trade. It will deliberate on toolkits for understanding trade patterns and policies, employing a theoretical understanding of empirical trade and bringing out the knowledge gaps in analysis as well as data. As the nature of trade has structurally changed, there is a strong need for retooling resources in terms of recent innovations with granular data and methods that are conventionally not employed in the analysis of agri-food trade. The toolkits, data and understanding of analytical outputs can be a great resource for other researchers.

Agri-food trade is increasingly looking like merchandise trade in manufacturing, and value capture through varieties and product differentiation based on attributes like quality, safety, and branding is the main driver. Not understanding and incorporating the changing trade structure has meant a lack of understanding in assessing agricultural trade and exploring policy options. The common affirmation has been that there is under-trading by India, a reality given its size and that of the agriculture sector. International trade has evolved, therefore, understanding trade and drawing policy lessons for subpar performance in trade requires new methods with supporting data and a careful and granular understanding of the policy.

As India embarks on many different trading arrangements and trade and commerce linkages, change with infrastructure and political alignments, understanding the potential and implications for agri-food trade is necessary for assessing trade potential and realizing the maximum gains from trade.

The free flow of goods within the country or internationally continues to be impeded by high tariff (tax) and non-tariff barriers. To address this issue, we need a dual approach consisting of liberalization of trade policies at all levels but also several trade facilitation initiatives. How the tax integration through GST, forthcoming dedicated freight corridors and the system of dry ports that are coming up affect the prospect of agri-food trade are pertinent areas for research. The former may be specifically designed to eliminate or minimize the tariff barriers that hinder intra-regional trade, while the latter aims to tackle the non-tariff barriers that affect India's global agri-food, intra-regional and domestic agri-food trade.

Average tariff protection for agricultural products remains considerably higher than that for non-agricultural products in India and on products from India. India's average tariff for agricultural products was 39.2% compared to 14.9% for non-agricultural products in 2021, World Trade Organization (WTO). Even among countries with high average tariffs on agri products, Thailand's average tariffs for agricultural products and non-agricultural products were 31.2% and 8.4%, respectively, in the same year,

The imposition of tariffs on imports can serve as a deterrent to the growth of agro-food export earnings as it raises the cost of intermediates for domestic producers.⁵ High import tariffs on agricultural equipment and machineries might be an inhibitor towards mechanization in Indian agriculture where countries like Bangladesh and Thailand have moved at a faster pace in mechanization. Import taxes function as export taxes not only due to relative attractiveness of import competing sector but also due to restrained productivity that checks trade growth. Consequently, the imposition of high import taxes has created an environment in which import-competing sectors become more profitable, and productivity growth which is a precursor to exporting has been

⁵ <https://www.oecd.org/agriculture/topics/global-value-chains-and-agriculture/>

small leading to a significant shift of resources from the exportable sector to the import-competing sector. For example, the dry land of Maharashtra in India continues to focus on sugar production may be because of the country's restrictive trade policy on sugar, which makes domestic production more profitable. This resource allocation toward sugar production detracts from the cultivation of other commodities, such as Millet, which requires less water and could be exported.

The high tariff can also create a recipe for arbitrage of duty by rerouting of imports. For instance, due to the high duty differentials of edible oil between India and Nepal (India imposes high tariff and Nepal imposes low import tariff on the same commodities) created a recipe for duty arbitrage by re-routing imports: First Nepal imports crude edible oils from producing countries, and do some processing (refines to address the rules of origin requirements) and then export to India under lower tariffs due to SAFTA agreement, the setup akin to GVC, remarkably policy induced rather than based on comparative advantage.

Indian agri-food exports also grapple with a diverse array of nontariff measures (NTMs) that pose significant obstacles. These measures encompass a wide spectrum, ranging from sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBT), to import licenses, quotas, and regulations governing health and environmental concerns, as well as domestic support and domestic trade costs. India has limited mutual recognition agreements, uniform testing protocols, and lacks regional single window system with her partners as it has in the ASEAN. These barriers can coalesce time to trade and cost to trade, limit the flow of agricultural goods and raise costs for businesses. Addressing these issues will require concerted effort and collaboration among policymakers, industry leaders, and other stakeholders, but the potential benefits of doing so cannot be overstated.

The logistic performance index paints a concerning picture for India's trade and transport-related infrastructure that is particularly important for time sensitive agri-food trade. Despite having made significant strides in recent years, India still lags most other parts of the world. with regards to the quality of its ports, railroads, roads, and information technology. This comparison becomes even more striking when juxtaposed against the trade and transport infrastructure of neighboring ASEAN countries. These countries have managed to secure a commendable position, trailing only North America and Europe and Central Asia - the highest-ranked regions globally.

These constraints can impede the ability to leverage India's vast market potential. It will be important to assess the effects of new infrastructure and institutions coming up like Trilateral Highway and Multi model connectivity in the neighbourhood in addition to domestic improvements discussed above. Once it is completed, will lead to better transport connections and greater trade between the three countries (India, Myanmar and Thailand).

15. Food safety

Foodborne diseases (FBD) are illnesses caused by contaminated or naturally harmful food or beverages. These hazards are biological, chemical, and physical, such as foreign objects in food. FBDs have been shown to have a significant effect on human health and create significant costs for both the patients as well as the health system. This health burden is borne disproportionately by the poor and is estimated to be comparable to malaria and tuberculosis, which are still prevalent in different regions. Apart from some mild and short-term symptoms, it is recognized that FBD also produces severe and lasting symptoms, including paralysis, epilepsy, arthritis, and birth defects. FBD

directly relates to SDG 3, i.e., good health and well-being, and SDG 6, i.e., clean water and sanitation.

The health impacts of FBD can be measured in different ways, including annual cases of sickness and death. There is also a standard metric for measuring disease burden: the Disability Adjusted Life Year (DALY). One DALY is the equivalent of one lost year of healthy life. Measuring health impact in DALYs helps comparisons between dissimilar diseases and aids in prioritization.

FBDs are associated with a wide range of economic costs as well i.e., including lost or low productivity due to illness, the costs of treatment and cost of prevention (e.g. food safety governance, risk reducing practices). Alternatively, costs fall on different actors in the value chain, viz., the public health agencies, food industry, consumers, and Hotels, Restaurants, and Institutions (HRI).

Apart from the health burden, for India, it has been a major barrier to accessing high-end international markets and has diminished value generation in the domestic markets and limited domestic market integration. Without awareness and systems of grading and certification, farmers and other agents are hardly rewarded for delivering products with higher standards of food safety.

India is the second largest producer of fruits and vegetables in the world but is a failed exporter of these. Similarly, in dairy. There is also ambiguity about whether the food safety requirements are a threat or an opportunity for the poor smallholders in India, and robust research is required.

Also, food safety in most cases has not been considered a development priority, and managing FBD or delivering on food safety has often been thought of as the responsibility of the private sector, and it is an area where probably significant under-investment has occurred. This is partly because the burden of food-borne diseases was not recognized or measured for a long time. In 2015, WHO presented the first comprehensive set of measures for food-borne diseases.

In India, whatever food safety interventions have taken place, research on their effectiveness and cost-benefit analysis has been lacking. This is even when the consumption patterns are changing significantly, including greater consumption of perishables, processed food and greater incidence of eating out and value chains getting to be more complex.

There are several reasons that can be forwarded for greater focus to research and capacity strengthening related to food safety in India with rapidly transforming food systems under fast economic growth. As part of the transformation, there is a rapid increase in urban and peri-urban farming, diversification of the diets, greater use of ICT in the food markets, greater concern for food safety among consumers, greater food imports, greater exports of high-value items and the emergence of modern marketing channels in processing and retail. The implications of these changes for food safety are not well understood and may be counterintuitive.

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Table 1

Statement 6: Trend in percentage composition of MPCE since 1999-'00: Rural India					
Item group	% share in total MPCE				
	1999-00 NSS (55 th round)	2004-05 NSS (61 st round)	2009-10 NSS (66 th round)	2011-12 NSS (68 th round)	2022-23
cereal	22.16	17.38	13.71	10.69	4.89
cereal substitutes	0.07	0.07	0.06	0.06	0.02
gram	0.13	0.13	0.13	0.14	0.24
pulses and pulse products*	3.81	2.97	3.19	2.76	1.77
sugar & salt	2.60	2.48	2.34	1.83	0.93
milk and milk products	8.75	8.17	7.64	8.04	8.33
vegetables	6.17	5.88	8.29	6.62	5.38
fruits (fresh)	1.42	1.46	1.93	2.25	2.54
fruits (dry)	0.30	0.34	0.49	0.58	1.17
egg, fish & meat	3.32	3.21	4.74	4.79	4.91
edible oil	3.74	4.44	3.69	3.74	3.59
spices	2.74	2.21	3.36	3.50	2.98
beverages, processed food* etc.	4.19	4.38	7.40	7.90	9.62
food: total	59.40	53.11	56.98	52.90	46.38

Source: Household Consumption Expenditure Survey, 2022/23, NSSO

Table 2:

Statement 7: Trend in percentage composition of MPCE since 1999-'00: Urban India					
Item group	% share in total MPCE				
	1999-00 NSS (55 th round)	2004-05 NSS (61 st round)	2009-10 NSS (66 th round)	2011-12 NSS (68 th round)	2022-23
cereal	12.35	9.58	8.12	6.61	3.62
cereal substitutes	0.04	0.05	0.04	0.05	0.02
gram	0.11	0.10	0.10	0.11	0.18
pulses and pulse products*	2.84	2.04	2.37	1.93	1.21
sugar & salt	1.80	1.57	1.49	1.15	0.60
milk and milk products	8.68	7.54	6.90	7.01	7.22
vegetables	5.13	4.24	5.67	4.63	3.80
fruits (fresh)	1.95	1.68	2.54	2.64	2.50
fruits (dry)	0.47	0.46	0.63	0.78	1.31
egg, fish & meat	3.13	2.58	3.63	3.65	3.57
edible oil	3.14	3.29	2.66	2.66	2.37
spices	2.07	1.47	2.21	2.42	2.13
beverages, processed food* etc.	6.35	5.91	8.03	8.98	10.64
food: total	48.06	40.51	44.39	42.62	39.17

Source: Household Consumption Expenditure Survey, 2022/23, NSSO

Table 3: Inequality in Food Consumption, 1993/94 – 2011/12

% difference between top 10% and bottom 30%	1993-94	2004-05	2011-12
Cereal	100	-9	-77
Pulse	100	92	66
Milk	100	79	53
Edible Oil	100	74	44
Fish & Meat	100	120	86
Vegetables	100	81	41
Fruits	100	76	72
Sugar	100	74	50
Salt	100	77	109
Spices	100	79	111
Income	100	126	135

Source: Computations from the Consumer Expenditure Survey of NSSO

Table 4: Simple Average MFN Tariffs, 2021

Country	Simple Average MFN Tariffs ⁶ (%)		
	Agriculture	Non-Agriculture	Difference
India	39.2	14.9	24.3
Thailand	31.2	8.4	22.8
Bangladesh	17.6	13.4	4.2
Sri Lanka	17.0	4.2	12.8
Nepal	16.7	12.0	4.7
Bhutan	12.4	9.3	3.1
Myanmar	9.5	6.0	3.5

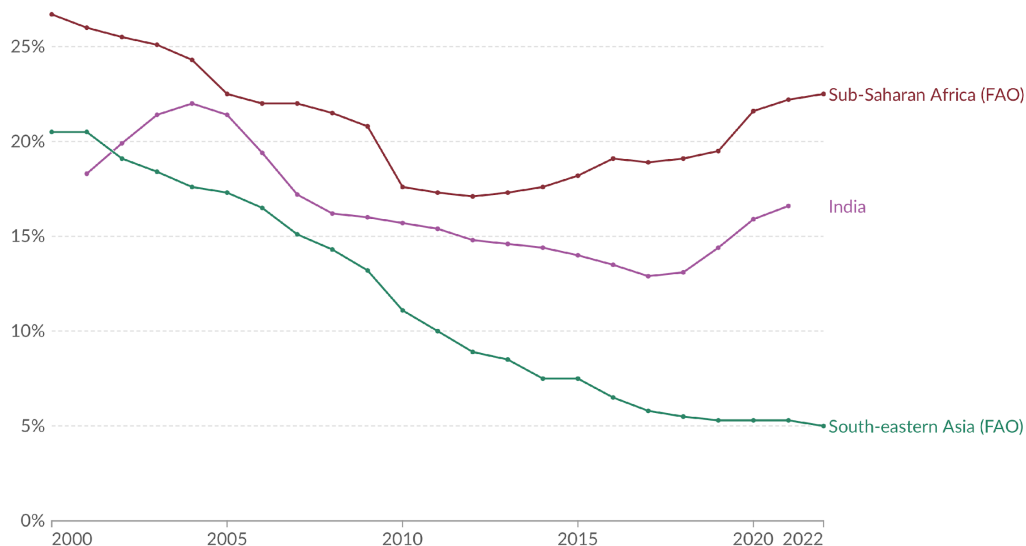
Source: WTO Tariff Profiles (2022)

⁶ Normal non-discriminatory tariff charged on imports (excludes preferential tariffs under free trade agreements and other schemes or tariffs charged inside quotas).

Figure 1

Share of the population that is undernourished

Share of individuals that have a daily food intake that is insufficient to provide the amount of dietary energy required to maintain a normal, active, and healthy life.

Data source: Food and Agriculture Organization of the United Nations (2023)

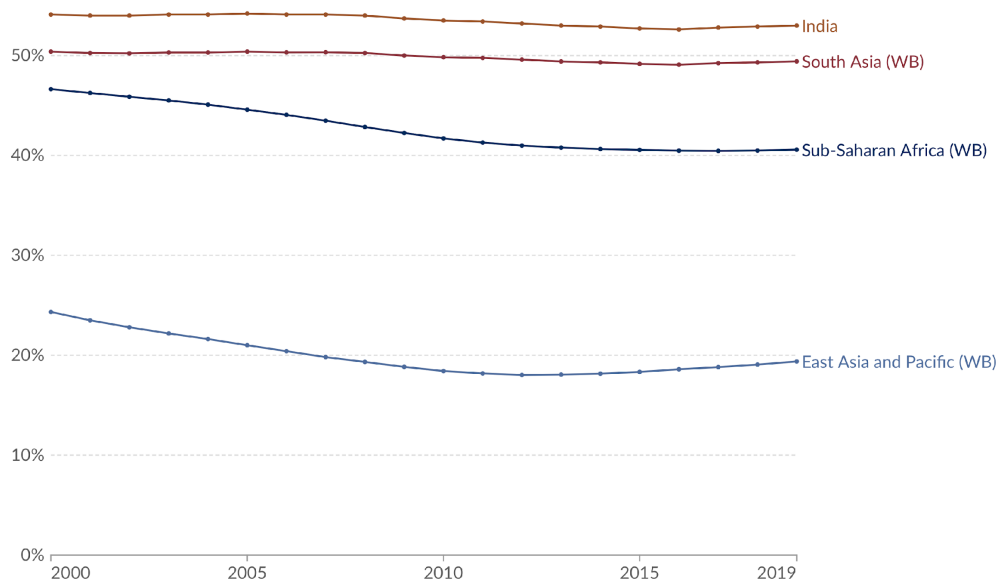
Note: Countries and regions with rates below 2.5% are coded as "2.5%" in the FAO dataset.

OurWorldinData.org/hunger-and-undernourishment | CC BY

Figure 2

Share of women of reproductive age who have anemia, 2000 to 2019

Prevalence of anemia in women of reproductive age (aged 15-49), measured as the percentage of women with a hemoglobin level less than 110 grams per liter at sea level.

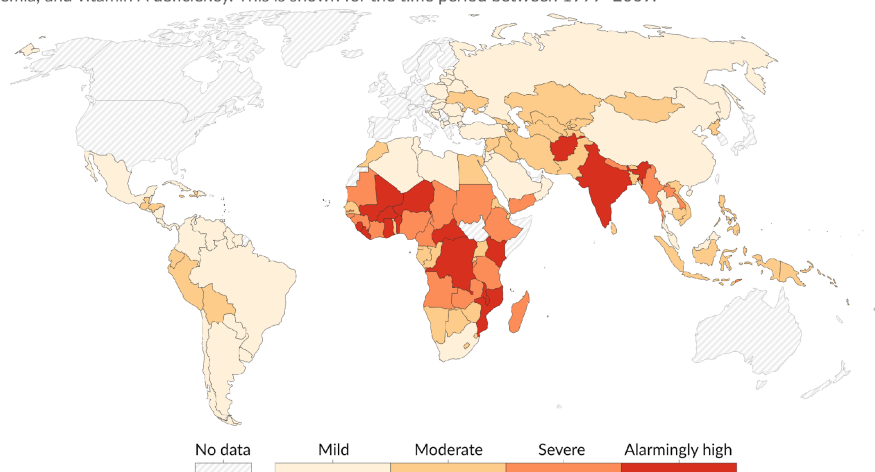
Data source: Multiple sources compiled by World Bank (2024)

OurWorldinData.org/micronutrient-deficiency | CC BY

Figure 3

Hidden Hunger Index in pre-school children

Global Hidden Hunger Index scores in preschool (under-5) children (GHI-PD), which considers rates of stunting, anemia, and vitamin A deficiency. This is shown for the time period between 1999–2009.



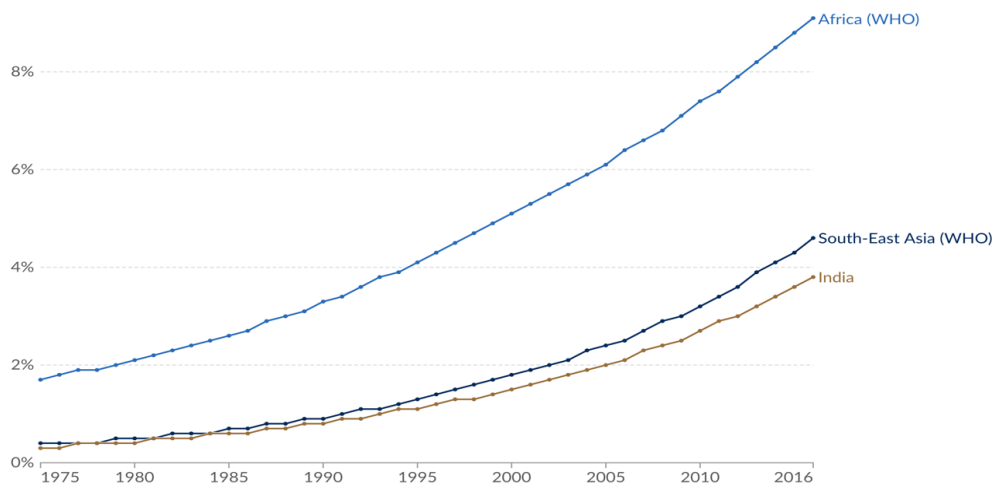
Data source: Hidden Hunger Index in pre-school children - Muthayya et al. (2013) OurWorldinData.org/micronutrient-deficiency | CC BY

Note: The Hidden Hunger Index (HHI-PD) for preschool-age children is calculated as the average of three deficiency prevalence estimates: preschool children affected by stunting, anemia due to iron deficiency, and vitamin-A deficiency. The HHI-PD score ranged between the best and worst possible scores of 0 and 100, respectively. Applying arbitrary cut-offs, HHI-PD scores between 0 and 19.9 were considered mild, 20-34.9 as moderate, 35-44.9 as severe, and 45-100 as alarmingly high.

Figure 4.

Obesity in adults, 1975 to 2016

Estimated prevalence of obesity¹, based on general population surveys and statistical modeling. Obesity is a risk factor² for chronic complications, including cardiovascular disease, and premature death.



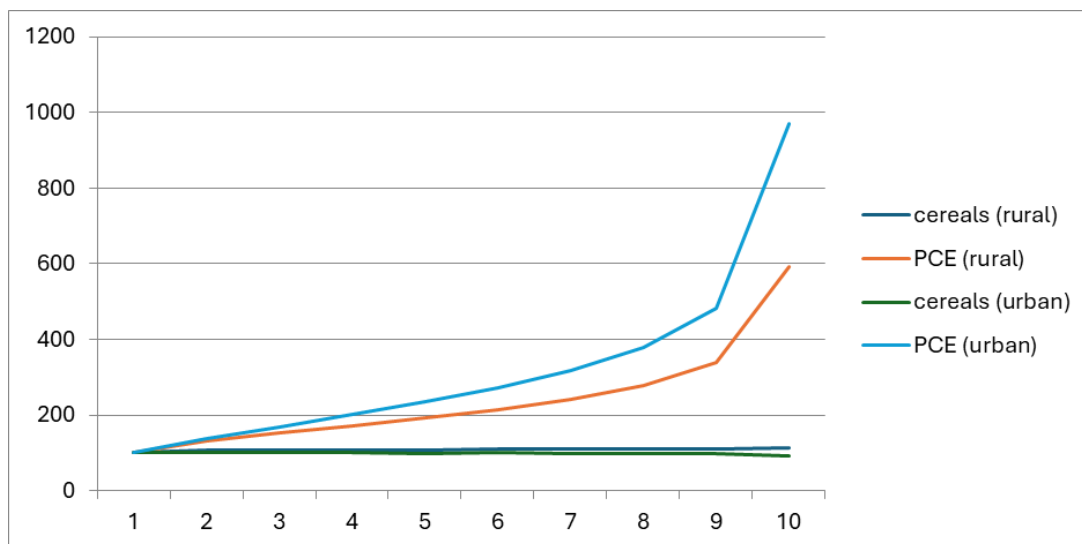
Data source: World Health Organization - Global Health Observatory (2024)

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1. **Obesity:** Obesity is defined as having a body-mass index (BMI) above 30. A person's BMI is calculated as their weight (in kilograms) divided by their height (in meters) squared. For example, someone measuring 1.60 meters and weighing 64 kilograms has a BMI of $64 / 1.6^2 = 25$. Obesity increases the mortality risk of many conditions, including cardiovascular disease, gastrointestinal disorders, type 2 diabetes, joint and muscular disorders, respiratory problems, and psychological issues.

2. **Risk factor:** A risk factor is a condition or behavior that increases the likelihood of developing a given disease or injury, or an outcome such as death. The impact of a risk factor is estimated in different ways. For example, a common approach is to estimate the number of deaths that would occur if the risk factor was absent. Risk factors are not mutually exclusive: people can be exposed to multiple risk factors, which contribute to their disease or death. Because of this, the number of deaths caused by each risk factor is typically estimated separately. Read more: How do researchers estimate the death toll caused by each risk factor, whether it's smoking, obesity or air pollution? Read more: Why isn't it possible to sum up the death toll from different risk factors?

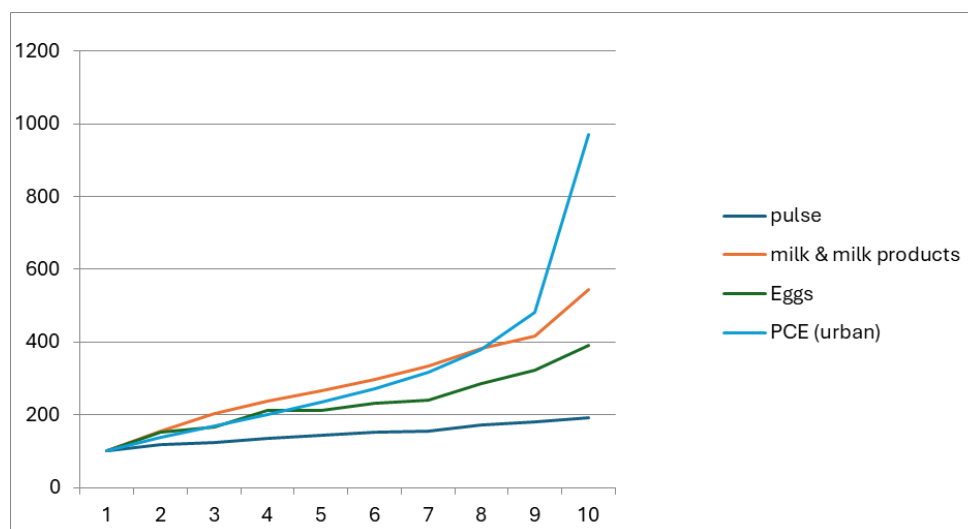
Figure 5: Inequality in Cereal Consumption



The horizontal axis plots the deciles of consumer expenditure. The vertical axis plots per capita expenditures or quantities of cereals consumed for each of the deciles, normalized by the levels in the first decile.

Source: Computations from NSS consumer expenditure survey, 2011/12

Figure 6

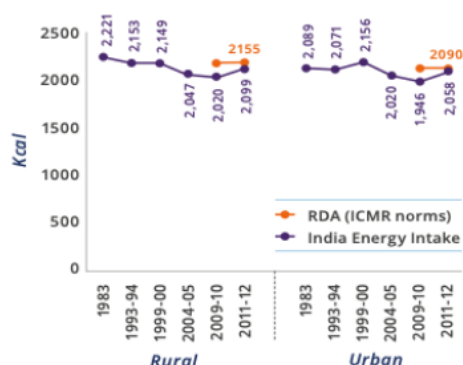


The horizontal axis plots the deciles of consumer expenditure. The vertical axis plots per capita expenditures or quantities of cereals consumed for each of the deciles, normalized by the levels in the first decile.

Source: Computations from NSS consumer expenditure survey, 2011/12

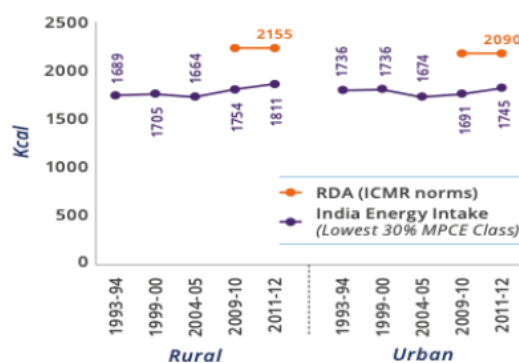
Figure 7

Figure 4.8: Trends of Per Capita Per Day Intake of Energy in India, 1983 to 2011-12



Source: Various rounds of NSSO Consumer Expenditure Survey published by Ministry of Statistics and Programme Implementation, Government of India

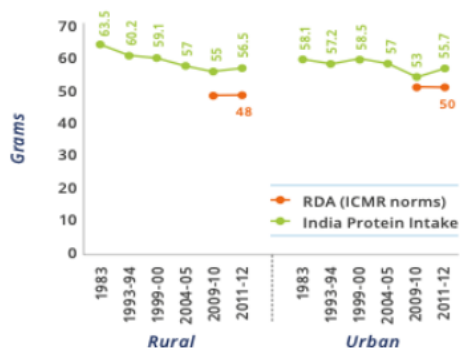
Figure 4.11: Trends of Per Capita Per Day Intake of Energy among Poorest (Lowest 30 percent MPCE class) in India, 1983 to 2011-12



Source: The World Food Program, Food and Nutrition Security Analysis, India, 2019,

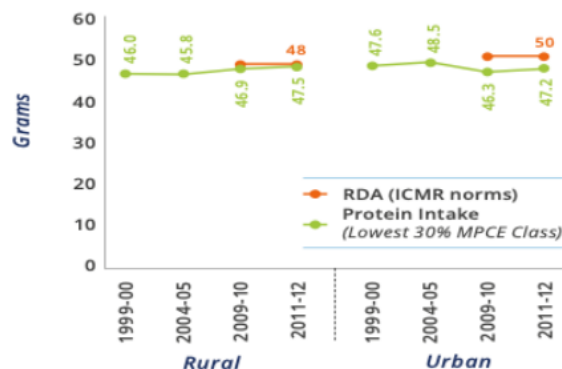
Figure 8

Figure 4.9: Trends of Per Capita Per Day Intake of Protein in India, 1983 to 2011-12



Source: Various rounds of NSSO Consumer Expenditure Survey published by Ministry of Statistics and Programme Implementation, Government of India

Figure 4.12: Trends of Per Capita Per Day Intake of Protein among Poorest (Lowest 30 percent MPCE class) in India, 1983 to 2011-12



Source: The World Food Program, Food and Nutrition Security Analysis, India, 2019,

Figure 9

Figure 4.10: Trends of Per Capita Per Day Intake of Fat in India, 1983 to 2011-12

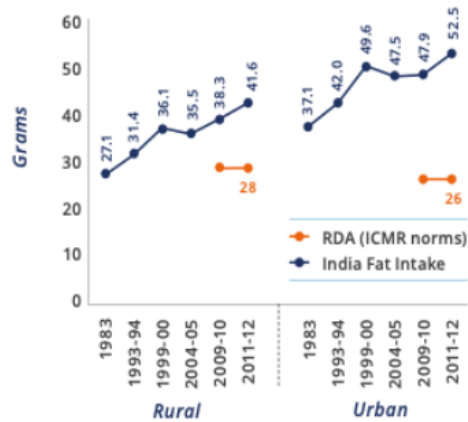
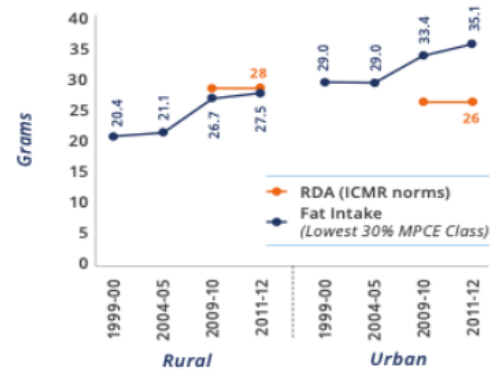
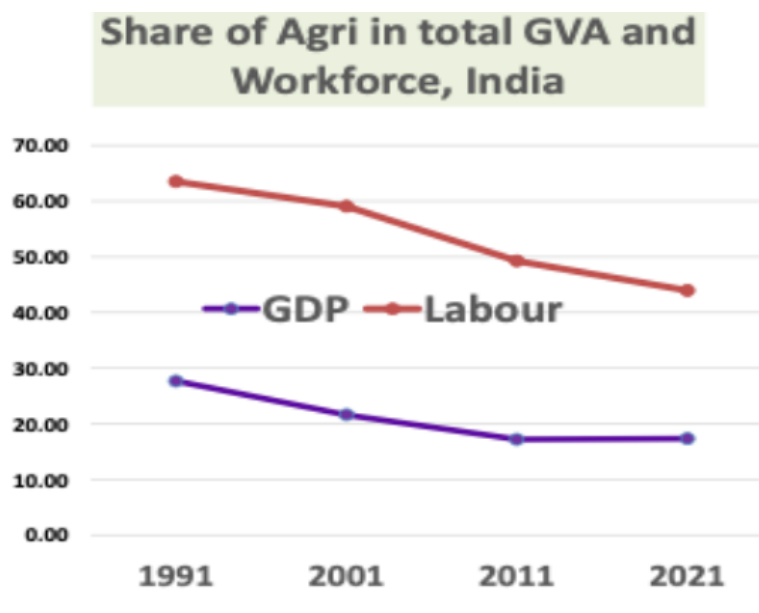


Figure 4.13: Trends of Per Capita Per Day Intake of Fat among Poorest (Lowest 30 percent MPCE class) in India, 1983 to 2011-12



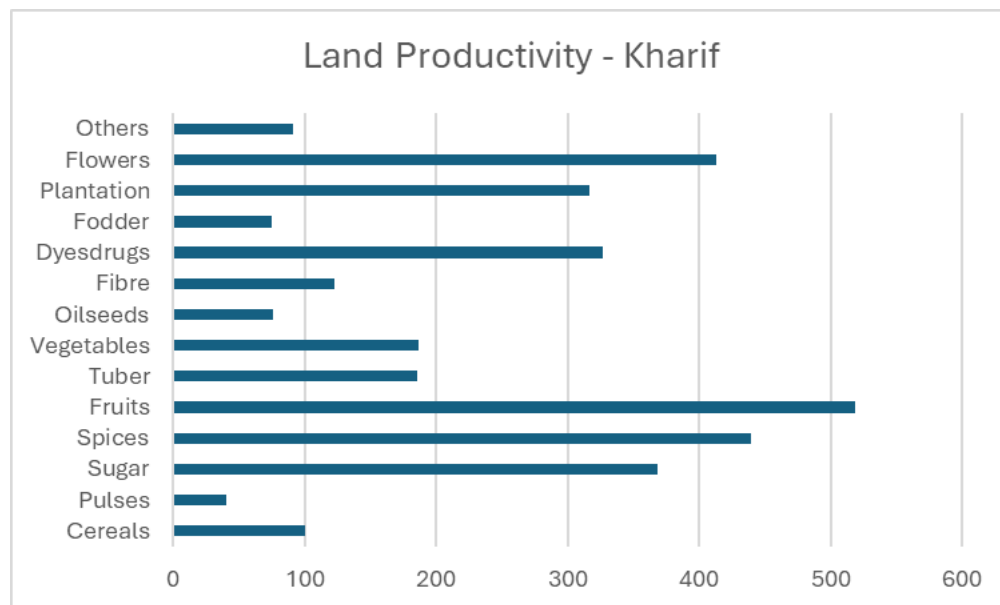
Source: The World Food Program, Food and Nutrition Security Analysis, India, 2019,

Figure 10



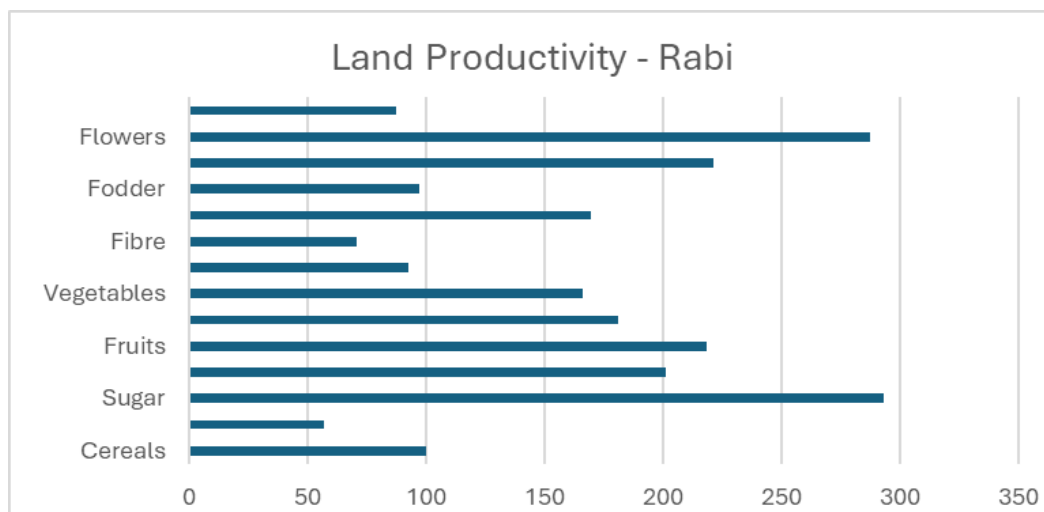
Source: Ramesh Chand, Reimagining Agriculture for Development, Kautilya Economic Conclave

Figure 11: Land Productivity for the Kharif Season



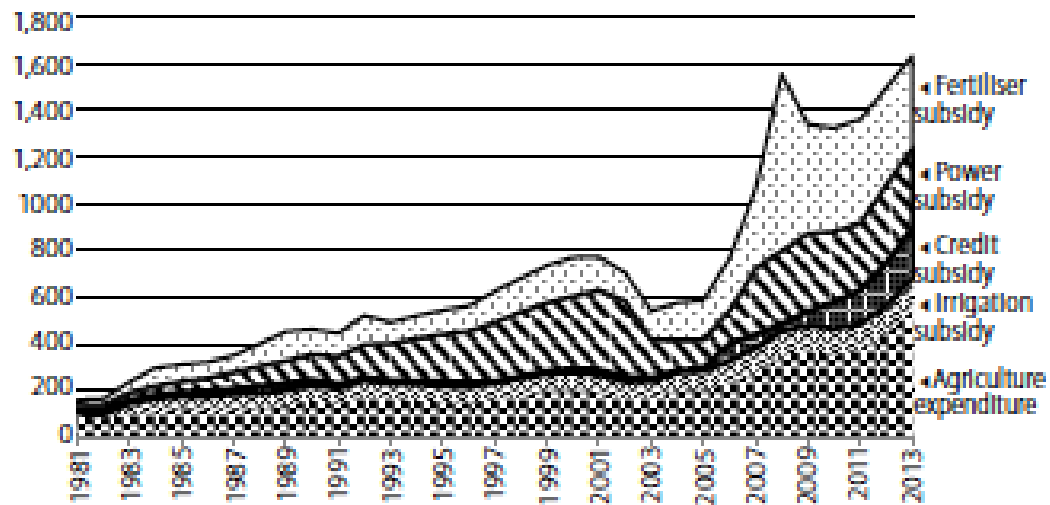
Source: Computations from Situation Assessment Survey of Farmers, 2019 (NSSO)

Figure 12: Land Productivity for the Rabi Season

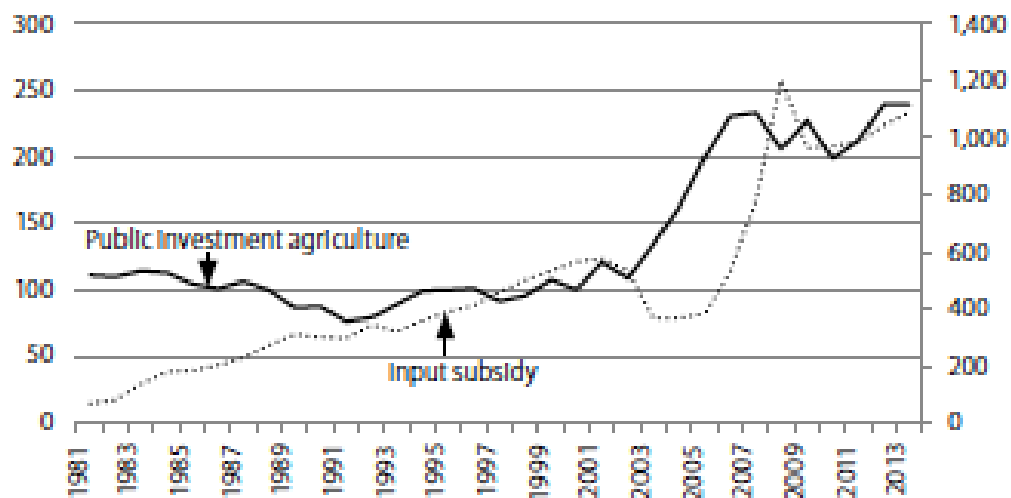


Source: Computations from Situation Assessment Survey of Farmers, 2019 (NSSO)

Figure 13: Subsidies in Indian Agriculture

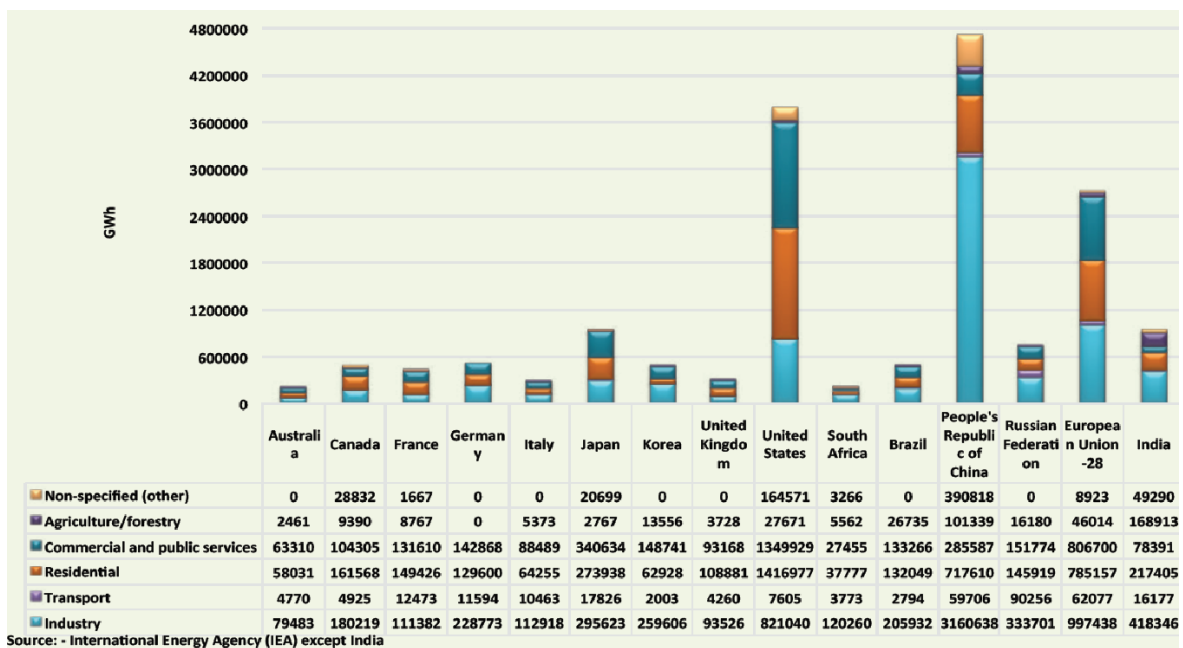


Source: Bathla, Thorat, Joshi and Yu (2017)



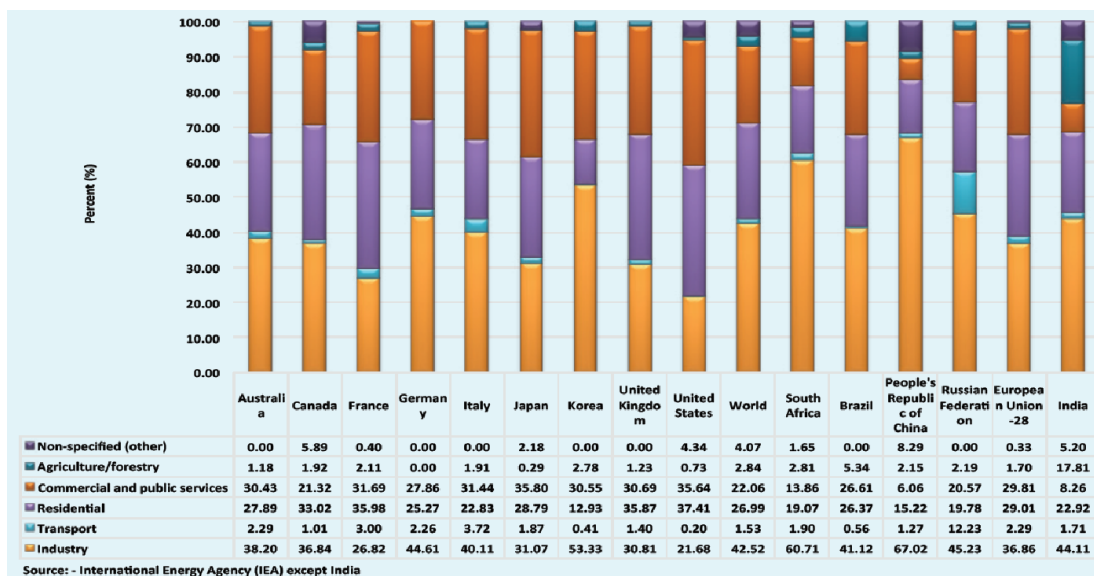
Source: Bathla, Thorat, Joshi and Yu (2017)

Figure 14: International Comparison of Electricity Consumption Across Sectors (Absolute Amounts)



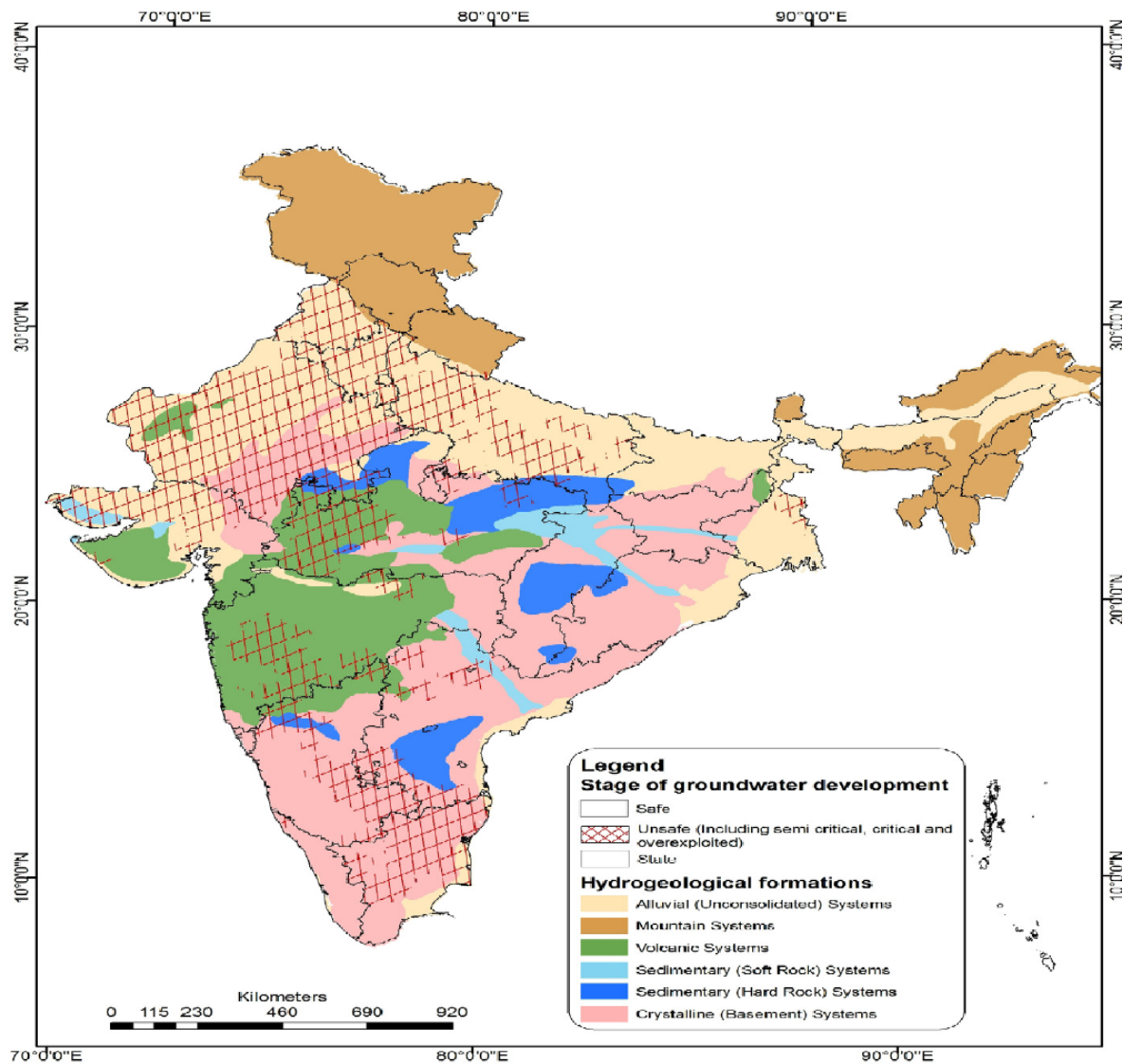
Source: Central Electricity Authority (2017)

Figure 15: International Comparison of Electricity Consumption Across Sectors (Proportions)



Source: Central Electricity Authority (2017)

Figure 16: Groundwater Extraction Relative to Recharge



Source: Kulkarni, Shah and Shankar (2015)



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