NITI Aayog

A NEW PARADIGM FOR

INDIAN AGRICULTURE

FROM AGROINDUSTRY TO AGROECOLOGY

सत्यमेव जयते
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A New Paradigm for Indian Agriculture from Agroindustry to Agroecology

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Authors: Neelam Patel; Bruno Dorin and Ranveer Nagaich

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ABSTRACT

The importance of agriculture in an economy usually declines as it climbs the development ladder. Raising agriculture productivity has been known to be an important precursor. Labour productivity in agriculture can either be increased by higher land productivity or higher land availability per farmer and mechanisation. In India, however, the dramatic increase in land productivity through industrial farming has caused severe environmental damage and did not boost agricultural labour productivity. Going ahead, India faces the challenges of both increasing farm productivity and increasing sustainability and resilience to climate change. These policy goals have the potential of creating a trade-off for policymakers. By showing that India's path of structural transformation is unsustainable, this paper calls for a new paradigm in Indian agriculture through the adoption of agroecological principles at scale.

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1 Dr. Neelam Patel is Sr. Adviser (Agriculture), NITI Aayog, Dr. Bruno Dorin, is Senior Economist at CIRAD/CIRED (France) and CSH (India), & Ranveer Nagaich is Public Policy Consultant, NITI Aayog. Corresponding author: Ranveer Nagaich (ranveer.nagaich@gov.in)

EXECUTIVE SUMMARY

Conventional wisdom tells us that as an economy moves along the development path, the importance of agriculture declines, both in terms of employment and contribution to national income (as measured by gross domestic product or GDP). This process of structural transformation has received substantial treatment in the literature. The diminishing share of agriculture has led scholars such as Timmer (2009) to claim that we are headed to a 'world without agriculture', wherein the shares of agriculture in both GDP and employment are less than 3%. Timmer (2009) also emphasises that in terms of labour productivity, there is no discernible difference between the agriculture and non-agriculture sectors, meaning that income gaps between the two groups are miniscule at best.

This paper first examines where India and individual states lie on this path put forward by Timmer (2009) between the years 1993-94 to 2019-20. The findings are hardly surprising. India's structural transformation is incomplete. While the share of agriculture in GDP has been falling, the share of agriculture in employment has not been falling at a commensurate pace. This has created an imbalance between labour productivity in the agriculture sector vs. labour productivity in the non-agriculture sectors. For example, at an all-India level, in 2019-20, the share of agriculture in employment is 45.6%, whereas the share of agriculture in GDP stood at 13.5% While some states are further along this path of structural transformation, it has been found India still remains someway away from the canonical structural transformation path. The work of Timmer (2009) largely assumes that the conditions in which most present day developed countries, such as the present OECD countries that have completed their transformation would continue to hold true for developing countries such as India.

It has so far been assumed that all economies follow the trajectory first laid out by Lewis (1954). Yet, this path of structural transformation assumes certain pre-conditions. First, labour is pulled out of agriculture into more productive sectors of the economy, leaving behind fewer farmers to work on larger farms. This allows the productive capacity of the agriculture sector to rise, both in terms of land productivity, through intensification of inputs and labour productivity, through mechanisation. Rising land availability per farmer is an important precursor to this process. Indeed, raising agriculture productivity is seen as the precursor to the development process.

The paper then examines the challenges agriculture in India faces in raising productivity. The mechanisms through which countries in the past have raised agriculture productivity are not necessarily true for India. First, the size of the average farm in India has been falling over time, whereas in developed countries, farms got bigger, as labour migrated out of agriculture into urban areas. While India has seen urban migration and a spillover of workers in agriculture to other sectors, the pace has not been commensurate with that of conventional knowledge.

Raising irrigation coverage is another mechanism to increase productivity. Nearly half of India's cropped area remains rain-fed. Informal credit, especially to small and marginal farmers remains prevalent. The literature has found a positive relationship between formal credit availability and agriculture growth. Nor have the best scientific practices permeated at the field level. Perhaps more important than the productivity enhancing challenges are the environmental challenges that the India faces in ensuring sustainable agriculture.

The current practices prevalent are causing serious environmental damage, in terms of declining soil health, depleting water tables, greenhouse gas emissions etc. Analysis of data from the soil health card scheme shows the alarmingly low levels of soil organic carbon (SOC) across India, an important indicator of soil health. Imbalance in the use of fertilisers has been linked to declining soil health, as per a study by the National Academy of Agricultural Sciences (NAAS, 2018). This paper demonstrates the imbalance in fertiliser use at the state-level. Sources of irrigation water have shifted from surface water channels such as canals to groundwater. Presenting administrative data on groundwater extraction, this paper demonstrates the alarming level of water extraction, in the most productive states. Based on these discussions, the paper concludes that India faces the twin challenges of improving productivity, but also doing it in an environmentally friendly manner, which the current system of production is at odds with. Therefore, prima facie, these two goals may seem mutually exclusive.

Diminishing marginal returns are now evident in the current system of production. The canonical path of structural transformation is also not evident in the case of India. As mentioned earlier, the conditions in which the developed countries of today were able to transform themselves, and the conditions which informed the work of Timmer (2009) may not necessarily hold, as this paper has shown. Dorin et al. (2013), identified three other paths of structural transformation along with the path laid down by Lewis (1954) and Timmer (2009). Apart from the canonical path, termed the 'Lewis Path', the other three are: 'Farmer Developing Path', 'Farmer Excluding Path' and 'Lewis Trap Path'. Crucial in determining these paths is the labour-income ratio (LIR) defined by Dorin et. al (2013), which is the ratio between the share of agriculture in GDP and in employment. As the LIR $\rightarrow$ 1, this indicates a convergence between farm and non-farm incomes. If the LIR $\rightarrow$ 0, then there is divergence between the two. In the 'Lewis Path', the LIR $\rightarrow$ 1 as the number of farmers decreases, but productivity rises. This is the path taken by most OECD countries. In the 'farmer developing path', LIR $\rightarrow$ 1, as labour productivity in agriculture increases, but the number of farmers also increases. On the opposite we have the 'Lewis Trap', where the income gap between the farm and non-farm sectors widens, and the agriculture workforce increases. The final path identified is the 'farmer excluding path', where the income gap between farm and non-farm sectors widen, and the number of farmers decreases.

The key contribution of this paper is that it identifies the path taken not just at the national level, but also the state level. The findings indicate that rather than on the 'Lewis Path' of transformation as theory tells us, India is on the 'Lewis Trap Path'. Individual states are either on the 'Lewis Trap Path' or the 'Farmer Excluding Path'. Only two North-Eastern States (Manipur and Nagaland) are found to be on a 'farmer developing path'. This indicates that India's path of structural transformation will continue to exacerbate inequalities. While India has made significant strides in raising land productivity, but shrinking land availability has meant that labour productivity has grown at a much slower pace than average labour productivity in the economy.

The paper then introduces the concept of agroecology as a potential solution to the supposed tradeoff between productivity and sustainability, and also as a solution to a path of structural transformation where inequalities are not exacerbated. Altieri & Nicholls (2020) assert that there are five main areas through which agroecology can point a new way for agriculture: reduced reliance on pesticides, enriching biodiversity, revitalising small farms, creating alternative animal production systems and enhancing urban agriculture. The paper then introduces natural farming being practised in some parts of India, which is a chemical-free method of farming. Evidence from recently conducted field studies on natural farming are presented, showing that natural farming has the potential to reduce input costs and in many cases, exceed the yield of conventional farming. The paper also attempts to distil some policy implications from the discussion. At the outset, we note that these suggestions are an attempt to further policy discourse on this matter, and in no way are finalised suggestions. However, they do represent promising areas of future research to further agroecological farming in India.

I

INTRODUCTION

Despite its declining share in gross domestic product (GDP) all across the world, agriculture still remains an important policy priority for governments around the world. This declining share of agriculture in national income and employment has been described as the structural transformation of an economy. Rural to urban migration and a decline in birth rates and mortality rates are other characteristics of this transformation (Herrendorf et al. 2014). Lewis (1954) pioneered the work on the structural transformation of an economy, with his dual-sector model. He postulated that the 'capitalistic' sector drew excess labour from the 'subsistence' sector, raising the wages of those entering the 'capitalistic' sector. Johnston & Mellor (1961) term the decline of the agricultural sector as the 'general transformation model'. They note that the important precursors to a structural transformation are an income elasticity of food of less than one and the ability to expand agricultural production with a declining workforce. The authors reiterate the conclusion from Lewis (1954), that overall economic growth demands a structural transformation of an economy, one which sees a declining role of the agriculture sector.

This has led many to claim that this process of structural transformation will lead to a 'world without agriculture' (Timmer, 2009), as today in OECD countries where the share of agriculture in both GDP and employment is less than 3%. However, when Timmer (2009) talks about a world without agriculture, it may be a misnomer. He does not mean economies are functioning 'without agriculture', rather, that the share of agriculture in national income is diminished to the point where the share of value added in agriculture is miniscule compared to the rest of the economic sectors (< 3 %). However, Timmer (2009) also notes that the labour productivity of those remain in the agriculture sector are no different to those in other sectors of the economy.

However, despite this declining role for agriculture, it still has an important role to play in ensuring this structural transformation is underway. Raising agriculture productivity is critical to create a surplus of food, labour, and savings. In OECD countries, despite a considerable decline in the shares of agriculture in GDP and employment, this decline was met by an increase in agriculture labour productivity relative to non-agriculture, closing the gaps of labour productivity between the two sectors. Therefore, in a 'world without agriculture' there is no discernible difference between the average labour productivity of a worker in the agriculture sector compared to a worker outside it. Agricultural poverty has been eliminated.

With the goal of raising agriculture productivity established, the historical sources of increased labour productivity were through intensification in 'modern inputs' use and/or mechanisation (Dorin et al. 2013). Intensification with these inputs involve raising the area under irrigation, usage of high-yielding varieties of seeds, enhanced synthetized fertiliser and pesticide use, to raise land productivity. Mechanisation in turn affects productivity by allowing more land to be worked per worker. India has made significant strides in improving land productivity, but at the expense of sustainability. Declining soil health and water availability are the two biggest issues India faces in maintaining food security going forward. With climate change expected to negatively impact crop productivity, developing countries are now grappling with the twin goals of raising productivity whilst trying to enhance sustainability and resilience. The goals can often seem to be at odds with each other.

In fact, the OECD canonical path of structural transformation has been questioned by some authors. Dorin et al (2013) show that rather than a singular path as envisaged by Timmer (2009), a country can actually be on one of any four different paths. Critical in determining which path a country is on is first, the income gap (defined as the difference in shares of agriculture in GDP and employment). This gap is usually negative at first, as the share of agriculture in employment is greater than the share of agriculture in GDP. As a country develops, this gap tends to zero as observed in OECD countries. The second element of Dorin's typology is the growth rate of active population in agriculture, over the chosen time period. A country on the path to a structural transformation described by Timmer (2009) will see the income gap close over time and see negative growth rates of the active population in agriculture. The path as described by Timmer (2009) has been termed as a 'Lewis Path' by Dorin et al., where the active population in agriculture declines and income gaps become smaller. The polar opposite of this path is the 'Lewis Trap', where the active population in agriculture increases, and income gaps widen, leading to greater inequality and poverty. The other path is termed as a 'Farmer Developing Path', where the income gap decreases, but the active population in agriculture decreases. The opposite of the 'Farmer Developing Path' is the 'Farmer Excluding Path', where the active population in agriculture decreases, with income gaps widening.

The purpose of this paper is manifold. Section II briefly reviews the process of structural transformation in India, its key characteristics, and the role of agriculture in the development process. This section tells us that raising land and labour productivity in agriculture is critical in the process of structural transformation. By imagining India and its constituent States on the path to a World Without Agriculture (WWA), section III reviews trends in labour productivity and terms of trade to discern trends in India's performance towards that path. It is found that overall, India is still a long way from a WWA, but some states are closer than the others. The paper then reviews the challenges faced by current Indian agriculture in Section IV, delineating them into productivity enhancing challenges and sustainability challenges. It is found that whilst India has done well in increasing land yields, labour productivity is still constrained, keeping agriculture productivity growth deflated. The discussion in this section also shows that increasing intensification of agriculture has led to severe environmental damage. In the face of climate change mitigation and adaptation, India now faces the twin goals of raising productivity, whilst seeking to enhance sustainability and resilience. Section V reviews the Indian situation with Dorin's four paths of structural transformation. The primary conclusion from this section is that land constraints appear to be a significant explanator of low labour productivity growth rates. It then shows that Indian States have been following one or other of these four paths since 1993. But most States, as well as India overall, are on a 'farmer excluding path', where the active population in agriculture has seen a decline, but income gaps continue to widen. Many of the other States are seen to be on the 'Lewis Trap' path, and very few in a 'Lewis Path' or 'Farmer Developing' path. The key conclusion from this section is that a paradigm shift in agriculture is necessary to ensure the long-term health of India's agriculture sector. Section VI introduces the concept of agroecology as an alternative to today's industrial farming systems. It calls for a complete shift in the approach towards agriculture as the only solution to these seemingly mutually exclusive goals of raising productivity and ensuring sustainability. Section VII presents some high-level policy implications that such a shift would necessitate, and Section VIII concludes.

II

THE PROCESS OF STRUCTURAL TRANSFORMATION

The economy of India at the time of independence and now is starkly different. We have gone from an era of shortages to surpluses in grains. This change is reflective of the structural transformation India has undergone. Indeed, this process is something all countries in the world have gone through or will go through. Structural transformation has been defined as both the cause and effect of economic growth. Timmer (2009) identifies three interrelated processes that define the structural transformation:

i. **A declining share of agriculture in national income & employment, with rising secondary & tertiary sectors of the economy.** At the end of the process, the productivity gap between agriculture & non-agriculture sectors is extremely small. Several OECD countries have transitioned into a 'World Without Agriculture' (WWA), where both the share of agriculture in GDP and in employment is now less than 3%.

ii. **Rural to Urban Migration**: Increasing urbanisation is witnessed in all countries that are undergoing the process of structural transformation. Industrialisation has had a key role to play in this regard. New urban centres come up, with Shenzhen in China being the most pertinent contemporary example.

iii. **From High Birth Rates & Deaths to Low Birth Rates and Deaths:** As health systems improve, high mortality rates gradually improve. Birth rates decline.

A. INTERNATIONAL EVIDENCE

The evidence presented by Timmer (2009) spanned 86 countries between 1965 and 2000. He finds a negative relationship to exist between per-capita incomes and share of agriculture in GDP in employment. This provides statistical evidence that as per-capita incomes increase, the role of agriculture in the overall economy becomes smaller. The results also show that the rate of decline in agriculture's share in GDP is faster than employment, setting up a potential mismatch between the two. The author defines this difference in shares as a gap and constructs a measure of a rural-urban income gap based on these gaps.

The author finds that the rural-urban income gap only becomes larger as an economy grows. This is due to labour productivity growing faster in the urban areas rather than rural ones. Further, he finds that agriculture terms of trade (ToT) are used as an effective policy tool to smoothen the integration of agriculture with the rest of the economy. It is also becoming increasingly harder to close this productivity gap between the agriculture and non-agriculture sectors. The author claims that the global growth process has been failing to integrate low-productivity agricultural labour into the rest of the economy. This finding has serious implications for India.

An interesting finding from this work is the divergent paths taken by Asian countries compared to others. He finds that the pattern of employment change in the agriculture sector in Asian economies did not follow the pattern set by non-Asian ones. The results indicate that Asian countries employed a disproportionately large number of agriculture workers in the early stages of development. The ToT variable was positive and statistically significant for Asia, whilst it was negative and statistically significant for others. This finding leads the author to conclude that Asian countries provided price incentives to the agriculture sectors as a way to prevent the movement out from being "too fast".

B. THE ROLE OF AGRICULTURE

Despite a shrinking role of agriculture in the process of structural transformation, agriculture still has an important role in catalysing this transformation, according to Timmer (2009). The linkages between agriculture and development were first discussed by Lewis (1954), in the classic dual-sector model of an economy, where growth is explained as a transition of labour between two sectors, the 'capitalist' sector and the 'subsistence' sector. For 'overpopulated' countries (as termed by Lewis), the central to the process of development was moving a large number of underemployed workers with low productivity to a modern 'capitalist' sector, with higher productivity and wages (Gollin, 2014). These conclusions are similar to the ones drawn by Jorgenson (1967). Lewis further assumed that capital could only be employed in the modern sector, giving us the distinction between the two sectors. According to Gollin (2014), this assumption required either a market failure or technological barriers keeping capital from flowing to the subsistence sector. These assumptions may perhaps be weakly true in the case of India. Whilst the agriculture sector has seen modernisation, there still remains a credit gap. Similarly, farmer returns have not been growing at the same pace as non-farm returns, reflecting a widening income gap. The distinction between India's agriculture sector and non-agriculture sectors are clear to see.

Timmer (2009) claims that historically, no country has been able to sustain a rapid transition without increasing productivity in the agriculture sector first. Through higher productivity, agriculture is able to provide food, labour, and savings to the process of urbanisation and industrialisation (Johnston and Mellor, 1961). This finding is also supported by the results of Gollin, Parente & Rogerson (2002), who showed that low agricultural productivity slows down the industrialisation process. Studying the process of structural transformation in Asia, it is found that the 'Lewis turning point', where the shift from surplus labour to shortage in agriculture labour, reflected in rising agricultural wages is yet to be reached by most Asian countries (Briones and Felipe, 2013). These findings corroborate the conclusions in Timmer (2009). However, Timmer also noted that this 'turning point' is coming at higher and higher levels of per-capita incomes, making the transition harder and more challenging for developing countries. Until this turning point is reached, income gap between farm and nonfarm activities continues to widen. Based on the literature discussed above, the role of agriculture in the structural transformation seems clear. Productivity in this sector needs to increase to generate a surplus of food, labour, and savings, which then fuel the growth of industrialisation and urbanisation. Therefore, even though countries are moving to a 'world without agriculture', this path is built on the back of a modernising agriculture sector.

III

IS INDIA HEADED FOR A WORLD WITHOUT AGRICULTURE?

Based on the discussion in Section II, this section investigates where India lies on the path of a world without agriculture (WWA). Data has been sourced from National Accounts and labour force survey reports published by the Ministry of Statistics and Programme Implementation (MoSPI).

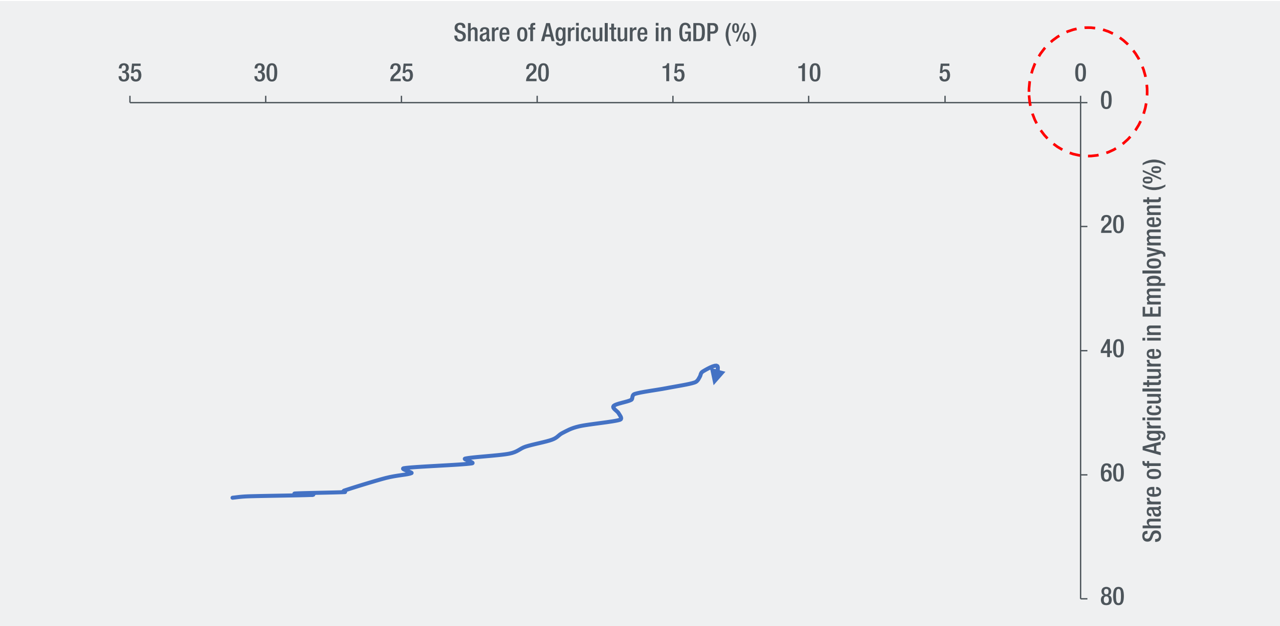


Figure 1: *India's Path towards a World Without Agriculture: 1993-94 to 2019-20*

Source: *MoSPI. Note: Data from 1993-94 to 2019-20. Share of GDP in constant 2011-12 prices. Back Series of National Accounts published by MoSPI used. Employment data interpolated from NSSO EUS & PLFS Reports.*

As it can be seen from the figure above, there is some long way to go for India in reaching a WWA. While the share of agriculture in GDP has been falling, it has not fallen by a commensurate pace in employment. Figure 2 plots the path of various states on the WWA. Sufficient heterogeneity is revealed. The southern states of Kerala, Tamil Nadu & Karnataka seem to closest to a WWA, relative to others. States in north India are found to be right in the middle of the chart. In absolute terms, all states, have a long way to go to a WWA, where the share of agriculture in employment and in GDP is less than 3%.

The gap between agriculture share of employment and GDP is also evident from Figure 2. States like Punjab & Haryana for example, exhibit a small gap, indicating the relatively more prosperous nature of farmers there, compared to the rest of India. Then there are states such as Maharashtra, Karnataka, Kerala, Tamil Nadu, and Gujarat, where the gap is much wider. These states have seen their secondary and tertiary sectors grow, with the share of agriculture in GDP falling below 10%. Yet, in terms of share in employment, the decline has been less steep. This in fact, was a finding emphasised by Timmer (2009). This gap in agriculture's income share and employment share is a major driver of inequality in developing countries.

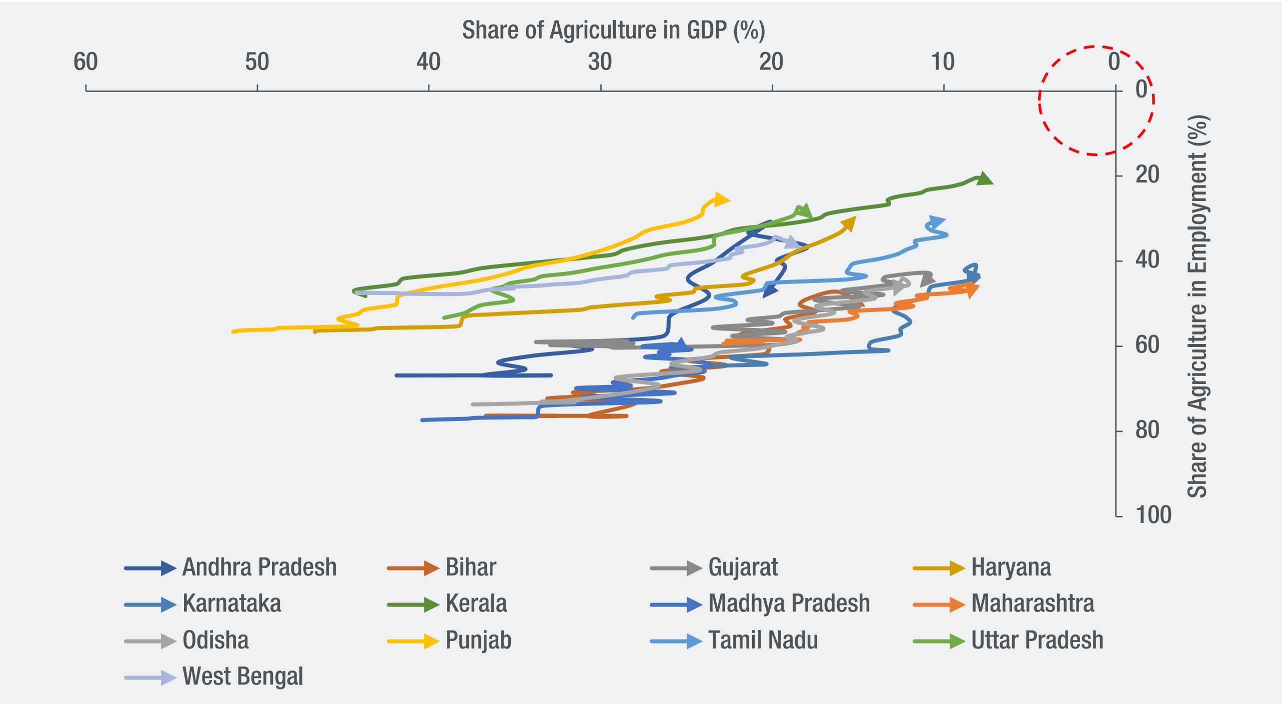


Figure 2: *States' Path toward a World Without Agriculture (1993-94 to 2019-20)*

Source: *Authors calculations using MoSPI data. Notes: Data from 1993-94 to 2019-20. Share of GDP in constant 2011-12 prices. State GDP has been rebased to the 2011-12 series. Employment data interpolated from NSSO EUS & PLFS Reports.*

The inequality caused by this gap is exacerbated when farm incomes grow at a slower rate than non-farm incomes. Proxied by labour productivity (measured as gross value added per worker), we find that non-farm incomes have been growing at a faster pace in India since 1993-94.

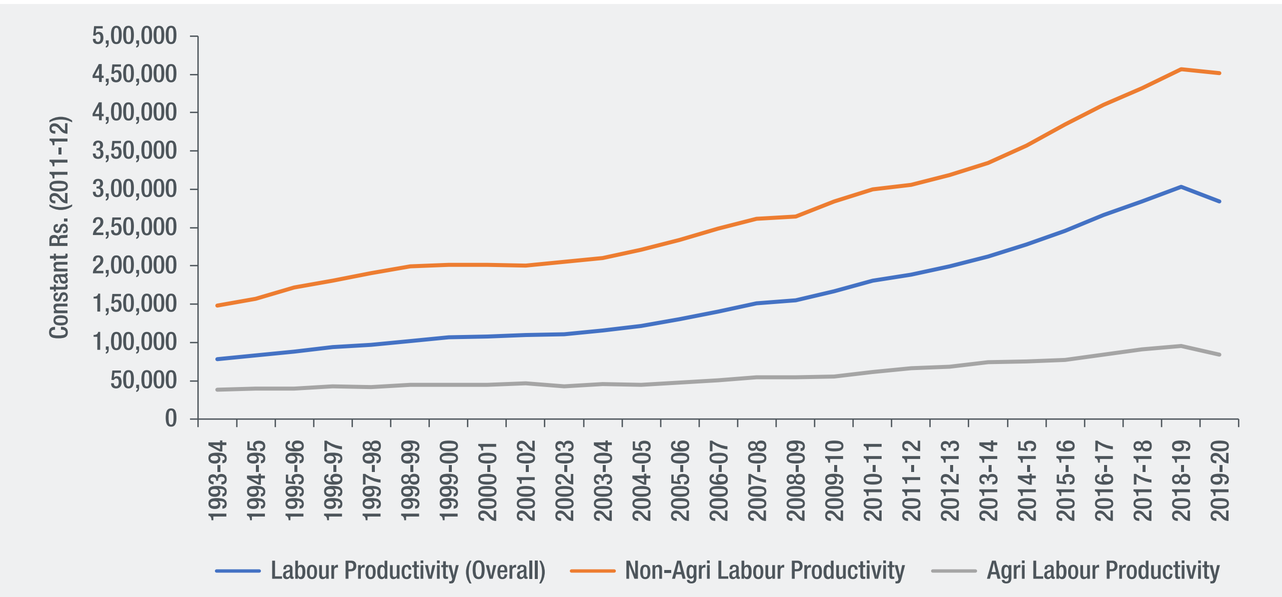


Figure 3: *Labour Productivity in Agriculture, Non-Agriculture Sectors & Overall: 1993-94 to 2019-20*

Source: *MoSPI & Authors calculations*

As it can be seen from the figure above, the productivity gap between the agriculture and non-agriculture sector has only widened. Between 1993-94 and 2019-20, labour productivity in agriculture grew at 3.2% per annum, compared to 4.4% in the non-agriculture sector. This has resulted in widening income gaps between the rural and urban sectors of the economy.

Timmer (2009) also argued that Asian countries were able to slow the movement of labour out of agriculture using price policy as an effective tool. We measure relative prices using terms of trade (ToT), which is defined as the ratio between GDP deflators in the agriculture and non-agriculture sectors. This allows us to discern any noticeable trends in relative prices.

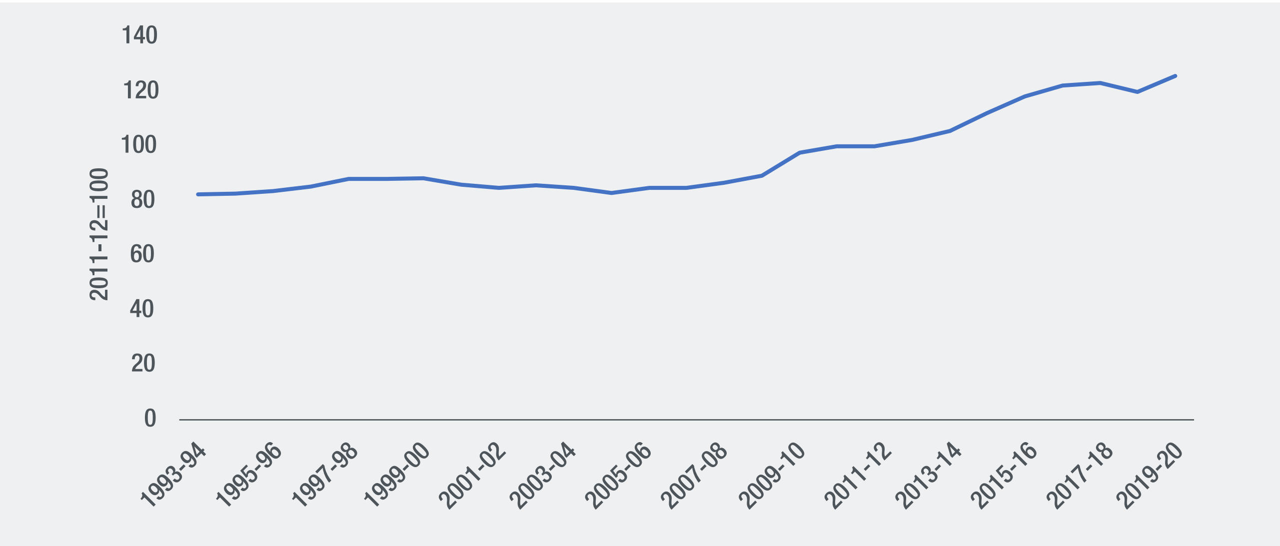


Figure 4: *Agriculture Terms of Trade: 1993-94 to 2019-20*

Source: *MoSPI & Authors Calculations. Base = 2011-12.*

As it can be seen from the figure above, the agriculture terms of trade (AgToT) remained relatively flat between 1993-94 to 2007-08, even exhibiting a small decline. This trend was reversed in 2008-09, at the onset of the Global Financial Crisis. Since then AgToT have been moving upwards. The growth rates computed for various periods confirm these findings. In the 15 odd years between 1994-95 and 2008-09, AgToT grew by 0.5% per annum. Since 2009-10, AgTOT have grown by 3.2% per annum.

Table 1: Average Growth Rates in Agriculture Terms of Trade (%)

Time Period	Average Growth Rate in AgToT (%)
1994-95 to 1998-99	1.3
1999-00 to 2003-04	-0.8
2004-05 to 2008-09	1.1
2009-10 to 2013-14	3.5
2014-15 to 2019-20	3.0

Source: *Authors calculations using MoSPI data.*

AgToT can improve if farmers are receiving better prices for their produce. This can be owing to better market access or through higher support prices. The improvements in average AgToT growth rates can perhaps be attributed to the latter. Figure 5 plots the announced minimum support prices (MSPs) for paddy and wheat (including bonuses).

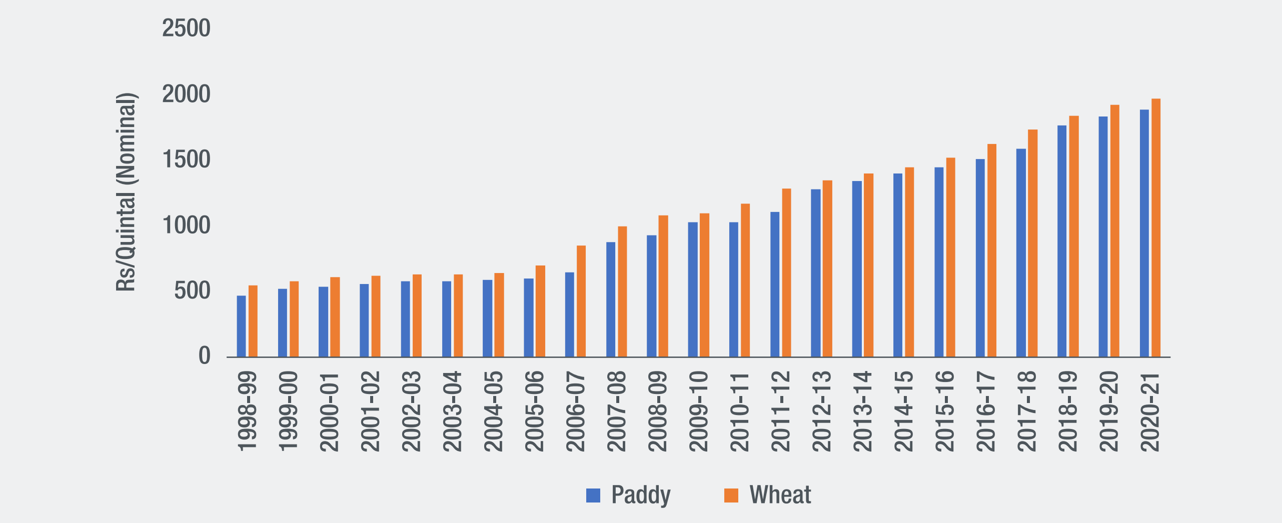


Figure 5: *Minimum Support Prices of Paddy & Wheat: 1998-99 to 2020-21 (Nominal)*

Source: *Ministry of Agriculture*

As it can be seen, since 2007-08, there has been a clear expansion in price support, which could explain why AgToT have grown in this period. During this time, we have also witnessed a slowing in the pace at which the share of agriculture in employment was declining.

From the analysis above, it is clear that India's structural transformation, as defined by Timmer (2009) is incomplete. India is still a long way from a 'world without agriculture'. There remains a substantial gap between the share of agriculture in employment and national incomes. The productivity gap between agricultural workers and non-agricultural workers continues to widen. However, these are factors that Timmer (2009) predicted in his seminal work. The only way out according to him was raising investments in agriculture to boost productivity, which would eventually close both, the gap in share of agriculture in employment and national income and the gap in labour productivity between agriculture and non-agricultural sectors of the economy.

Since the mid-20th century, raising labour productivity in agriculture is a function of input intensification and motorisation (Dorin et al, 2013). This means raising the intensity of inputs such as using high-yielding varieties (HYVs) seeds, expanded irrigation coverage, use of chemical fertilisers and pesticides, paired with the mechanisation of agriculture, through lesser use of farm labour, the use of tractors, threshers and other machineries and robots to replace them. The strides made by India during the Green Revolution were both in and out of this policy prescription. However, new challenges are on the horizon, whilst the old ones still remain. The next section analyses these challenges.

IV

CHALLENGES IN INDIAN AGRICULTURE

Over the years, several legacy issues have emerged in Indian agriculture. One set of challenges is related to increasing labour productivity in the average Indian farm. Many Indian farms are caught in a low labour productivity trap, leading to depleted incomes. Intensification of inputs have been one avenue of increasing land productivity, which have delivered impressive results. Increase in area under irrigation since the Green Revolution and increased use of chemical fertilisers and pesticides have seen land productivity increase manifold. This Green Revolution ensured India going from a cereal deficit country to a cereal surplus one. However, the intensification of inputs, apart from their rising costs to farmers, are also posing serious environmental costs to the nation and indeed, the world. This is where the second set of challenges comes in to play, which are related to the sustainability of the current set of practices being prescribed in India. The first part of this section will explore the factors impeding productivity in India. The second part of this section will present evidence on the environmental costs being incurred by these practices.

A. PRODUCTIVITY-ENHANCING CHALLENGES

Farm Sizes

Labour productivity is constrained owing to land sizes. The average farm size in India has been consistently becoming smaller, hampering labour productivity, and limiting economies of scale. As Table 2 shows, the average farm size in India has roughly halved in size since 1970-71. This also implies a prevalence of small landholders. Close to 85% of India's holdings are operated by small and marginal farmers (SMF).

Table 2: Average Size of Operational Holdings (Hectares): 1970-71 to 2015-16

Year	Size
1970-71	2.28
1976-77	2.00
1980-81	1.84
1985-86	1.69
1990-91	1.55
1995-96	1.41
2000-01	1.33
2005-06	1.23
2010-11	1.15
2015-16	1.08

Source: *Agriculture Census 2015-16*

Owing to small plot sizes, the labour productivity of these farms is hampered, as mechanisation is not a viable option. The gains to labour productivity from mechanisation accrue at the large land holding level (> 10 ha). It makes little economic sense to investment in mechanisation for a small and marginal farmer.

Irrigation Coverage

Despite significant strides since independence, a large proportion of farms in India still depend on the monsoon for irrigation, limiting their ability to increase cropping intensity. At the national level, 52% of India's gross cropped area (GCA) is under irrigation coverage. The chart below gives the status, state-wise.[2] The heterogeneity amongst Indian States in agriculture starts to become evident here. Unsurprisingly, it is the States where the Green Revolution was initially unleashed that have the greatest irrigation coverage. Increasing irrigation coverage is also critical to the goal of doubling farmers' income. A NITI Policy Paper noted that irrigation coverage needed to expand to 53% by 2022-23, enabling greater cropping intensity (Chand, 2017).

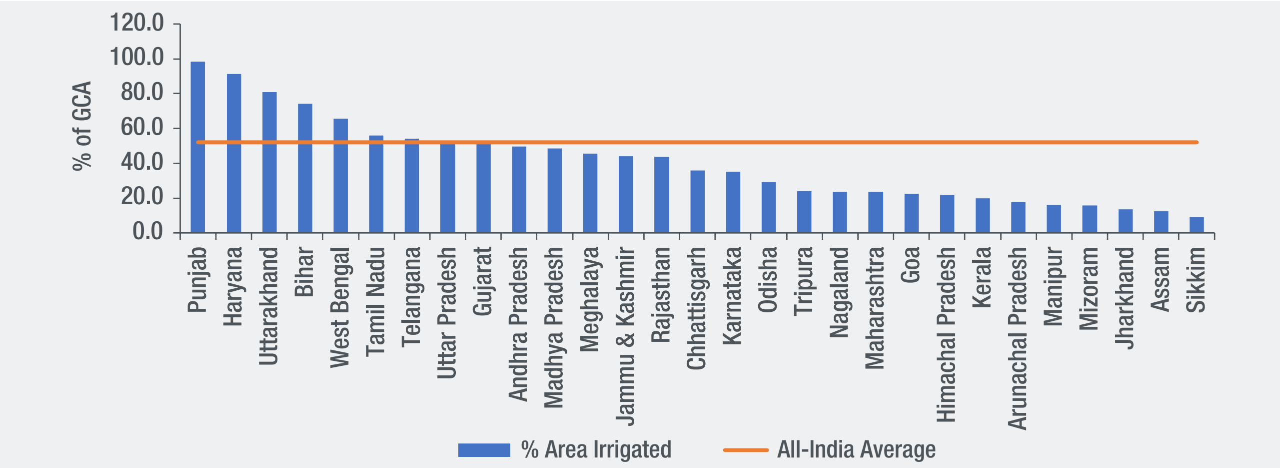


Figure 6: *State-Wise Irrigated Area: 2019-20*

Source: *Ministry of Agriculture*

Despite gaps, there has been a substantial expansion in the availability of technologies such as high-yielding varieties of seeds, irrigation, fertilisers, and pesticides to farmers. This resulted in an expansion in land productivity, ensuring India's cereal security and resilience to famines. The public procurement and distribution network ensured cereals were procured from farmers at announced minimum support prices (MSPs).

Credit

Despite a provision of Rs. 15 lakh crores (Rs. 15 trillion) of credit to the agriculture sector in the Union Budget of 2020-21, access to formal credit still remains constrained for many of India's farmers. According to a NABARD survey, approximately 30% of all agricultural households had borrowed money from non-institutional sources, which is primarily made up of relatives/ friends or informal moneylenders. As per the survey, farmers with smaller plot sizes took a greater share of loans from the non-institutional lenders than did farmers with larger plot sizes (> 2 hectares) (NABARD, 2018). This indicates that more small and marginal farmers rely on (expensive) informal sources of credit than large ones.

A positive relationship has been found with increased formal credit availability and agriculture GDP growth, primarily through enabling greater input use. The results obtained by the author (Narayanan, 2016) show that a 10% increase in institutional credit flow to agriculture leads to a 2.1% increase in GDP, controlling for inflation. Similarly, Narayanan shows that a 10% increase in institutional credit leads to a 1.7% increase in fertiliser consumption, a 5.1% increase in pesticide consumption and 10.8% increase in tractor purchases. Therefore, through enabling the use of more inputs, credit should lead to an increase in land productivity, at least to a certain point.

2 The latest published data available is for the year 2018-19. Source: 'Land-Use Statistics', published by the Directorate of Economics and Statistics, Ministry of Agriculture & Farmers' Welfare.

Extension

Extension services serve the purpose of bringing best modern practices to the level of the farmer. Extension services are perhaps the most critical link in raising land productivity through industrial agriculture (Gulati et al., 2018). Gulati et al. note that India has one of the largest agricultural research systems in the world, and provide an excellent overview of India's network of agriculture extension. The authors call for expanded investments in agriculture research and education to 1% of agri-GDP from 0.7% of agri-GDP to boost land productivity.

The Committee on Doubling Farmers Income recognised several shortcomings with the existing system of extension. They recognised that extension services have been focusing more on production aspects, whereas the need of farmers had shifted to post-production aspects. Gulati et al. (2018) noted that public extension services are skewed in favour of the crop sector and needed to take a more holistic view of the agriculture sector, including animal husbandry for instance. The Committee on Doubling Farmers Income also questioned whether the current system of extension was able to discourage inefficient farm practices, such as flood irrigation, imbalance in the use of fertilisers and pesticides. They also recognised that extension services were not focused on serving all aspects of the agricultural supply chain. Nor were the targets set for extension agencies outcome oriented.

This short discussion serves the purpose of highlighting the underdeveloped nature of extension services in India. Funding constraints lead to manpower constraints. However, the effectiveness of the existing extension systems has also been questioned by a government committee. Underdeveloped extension services have not only created a yield gap, but also led to the proliferation of inefficient and unsustainable practices, causing major sustainability challenges.

B. ENVIRONMENTAL CHALLENGES

As mentioned, over the years, inefficient practices have come to dominate. Flood irrigation, excessive use of nitrogen (N) over potash (P) and potassium (K), and excessive pesticide use are some examples. Agriculture also contributes to air pollution through emission of greenhouse gases (GHGs). Independent estimates peg this figure to be 19.6% of total GHG emissions (Olivier et al., 2017). Similarly, stubble burning is a significant contributor to the fall in air quality all over North India during winter months. As a result, degrading soil health and declining availability of water are perhaps the critical issues facing farms in India today. As noted earlier, critical to raising productivity is raising the area under irrigation, as it would enable multi-cropping, application of fertilisers etc. This creates a dichotomy under the regime of industrial agriculture. The only way to increase productivity is to increase intensification in inputs, but this increased intensification will lead to environmental degradation, requiring more and more intensification with each cycle.

Soil Health

Degrading soil health is another factor that will affect productivity growing forward. According to the National Academy of Agriculture Sciences (NAAS, 2018), degradation of soil can occur due to four reasons: (i) salinisation/alkanisation; (ii) acidification; (iii) soil toxification through chemicals and (iv) depletion of nutrients and organic matter. Soil organic carbon (SOC) has been cited as an important indicator of soil health, due to its contributions to food production and adaptation to climate change (FAO, 2017). Data from the Soil Health Card (SHC) scheme launched by the Government of India in 2015 indicates prevalence of low SOC content across India.

Figures 7 & 8 plot the status of SOC in the samples tested under the SHC scheme. The samples have been divided into 5 categories to measure the level of SOC. The categories are very low, low, medium, high and very high. The categories have then been colour-coded and plotted, state-wise. Again, there is substantial variation across states. Figure 7 plots the status in cycle 1 of the scheme (2015-16 to 2016-17) and figure 8 plots the status in cycle 2 of the scheme (2017-18 and 2018-19). As it can be seen, in some states, a significant portion of samples tested either very-low or low. This is especially evident in the case of Punjab and Haryana. However, between the two cycles, both states have shown some improvements. Rajasthan & Uttar Pradesh are other major states with low SOC content.

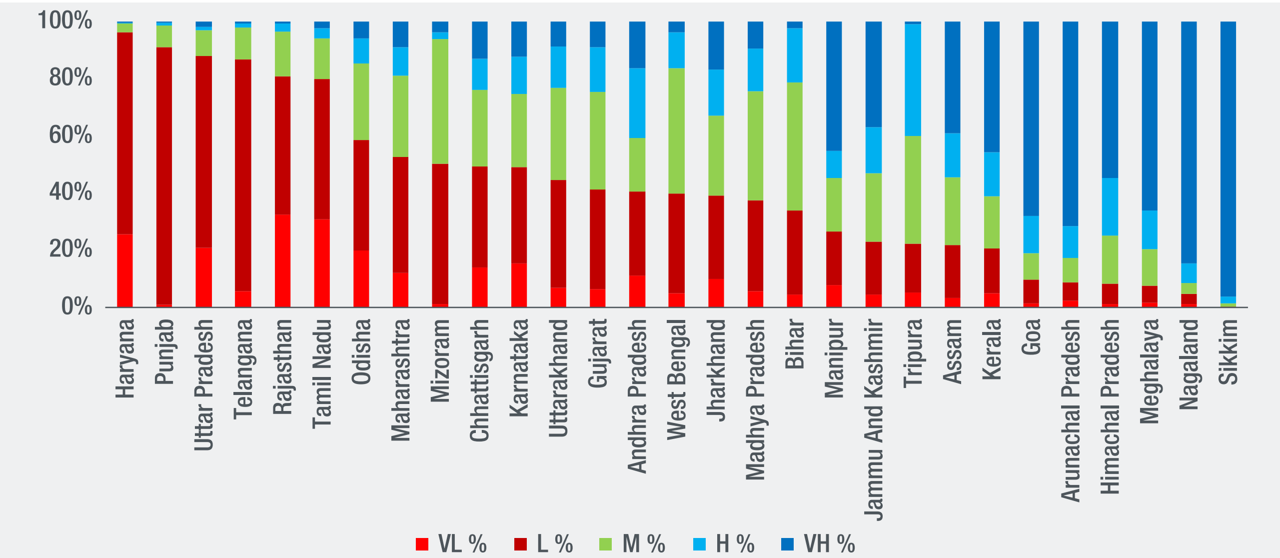


Figure 7: *Soil Organic Carbon Status in Cycle I of SHC Scheme: 2015-17*

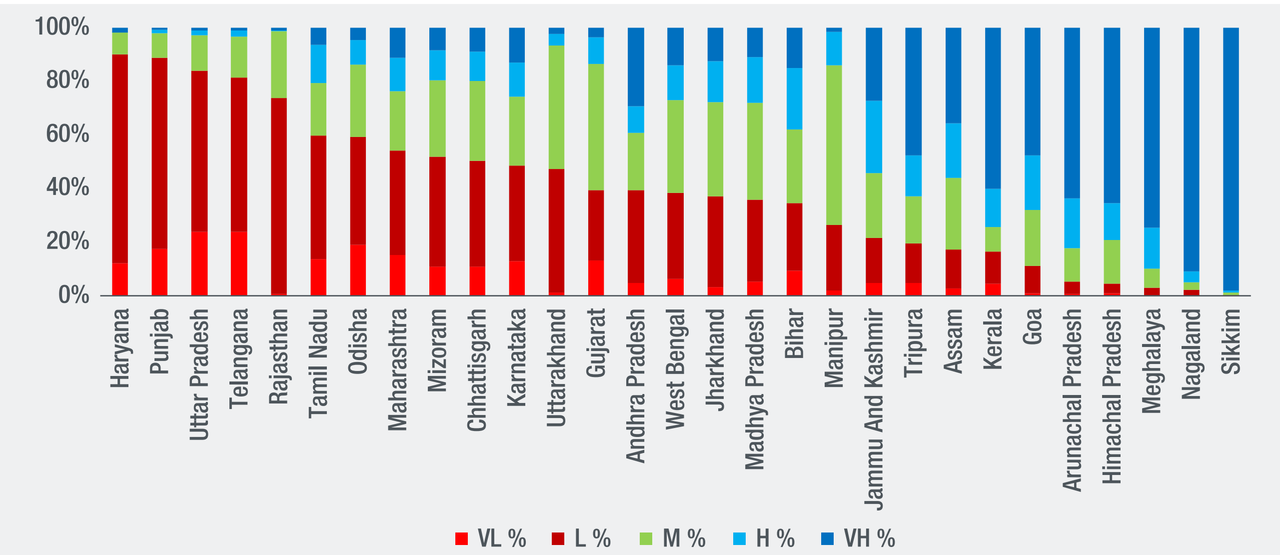


Figure 8: *Soil Organic Carbon Status in Cycle II of SHC Scheme: 2017-19*

Source: *Soil Health Card Portal, Ministry of Agriculture & Farmers Welfare, Government of India*

Note:

The link between imbalanced fertiliser use and soil degradation has been examined by the NAAS (2018). They note that skewed NPK ratios have led to degradation of soil health. Chand and Pavithra (2015) estimated the state-wise requirement of fertilisers. Table 3 notes the prescribed use of fertilisers to increase productivity, against the actual usage. Andhra Pradesh, Bihar, Haryana, Jharkhand & Punjab are applying fertilisers above the prescribed norms. The rest of the states are utilising less fertiliser than prescribed, as per the results of Chand and Pavithra (2015).

The conventional knowledge has been that at a national level, a ratio of 4:2:1 was ideal. However, as noted by Chand and Pavithra (2015), this norm needs to be revisited, especially as a national level norm cannot reflect the heterogeneity across and within states. Table 4 compares the normative ratios against the actual ratios. The imbalance in fertiliser use towards N is evident across all states. On the impact of imbalanced use of fertilisers on soil health, the authors note that where the actual use of fertiliser is below the prescribed use, the impact on soil health of NPK balance will be negligible. It is pertinent to note that the NPK imbalance is the greatest in States with the highest area under irrigation.

In interpreting tables 6 & 7, it must be kept in mind that the norms derived by Chand & Pavithra (2015) were based on the cropping patterns prevalent during 2011-12. Since the cropping patterns may have changed since then, the prescribed norms would have altered as well. It is for this reason the prescribed norms as per the paper are presented against the actual usage and ratios for 2011-12 and 2019-20. Recalculating the prescribed norms of fertiliser usage based on the package of practices published by State Agriculture Universities (SAUs) and the Indian Council of Agriculture Research (ICAR) is beyond the scope of this paper, as such an exercise is a paper in its own right. This remains a future avenue of research, where the normative fertiliser usage is calculated at regular intervals, to aid policymaking.

Yet, a preliminary analysis was undertaken to understand if there has been any major shift in cropping patterns, especially in the large producing states.

Table 3: % of Area under Rice & Wheat: 2011-12 and 2019-20

Rice	% of GCA		Wheat	% of GCA	
	2011-12	2019-20		2011-12	2019-20
Punjab	35.7%	37.2%	Uttar Pradesh	37.5%	35.4%
Haryana	19.1%	22.0%	Madhya Pradesh	21.7%	25.1%
Uttar Pradesh	22.9%	21.4%	Punjab	44.7%	44.7%
West Bengal	58.1%	54.8%	Haryana	38.8%	38.3%
Andhra Pradesh	29.8%	31.4%	Rajasthan	12.0%	12.3%
Odisha	80.6%	85.9%	Bihar	28.0%	30.4%

Table 4: % of Area under Pulses (Gram & Tur) : 2011-12 and 2019-20

Gram	% of GCA		Tur (Arahar)	% of GCA	
	2011-12	2019-20		2011-12	2019-20
Rajasthan	5.8%	9.7%	Karnataka	6.4%	11.4%
Maharashtra	4.8%	12.1%	Maharashtra	5.6%	6.3%
Madhya Pradesh	13.5%	7.4%	Uttar Pradesh	1.2%	1.1%
Karnataka	6.6%	7.7%	Gujarat	1.8%	1.8%
Uttar Pradesh	2.2%	2.3%	Jharkhand	7.7%	12.6%

Source: *Agriculture Statistics at a Glance, Ministry of Agriculture (various issues) & authors' calculations*

Table 5: % of Area under Oilseeds (Groundnut & Soyabean) : 2011-12 and 2019-20

Groundnut	% of GCA	
	2011-12	2019-20
Gujarat	12.9%	14.8%
Rajasthan	1.7%	2.9%
Andhra Pradesh	9.5%	9.0%
Karnataka	5.6%	4.2%
Tamil Nadu	6.6%	6.2%

Soyabean	% of GCA	
	2011-12	2019-20
Madhya Pradesh	25.2%	23.7%
Maharashtra	13.6%	21.1%
Rajasthan	3.7%	4.4%
Karnataka	1.6%	2.4%
Gujarat	0.0%	0.9%

Source: *Agriculture Statistics at a Glance, Ministry of Agriculture (various issues) & authors' calculations*

Tables 3-5 show that there have been some changes in cropping patterns, especially in pulses and oilseeds. Yet, in the case of rice and wheat, there have been no major changes in the areas they cover in the top producing states. This implies that the normative fertiliser usage calculated by Chand & Pavithra (2015) may not necessarily hold true in 2019-20.

Table 6: State-Wise Normative and Actual Use of Fertilisers (Thousand Tonnes)

		Normative Use (2011-12)				Actual Use (2011-12)				Actual Use (2019-20)			
	State	N	P	K	Total	N	P	K	Total	N	P	K	Total
1	Andhra Pradesh*	1,138	679	474	2,291	1,977	1,043	322	3,342	980	490	212	1,683
2	Bihar	688	368	245	1,301	968	297	115	1,380	1.235	423	162	1,821
3	Chhattisgarh	498	298	208	1,005	356	177	62	596	450	226	62	737
4	Goa	114	82	73	270	3	3	2	8	2	1	1	4
5	Gujarat	1,247	450	456	2,153	1,183	417	133	1,733	1,296	382	114	1,792
6	Haryana	807	339	202	1,348	1,021	370	38	1,428	1,070	303	38	1,411
7	Himachal Pradesh	82	43	33	158	33	10	9	51	38	10	10	59
8	Jammu & Kashmir	95	57	29	181	66	29	5	100	51	17	11	79
9	Jharkhand	84	51	42	177	118	42	11	171	132	45	5	182
10	Karnataka	1,043	655	651	2,349	1,216	787	333	2,336	1,018	560	283	1,861
11	Kerala	227	164	349	740	136	66	100	301	79	34	62	175
12	Madhya Pradesh	1,080	1,181	449	2,710	1,062	751	80	1,892	1,673	894	116	2,683
13	Maharashtra	1,745	1,176	654	3,575	1,610	1,012	400	3,022	1,561	898	482	2,941
14	Orissa	313	177	176	666	323	136	56	515	348	151	75	574
15	Punjab	951	375	235	1,561	1,417	449	53	1,918	1,500	363	43	1,906
16	Rajasthan	1,335	742	130	2,206	914	416	26	1,356	1,217	479	21	1,718
17	Tamil Nadu	673	270	298	1,241	685	316	264	1,265	582	234	171	987
18	Telangana	-	-	-	-	-	-	-	-	987	370	122	1,479
19	Uttar Pradesh	3,210	1,436	1,085	5,731	3,067	1,024	166	4,258	3,740	1,227	206	5,173
20	Uttarakhand	114	82	73	270	124	32	10	166	124	31	9	163
21	West Bengal	162	75	51	288	832	477	309	1,617	790	461	349	1,599

Source: *Chand & Pavithra (2015) & Ministry of Agriculture. Totals may not add up due to rounding.*

**Undivided Andhra Pradesh.*

Note: *Figures in thousand tonnes.*

Table 7: Actual vs Normative Fertiliser Use Balance in India: 2019-20

		Normative Ratios (2011-12)			Actual Ratios (2011-12)			Actual Ratios (2019-20)		
	State	**N**	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**
1	Andhra Pradesh	2.4	1.4	1.0	6.1	3.2	1.0	4.6	2.3	1.0
2	Bihar	2.8	1.5	1.0	8.4	2.6	1.0	0.0	2.6	1.0
3	**Chhattisgarh**	**2.4**	**1.4**	**1.0**	**5.7**	**2.9**	**1.0**	**7.3**	**3.6**	**1.0**
4	Goa	1.6	1.1	1.0	1.5	1.5	1.0	2.0	1.0	1.0
5	**Gujarat**	**2.7**	**1.0**	**1.0**	**8.9**	**3.1**	**1.0**	**11.4**	**3.4**	**1.0**
6	**Haryana**	**4.0**	**1.7**	**1.0**	**26.9**	**9.7**	**1.0**	**28.2**	**8.0**	**1.0**
7	Himachal Pradesh	2.5	1.3	1.0	3.7	1.1	1.0	3.8	1.0	1.0
8	Jammu & Kashmir	3.3	2.0	1.0	13.2	5.8	1.0	4.6	1.5	1.0
9	**Jharkhand**	**2.0**	**1.2**	**1.0**	**10.7**	**3.8**	**1.0**	**26.4**	**9.0**	**1.0**
10	Karnataka	1.6	1.0	1.0	3.7	2.4	1.0	3.6	2.0	1.0
11	Kerala	0.7	0.5	1.0	1.4	0.7	1.0	1.3	0.5	1.0
12	**Madhya Pradesh**	**2.4**	**2.6**	**1.0**	**13.3**	**9.4**	**1.0**	**14.4**	**7.7**	**1.0**
13	Maharashtra	2.7	1.8	1.0	4.0	2.5	1.0	3.2	1.9	1.0
14	Odisha	1.8	1.0	1.0	5.8	2.4	1.0	4.6	2.0	1.0
15	**Punjab**	**4.0**	**1.6**	**1.0**	**26.7**	**8.5**	**1.0**	**34.9**	**8.4**	**1.0**
16	**Rajasthan**	**10.3**	**5.7**	**1.0**	**35.2**	**16.0**	**1.0**	**58.0**	**22.8**	**1.0**
17	Tamil Nadu	2.3	0.9	1.0	2.6	1.2	1.0	3.4	1.4	1.0
18	Telangana	-	-	-	-	-	-	8.1	3.0	1.0
19	**Uttar Pradesh**	**3.0**	**1.3**	**1.0**	**18.5**	**6.2**	**1.0**	**18.2**	**6.0**	**1.0**
20	**Uttarakhand**	**1.6**	**1.1**	**1.0**	**12.4**	**3.2**	**1.0**	**13.8**	**3.4**	**1.0**
21	West Bengal	3.2	1.5	1.0	2.7	1.5	1.0	2.3	1.3	1.0

Source: *Chand & Pavithra (2015) for normative use. Ministry of Agriculture for actual use in 2011-12 and 2019-20. Actual ratios for 2011-12 differ from Chand & Pavithra (2015), as updated data on fertiliser consumption was available.*

Note: *Figures refer to the ratios of fertiliser use.*

Table 7 makes clear the lop-sided use of fertilisers, skewed in favour of nitrogen. The imbalance is severe in Punjab, where against a prescribed ratio of 4.05:1.60:1.00, the actual ratio is 35:8:1 in 2019-20. A similar story emerges in Haryana, Uttar Pradesh and Rajasthan. Even in 2011-12, the imbalance was quite evident in these states. Between 2011-12 and 2019-20, the imbalance seems to have been exacerbated. Clearly, there seems to be an impact of this imbalance on soil health. In fact, NAAS (2018) notes that between 1970 and 2008, the amount of fertiliser nutrients required to maintain the same yield increased by 5 times, a clear indicator of poor soil health. This in turn is leading to fertiliser use efficiency declining as well, and in particular nitrogen use efficiency (NUE). The NAAS report notes that without regular application of organic manures and recycling of crop residues, soil health cannot be maintained.

Water Efficiency & Availability

The situation of water availability going forward is perhaps more alarming. Figure 9 shows baseline water stress in India, defined as annual water withdrawals as a percentage of total annual available flow. Higher values indicate greater stress. As it can be seen, large parts of India are threatened with medium baseline ground water stress or above. NITI Aayog's Composite Water Management Index (CWMI) notes that approximately 820 million Indians have a per-capita availability of water of less than 1000 m^3, the official threshold for water scarcity as per the Falkenmark Index. With growing demand, water availability is likely to go down further. The CWMI further states that demand will exceed supply by a factor of 2 by 2030.

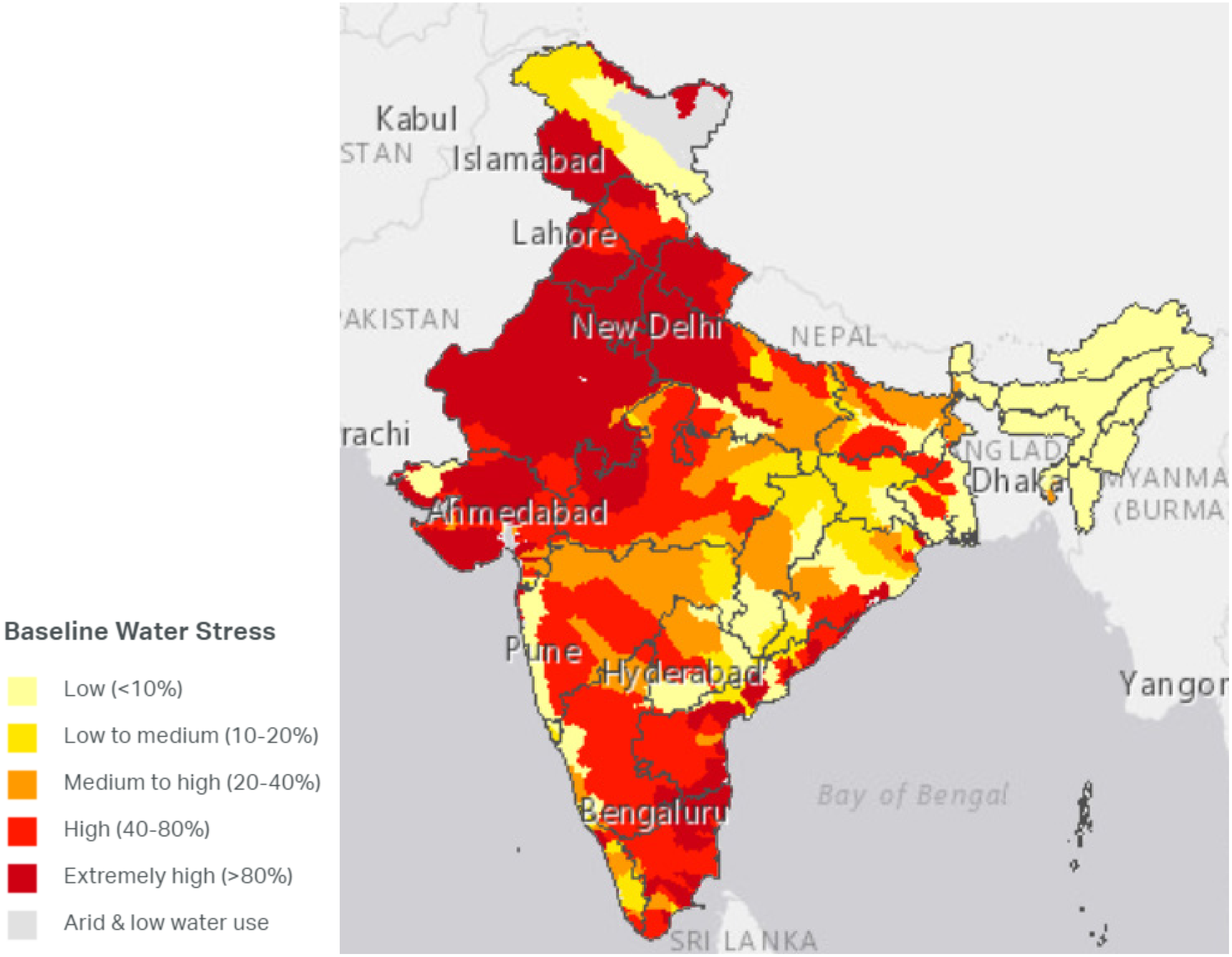


Figure 9: *Baseline Ground Water Stress in India, 2010*

Source: *India Water Tool.*

A large fraction of India's water use is in agriculture. As the table 9 shows, nearly 90% of India's groundwater extraction is in the agriculture sector. States such as Punjab & Haryana, where the area under irrigation is greater than 90%, extract the most water, and are at alarming levels of annual groundwater extraction. Overall, India extracts 61.1% of its annual extractable groundwater resources. With this stage of groundwater extraction and the need to provide adequate water for all uses, domestic, industrial and agriculture, efficiency in water use, particularly in agriculture is critical, going ahead.

Table 8: Share of Agriculture in Annual Groundwater Extraction & Stage of Groundwater Extraction: 2020

	State	Area Under Irrigation (%)	Agriculture Share in Annual Water Extraction (%)	Stage of Groundwater Extraction (%)
1	Andhra Pradesh	49.8	86.5	33.3
2	Bihar	74.2	79.3	51.1
3	Chhattisgarh	35.7	84.7	46.3
4	Goa	22.6	25.0	23.5
5	Gujarat	51.0	95.1	53.4
6	**Haryana**	**91.2**	**90.2**	**134.6**
7	Jharkhand	13.7	56.7	29.1
8	Karnataka	35.0	90.3	64.9
9	Kerala	20.0	43.8	51.7
10	Madhya Pradesh	48.6	91.4	56.8
11	Maharashtra	23.6	91.9	55.0
12	Odisha	29.0	80.2	43.7
13	**Punjab**	**98.5**	**96.9**	**164.4**
14	**Rajasthan**	**43.5**	**86.4**	**150.2**
15	Tamil Nadu	56.1	92.2	82.9
16	Telangana	54.2	89.0	53.3
17	Uttar Pradesh	80.7	89.7	68.8
18	Uttarakhand	52.4	72.4	46.8
19	West Bengal*	65.5	91.6	44.6
	India^	52.0	88.8	61.6

Notes: **The Ground Water resources assessment as of 2013 has been considered for the state of West Bengal. ^ All India figures include North Eastern & Himalayan States & Union Territories.

Source: *Central Ground Water Resources Board*

Irrigation, however, remains inefficient and unsustainable in India. Flood irrigation still forms part of the standard practices, with lower water use efficiency, when compared to micro-irrigation. Compared to other nations, India's water efficiency stands much lower. As it can be seen in table 6, India in comparison to USA & China, with the exception of sugarcane, there is a large gap in India's virtual water use in rice, wheat, soyabean and cottonseed. With food production only needing to expand, improving water use efficiency is imperative.

It is also pertinent to note that public procurement is concentrated in cereals and procured mostly from states such as Punjab & Haryana, where water stress is at its greatest. Whilst a review of public procurement policies is beyond the scope of this paper, it must be pointed out that one of the greatest incentives for farmers in Punjab, Haryana, and Western Uttar Pradesh, amongst others is public procurement of cereals at minimum support prices (MSP). Many states also make provision for free or subsidised power to farmers, enabling them to use borewells to extract groundwater for irrigation. Therefore, any solution must be looked at across the water-energy-agriculture nexus.

Table 9: Virtual Water Use for Crops

Crop	India	US	China
Rice	4,254	1,903	1,972
Wheat	1,654	849	690
Soyabean	4,124	1,869	2,617
Sugarcane	159	103	117
Cottonseed	8,264	2,535	1,419

Source: *National Water Mission, Ministry of Jal Shakti. Note: Units in M3/Tonne.*

With water-use efficiency in mind, the Government of India started promoting micro-irrigation. There have been some improvements as a result of this scheme. As of 2014-15, 8.0% of India's gross irrigated area (GIA) was covered with micro-irrigation. By 2018-19, this number increased to 11.1%, a 3.6 million hectares increase. As always, there exists substantial variance at the state level. Whilst some states, such as Sikkim & Andhra Pradesh are much higher than the national average, other large states lag behind. Uttar Pradesh, with 80.7% of its area under irrigation, has micro irrigation in 0.7% of its irrigated area. A similar story emerges in Punjab as well, where 0.6% of the area is under micro irrigation. The figure 10 illustrates the current substantial variance across states in the adoption of micro irrigation practices. In particular, states where water stress is acute, micro irrigation adoption lags behind.

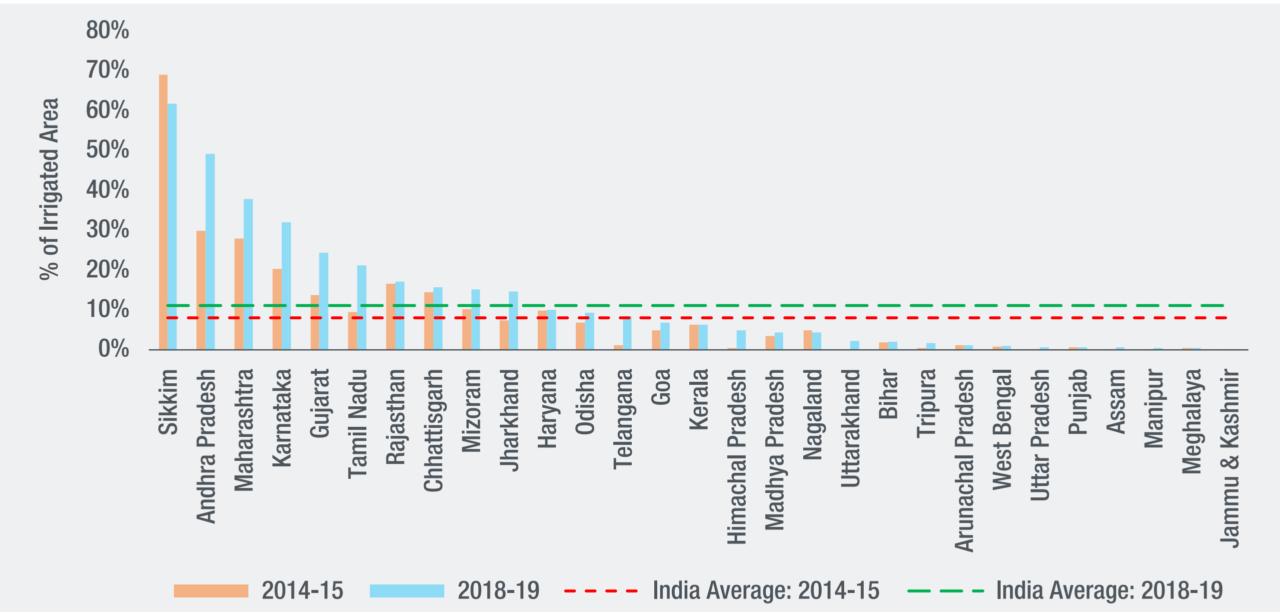


Figure 10: *Share of Micro Irrigation in Gross Irrigated Area: 2014-15 and 2018-19*

Source: *Ministry of Agriculture & Farmers Welfare*

Micro irrigation systems require substantial investments. As mentioned earlier, small, and marginal farmers are particularly constrained when it comes to investing in their farms. This constraint arises from both the demand side and the supply side. Some farmers may be constrained by

a lack of long-term institutional finance. The cost of capital expenditure, vis-à-vis the expected returns, tend to make little economic sense, especially as the benefits of economies of scale do not accrue to small and marginal farmers.

India is facing two interrelated challenges. The first is raising land productivity to continue meeting the demands of a growing population. The second challenge is raising productivity whilst ensuring sustainable and resilient farms. Both challenges are interrelated but at times, seem at odds with each other. Increasing the intensification of industrial agriculture, which has been an ongoing process, and resulted in increased land productivity, has resulted in environmental damage. However, without increasing productivity, India may face food shortages in the future. Therefore, the challenge in front of India and indeed, the rest of the developing world is to increase land and farm labour productivity, whilst maintaining sustainability and building resilience to climate change.

V

IS INDUSTRIAL TRANSFORMATION A POSSIBLE PATH FOR INDIAN AGRICULTURE?

So far, the literature has established that raising both land and labour productivity in agriculture is critical for a country to complete its structural transformation. However, Section IV showed that India faces severe challenges in raising both productivities with inputs of the Green Revolution. Moreover, ensuring sustainability and resilience of farms has emerged as a crucial policy goal in the face of climate change. At times it seems the goals of raising productivity and sustainability are at odds with each other.

Productivity in agriculture can be raised through intensification (higher production per unit of land) and/or motorisation (higher cultivated land per worker). Dorin et. al (2013) formulate a 'Technology, Affluence and Labour Productivity in Agriculture' (TALA) equation to represent this relationship, given below:

$$\frac{Q}{L} \cdot \frac{A}{L_a} = \frac{Q}{L_a}$$

Q = Agricultural Production (MT),

A = Cultivated Area (ha),

L_a = Workforce in Agriculture

Where $\frac{Q}{A}$ = Intensification (MT/ha)

and $\frac{A}{L_a}$ = Motorisation (ha/worker)

According to the TALA equation, and based on the evidence presented in Section III, it is clear that labour productivity in agriculture is being constrained by the net availability of land per worker. As Table 2 shows, the average farm size in India has been on a decline. While intensification has grown, as yields have increased, availability of land seems to be constraining India's labour productivity. Critical to the structural transformation is the share of labour in agriculture, as recognised by Timmer (2009). Dorin et al. (2013), derive two statistics:

$$\text{Labour Income Gap (LIG)} = \left(\frac{Y_a}{Y}\right) - \left(\frac{L_a}{L}\right)$$

$$\text{Labour Income Ratio (LIR)} = \frac{\left(\frac{Y_a}{Y}\right)}{\left(\frac{L_a}{L}\right)}$$

They note that in the structural transformation path envisaged by Timmer (2009), the LIG is initially negative and then tends towards zero. The LIR is initially less than 1 but tends to unity as the process continues. The authors derive two important results. First, the LIR increases only when agricultural labour productivity grows faster than average labour productivity. Second, the number of agricultural workers only decreases when labour productivity grows faster than agricultural output. Based on this analysis, the authors draw not one, but four potential paths to structural transformation.

i. **Farmer Developing Path:** In this path, farm & non-farm incomes converge (LIR → 1), while the number of farmers increases. The authors note that if the source of demand of agricultural commodities comes from foreign markets, then this path may be one of urban poverty.

ii. **Lewis Path:** This is the canonical structural transformation path as envisaged by Timmer (2009), and described later by Dorin (2021) as the path of industrialisation without land constraints. Here, the LIR $\rightarrow$ 1, and number of farmers decreases. This decreasing workforce in agriculture increases land availability per farmer, raising agricultural labour productivity at a faster pace than farm output and non-farm labour productivity.

iii. **Lewis Trap:** Here, farm and non-farm incomes widen and the agricultural workforce increases. Farm labour productivity grows at a slower pace than average labour productivity and farm output. Unless land availability per worker increases, then gains to farm labour productivity will be limited. This is the polar opposite of the Lewis Path.

iv. **Farmer Excluding Path:** Farm and non-farm incomes widen, and number of farmers decreases. There are fewer farmers, poorer than other workers.

Examining the path of several countries, Dorin et al. found that, from the 1960s to 2007, only a few countries, namely OECD countries and transition countries (Russia & Eastern Europe) have followed the Lewis Path of structural transformation. Latin America, the Middle East & Africa have been found to follow the Farmer-Developing Path, whilst Asia has entered a 'Lewis Trap'.

Land constraints emerge as a key determinant of the structural transformation path a country embarks on, according to the results of Dorin et al. (2013). An inverse relationship between farm size and labour productivity has long been claimed in India (Bhalla, 1979). Using measures of land fragmentation and the impact on cost of cultivation, it has been found that once land fragmentation falls below a threshold, mechanisation tends to become more difficult (Deininger et al., 2017). In turn, the inability to mechanise falls on small and marginal farmers. The correlation between larger farm sizes and mechanisation has found further support. Mehta et. al (2014) state that mechanising small plots is against economies of scale, especially for land preparation and harvesting. On the other hand, there is literature that emphasises that small farms are actually more productive per unit of land than their larger counterparts. For instance, it has been contented that small farms have been using higher doses of inputs, making more intensive use of land, and adopting new technology better than large farms (Chand and Srivastava, 2014). However, the authors also note that despite advantages in land productivity and a better production performance, per-capita availability of land constrains their income from agriculture.

From the discussion above, shrinking land availability per worker has been identified as a primary reason for widening gaps in labour productivity between agriculture and non-agriculture sectors of the Indian economy. As earlier sections have shown, there exists considerable heterogeneity amongst Indian States when it comes to agriculture. Therefore, examining the paths to structural transformation that Indian States have taken is important from a policy standpoint. The next section will attempt to place India and large Indian States on the four paths highlighted by Dorin et al. (2013).

Following the methodology of Dorin et al., the trajectory of Indian States on the four paths identified by them have been analysed. Data on gross state domestic product (GSDP) has been sourced from the Ministry of Statistics and Programme Implementation (MoSPI). Since a back-series of GSVA at 2011-12 prices does not exist at the state-level before, a rebasing exercise was undertaken to create a GSVA series for Indian states starting from 1993-94 to 2018-19.

Employment data has been sourced from the National Sample Survey Office (NSSOs) Employment-Unemployment Surveys (EUS) from 1993-94, 1999-00, 2004-05 and 2011-12.

Figures for 2018-19 & 2019-20 have been taken from the successor of the EUS, the Periodic Labour Force Survey (PLFS).[3] Annual estimates of population have been taken from interpolating between various Census periods (1991, 2001 & 2011). Population estimates for States since 2011 have been derived through GSDP data.[4] The worker-population ratio (WPR) estimates from these surveys have then been applied to the population estimates to arrive at estimates of total employment and agriculture employment in absolute terms. Based on these estimates, we are able to compute the variables of interest for Indian States to extend the analysis of Dorin et al (2013). Namely, the variables of interest are the active population in agriculture (on the x axis) and the 'Labour Income Ratio' (LIR, on the y axis)[5] whose annual growth rates are cumulated over the years to show their evolutions since 1993-94 (our starting year here, at the intersection of the x and y axes).

There exist however, some limitations with data, employment, and population in particular. First, there is no official back-series, which gives us GSDP at 2011-12 prices. The rebasing exercise undertaken is a quick workaround. Since we do not have any official annual estimates of population, except for decadal Censuses, the compound annual growth rate (CAGR) has been used to interpolate between Census years for instance. It also may be possible despite falling shares of agriculture in employment, the CAGR in agricultural workers may be positive, owing to population growth during this time. Furthermore, since 1993-94, several new States have been carved out of existing ones, namely: Chhattisgarh, Jharkhand and Uttarakhand (in 2001) and Telangana in 2014. Data for these states has been merged into their original states to give us a continuous series.

The results presented in figure 11 show that since 1993, India continued to sink into the Lewis Trap until 2010, as shown by Dorin et al. (2013) from 1971 to 2007 (with United Nation's annual statistics on India's GVA and employment), then bifurcated towards the Farmer Excluding path, where the active population in agriculture tends to decrease in absolute numbers while its income gap with non-farmers continues to widen. Now in 2019-20, we see India returning on to the path of the Lewis Trap, as the share of those employed in agriculture increased in 2019-20. This is perhaps reflective of the migration back to rural areas of migrant workers, owing to the pandemic induced lockdown in March 2020.

Against this national trend since 1993, table 10 and figure 12 shows heterogeneity amongst states. Most Indian states have remained locked either in the Lewis Trap or the Farmer Excluding path since 1993, moreover after at least three decades of growing agricultural labour force and income gap with non-farmers since 1970 (Dorin et al. 2013).

3 At this point, it is prudent to note that while data on GDP follows the financial year (April-March), the PLFS reports cover the period July-June. Therefore, for the last year of analysis, data of GDP is reflective till March 2020, and employment data till June 2020.

4 GSDP data provides both GSDP and GSDP per capita, allowing us to calculate population.

5 The LIR is defined as the ratio of agriculture's share in GSDP on agriculture's share in employment. In the Lewis Path of structural transformation, this ratio is initially less than 1, but then tends to one. Therefore, the closer to one, the lower the gap.

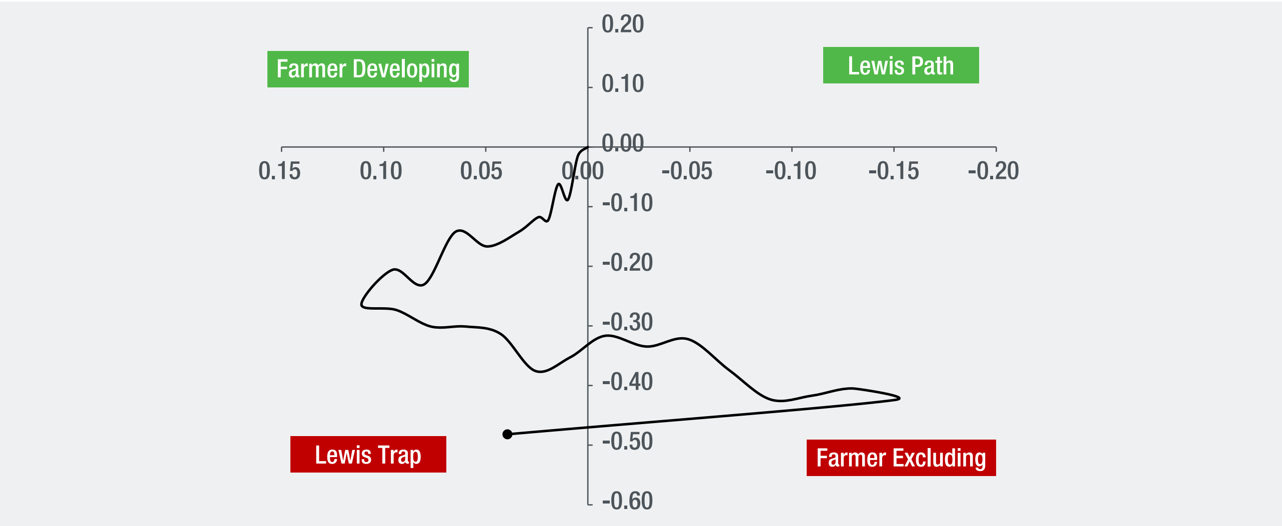


Figure 11: *All-India Path of Structural Transformation: 1993-94 to 2019-20*

Source: *Authors, based on the framework of Dorin et al (2013).*

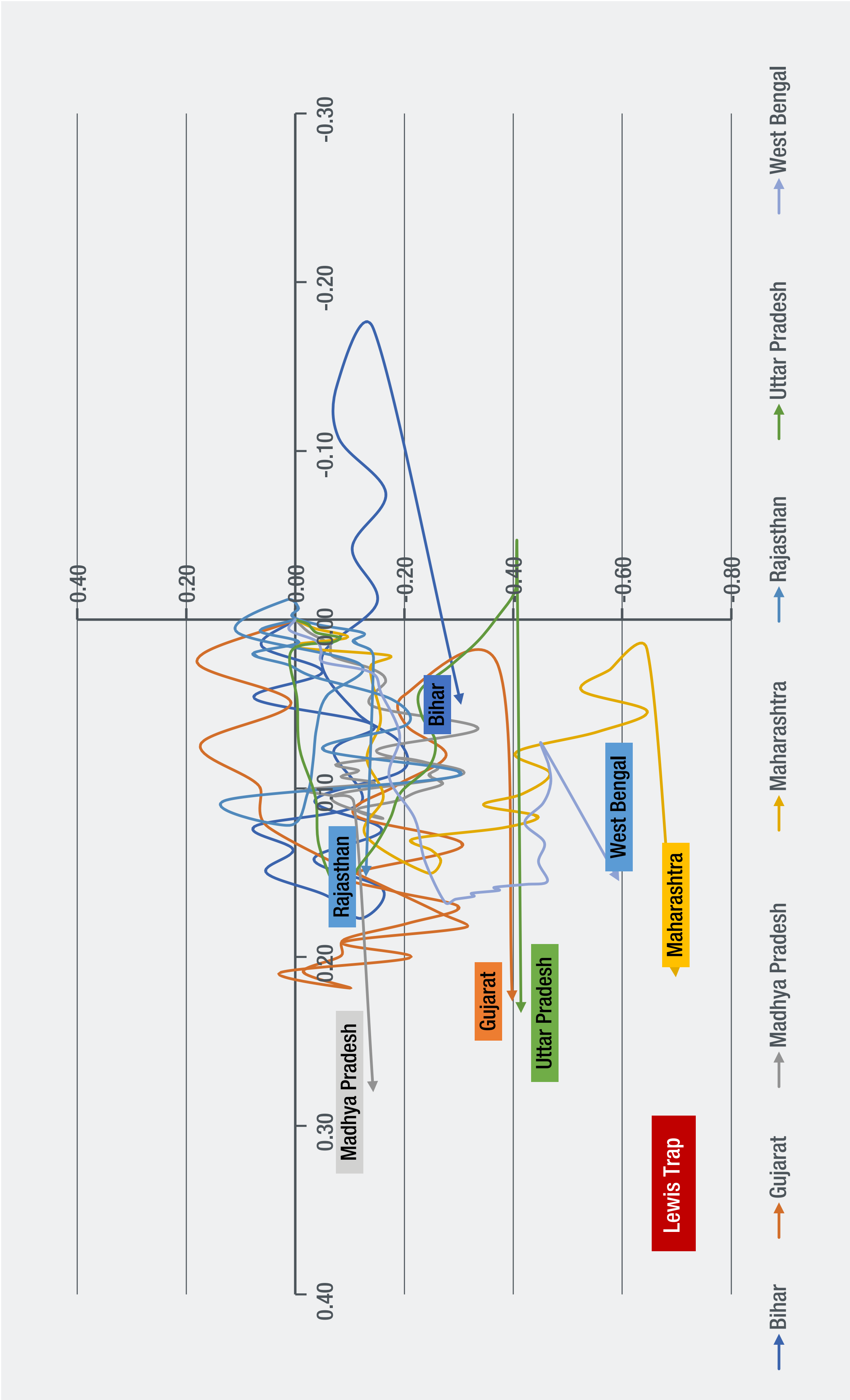
The starting year (1993-94) is represented at the intersection of the x and y axes, and annual growth rates of (i) employed persons in agriculture (x axis) and (ii) farm-nonfarm income gap (LIR, y axis), are summed year after year to show the overall evolution. Since these annual growth rates are equivalent to logarithms, they also represent a speed (the longer the curve, the faster the process). These values (log) can be converted into multipliers or dividers. For instance here, All-India get (–0.15, –0.40) in 2018-19, which means that employment in agriculture has been divided by EXP(0.15) = 1.16 between 1993-94 and 2018-19, and the LIR multiplied by EXP(0.40) = 1.5 during the same period.

Table 10: Structural Paths of Indian States from 1993-94 to 2019-20

Farmer Developing	Lewis Path
1. Manipur (0.02, 0.32) 2. Nagaland (0.67, 0.29)	1. Jammu & Kashmir [Incl. Ladakh] (-0.03, 0.05)
Lewis Trap	**Farmer Excluding**
1. Bihar (0.05, -0.30) 2. Gujarat (0.23, -0.40) 3. Himachal Pradesh (0.08, -0.68) 4. Madhya Pradesh (0.28, -0.14) 5. Maharashtra (0.21, -0.70) 6. Rajasthan (0.15, -0.13) 7. Sikkim (0.57, -0.61) 8. Tripura (0.65, -0.64) 9. Uttar Pradesh (0.23, -0.64) 10. West Bengal (0.16, -0.59)	1. Andhra Pradesh (-0.13,-0.31) 2. Arunachal Pradesh (-0.06, -0.49) 3. Assam (-0.30, -0.19) 4. Goa (-0.02, -0.51) 5. Haryana (-0.23, -0.43) 6. Karnataka (-0.05, -0.68) 7. Kerala (-0.64, -0.98) 8. Meghalaya (-0.01, 0.03) 9. Odisha (-0.16, -0.55) 10. Punjab (-0.34, -0.03) 11. Tamil Nadu (-0.37, -0.39)

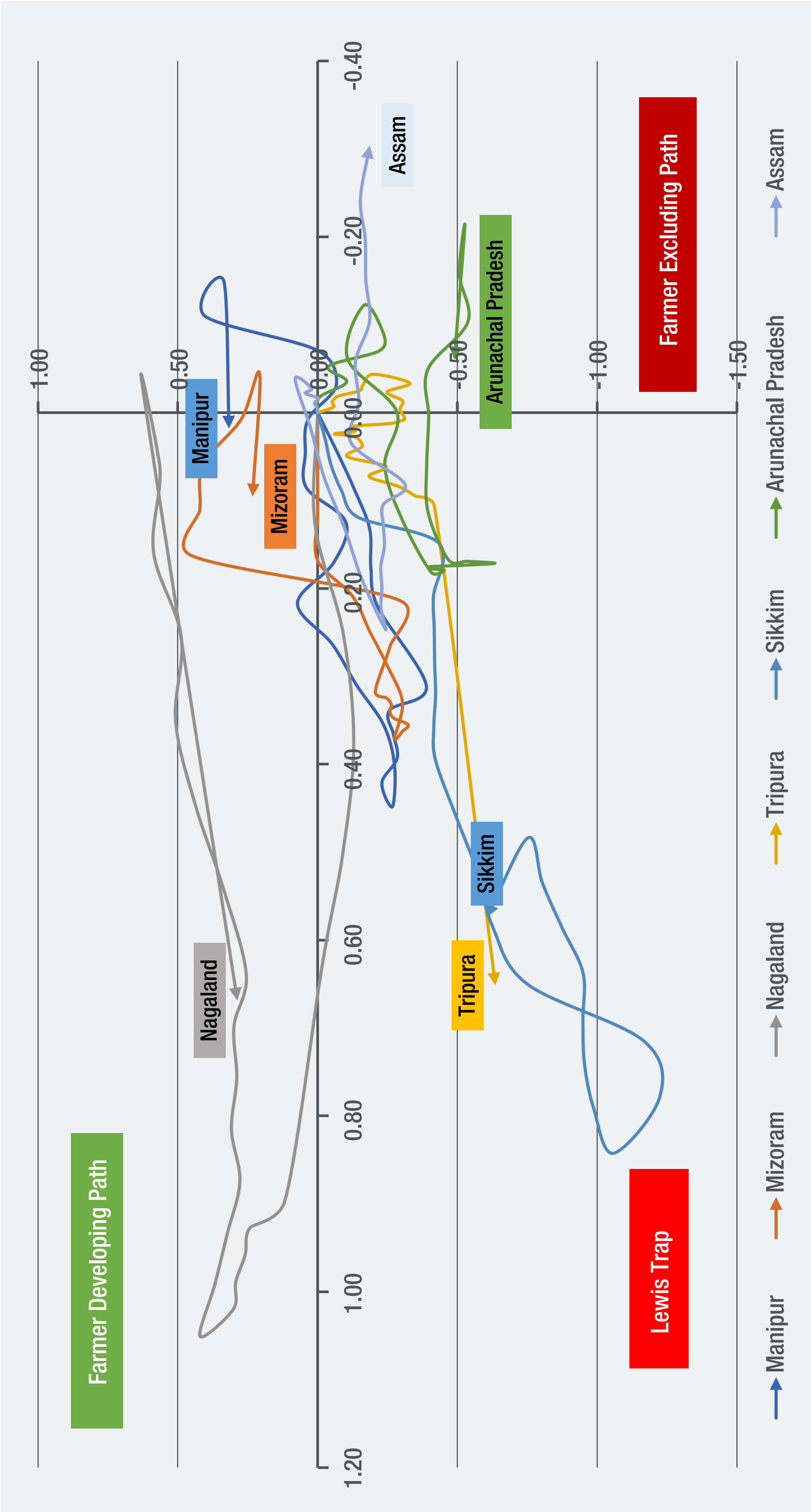
Source: *Authors*

Figures in brackets indicate sums of annual growth rates over the period from 1993-94 to 2019-20, first of employed persons in agriculture, second of farm-nonfarm income gap (LIR). Mizoram has been excluded due to time series starting in 1999 only, as well Indian territories or islands with no or too inconsistent data over the period.



-0.30
-0.20
-0.10
0.00
0.10
0.20
0.30
0.40
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
Bihar
Rajasthan
Madhya Pradesh
Gujarat
Uttar Pradesh
West Bengal
Maharashtra
Lewis Trap

Farmer Excluding Path
Kerala
Tamil Nadu
Punjab
Andhra Pradesh
Haryana
Odisha
Karnataka
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
Andhra Pradesh
Haryana
Karnataka
Kerala
Odisha
Punjab
Tamil Nadu


Farmer Excluding Path
Farmer Developing Path
Lewis Trap
Assam
Arunachal Pradesh
Manipur
Mizoram
Nagaland
Tripura
Sikkim
-0.40
-0.20
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.00
0.50
-0.50
-1.00
-1.50
Manipur
Mizoram
Nagaland
Tripura
Sikkim
Arunachal Pradesh
Assam

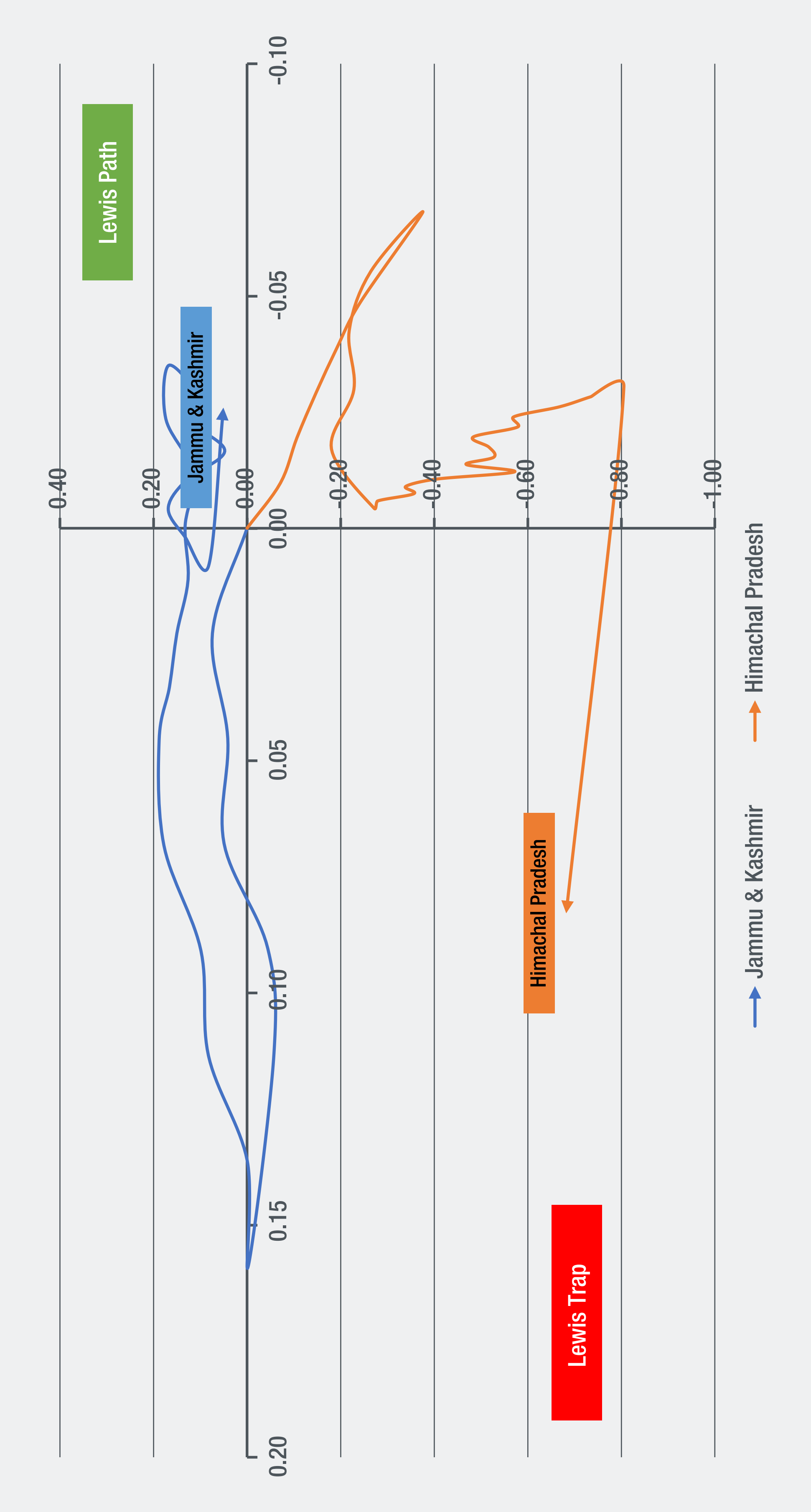


Figure 12: *Path of Structural Transformation of major Indian States: 1993-94 to 2019-20*

Source: *Authors. Only largest Indian states are represented.*

The findings in this section broadly seem to corroborate the findings of Dorin et al (2013). They are also consistent with the discussion in Section III of this paper. For any region to embark on the 'Lewis path', then not only does the active population in agriculture need to decrease, but agricultural productivity growth has to be faster than non-agriculture labour productivity, but also farm output productivity (which can be increased through intensification). Section III and IV showed us that productivity in the non-agricultural sector has grown at a faster pace than agriculture. India has made significant gains in increasing land productivity through intensification, but shrinking land availability, as evidenced through decreasing farm sizes, has meant that India's agriculture labour productivity has grown at a slower pace than non-agriculture labour productivity.

All in all, India does not seem to be on the canonical path to structural transformation. Raising productivity would require intensification of inputs, combined with an increase in per-capita availability of land. India is constrained on both fronts. As Section III showed, the average farm size in India is shrinking and intensification of inputs are causing severe environmental stress, and seem unsustainable, given the impending threat of climate change. Therefore, the policy goals in front of India can seem to be at odds with each other. A trade off emerges between raising productivity and ensuring sustainability. However, an idea that has been gaining traction is that of agroecology. A holistic agroecological approach has the potential to convert these seemingly at odds policy goals to complementary ones. The next section discusses agroecology, the attempts in India to promote natural farming, and offers policy suggestions, drawn from the literature.

VI

AGROECOLOGY AS A POTENTIAL SOLUTION

The canonical structural transformation path has been eluding India. Earlier sections have shown that whilst India has done well in improving land productivity through increasing intensification of industrial inputs, labour productivity remains constrained owing to declining availability of land. Intensification of inputs has also led to severe environmental degradation, calling into question the sustainability of such practices, going ahead. According to the Intergovernmental Panel on Climate Change (IPCC, 2014), we could see crop yield declines of 10-25 per cent by 2050. Therefore, the challenge in front of India is to increase agriculture productivity, whilst ensuring sustainability. The current policy paradigm of focusing on a few crops and crop monocultures, increasing intensity of inputs such as chemical fertilisers and pesticides, unchecked use of flood irrigation, has led to degrading soil health and stressed water availability.

At the same time, there exists a link between agriculture and nutrition. Sustainable Development Goals (SDG2) calls not only for zero hunger, but also to end all forms of malnutrition. India's nutritional outcomes, where 38.4% of children under 5 were stunted, 21.0% wasted and 35.8% under-weight, prompted a new national nutrition mission. The Food, Agriculture and Nutrition (FAN) report of 2020 shows that India's nutritional transition is in contrast to the transition made by other countries as they advance economically (TCI, 2020). The authors note that as a country advances economically, the first stage consists of increasing consumption of vegetables, fruits, and animal products. The second stage then involves increasing consumption of more calorie dense foods. India seems to have skipped to increasing consumption of calorie dense foods such as wheat and rice, aided by public policy since the Green Revolution era, the report notes. The FAN report also notes that agriculture impacts individual nutrition outcomes primarily through improving household food access. This improved access is a result of better incomes and access to diverse foods. SDG2 apart from calling for zero hunger and an end to malnutrition, also calls for a doubling of incomes and productivity of small-scale producers.

Therefore, the need is to usher in a new paradigm in Indian agriculture, one that combines the goals of increasing productivity, sustainability, and access to diverse foods. Dorin et al (2013), lay out the economic fundamentals of this alternative through a simple equation:

$$\theta_a = (pQ - Y^a_{na})/L_a$$

Where θ_a = Farmer Incomes, p = farmgate prices, Q = production,

Y^a_{na} = cost of inputs produced by nonagri sector (fertilisers, pesticides) and

L_a = number of farmers

According to the authors, we need to increase production (Q) and farm incomes (θ), without strongly downsizing the agriculture labour force (L_a) and threatening the environment. The authors note that past R&D efforts have focused on monocultures such as wheat, rice etc, which has substantially increased production, whilst raising input costs at the same time. The environmental effects were discussed in section IV. Based on the equation above, the authors devise the parameters of this alternative system. First, a reduction in industrial inputs (Y^a_{na}). Second, biological synergies between many plant and animal species, both above and below the ground, to boost production (Q) and increase resilience. Third, improved human abilities (L_a) in managing these small-scale and biologically complex synergies. Higher prices (p) to farmers for supply of diversified and nutritious food and for the wider ecological services they provide, (the positive externalities that accrue to the environment). The authors note that these parameters developed are in fact similar to those of agroecology. Overall, small-scale farmers like in India could not only be highly productive per unit of land, but also close their income gap with nonfarmers if diverse, tasty, nutritious and healthy foods are better priced on local and international markets, as well environmental goods or services that are of local or global value but are currently unpaid, such as biodiversity reservoirs, resilience to biotic and abiotic shocks, nutrient recycling, water saving and filtering, or soil carbon storage (Dorin, 2021).

The Report of the High-Level Panel of Experts (HLPE, 2019) on Agroecology notes that agroecology is trans-disciplinary science, which initially focused on understanding field-level farming practices, such as Natural Farming in India. It is increasingly being promoted to transform existing food systems into sustainable food systems (SFS), through regenerative use of natural resources in agriculture. While there is no definitive set of practices, there exist three characteristics which can be identified as agroecological: (i) reliance on ecological processes rather than purchased inputs; (ii) equitable, environmentally friendly, locally adapted and controlled and (iii) they adopt a systems approach. The HLPE has also set out 13 agroecological principles related to: soil health; animal health and welfare; biodiversity; synergy (managing interactions); economic diversification; co-creation of knowledge (embracing local knowledge and global science); social values and diets; fairness; connectivity; land and natural resource governance; and participation.

Various approaches can be encompassed under agroecology. At this point, a comparison between industrial agriculture and agroecology would be prudent. The excellent work of Frison (2016), provides a comparison, recreated in Figure 13. The differences in the two approaches are clear through this figure. The intentional inclusion of functional biodiversity at multiple spatial and temporal scales, through either traditional practices or scientifically developed ones is a distinguishing feature of agroecology (Kremen and Bacon, 2016). The authors note that whilst diversified farm systems share much in common with multifunctional, organic, and sustainable farming, it differs from these concepts in a subtle way. The critical differentiator, according to the authors is that the design of farming systems, to support functional biodiversity ensure that the critical inputs required by agriculture are supplied.

Most authors on agroecology emphasise the socio-economic facets of switching to agroecological systems. The first impact is that on farm incomes, through reduced input costs (Frison 2016; Kremen et al., 2012). Diversification also protects farmer incomes through reducing the risks associated with variable yields. Since organic products command a premium in markets, owing to their associated health benefits, farmer incomes increase owing to higher prices received as well. Given that agroecological systems are more labour intensive, there exist significant employment opportunities, especially in on-farm processing and direct marketing channels.

INDUSTRIAL AGRICULTURE	AGROECOLOGY
• Crop Monocultures, or select crops at farm/landscape level. Concentrated animal feeding operations	• Temporal Diversification (crop diversification) & Spatial Diversification (intercropping, mixed farming). Diversification at the farm and landscape level
• Use of genetically uniform varieties	• Less uniform, but locally adapted varities/breeds
• Vertical and horizontal segregation of product chains	• Integrated production types (mixed crop-livestock-tree farming system)
• Mechanised, labour saving systems	• Labour intensive systems
• Maximisation of yield from a single, or limited number of products	• Maximisation of multiple outputs
• Intensive use of external inputs	• Low external inputs; circular economy approach
• Long value chains: homogenous products	• Shorter value chains: less homogenous products

Figure 13: *Industrial Agriculture vs Agroecological Approaches*

Source: *Frison, E. A. (2016). From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems.*

Given the impact on the Covid-19 pandemic, agroecology has also been put forward as a solution, as it has been asserted that local food systems can better withstand disruptions in supply chains. Altieri & Nicholls (2020) assert that there are five main areas through which agroecology can point a new way for agriculture: reduced reliance on pesticides, enriching biodiversity, revitalising small farms, creating alternative animal production systems and enhancing urban agriculture.

This agroecological approach can be seen in many parts of India. Since 2019, Natural Farming in India is being promoted nationally as the *Bharatiya Prakritik Krishi Paddhati* (BPKP) Programme. This programme seeks to promote 'agroecology based diversified farming system which integrates crops, trees and livestock with functional biodiversity, reducing a reliance on externally purchased inputs.' The system is largely based on on-farm biomass recycling, stressing biomass mulching, use of on-farm cow dung-urine formulation and soil aeration. Clearly, this is in line with the characteristics of agroecological approaches discussed earlier. According to a NITI Aayog, roughly 2.5 million farmers across India are already practicing agroecological approaches. Over the next five years, an additional 2 million hectares are to be brough under Natural Farming.

The State of Andhra Pradesh is taking the lead in India in popularising Natural Farming. Starting from approximately 40,000 farmers and 704 villages in 2016-17, over 695,000 farmers across 3011 villages were practicing natural farming in 2019-20. Third party evaluations have shown improvement in yields (most significantly in paddy, bengal gram, pulses and chillies) and farm net income (Galab et al., 2020) and (Kumar et al., 2020). It was also shown that significant cost savings can be made by governments themselves through reductions in costly fertiliser and electricity subsidies (e.g.: Gupta et al., 2020). In turn, the reduced energy subsidy burden on agriculture could be utilised in the domestic and industrial sector, improving access and service there. Himachal Pradesh is another state that has been leading the efforts in switching to sustainable farming systems. Over 77,106 farmers have been trained in natural farming practices, covering 12 districts of the state. Lower disease incidence in apple and wheat have been recorded. Productivity of apples (a major produce in Himachal Pradesh) was seen to have improved under Natural Farming, when compared to prevalent practices.

The benefits of agroecological approaches to farming such as natural farming, in terms of reduced input costs and no discernible impact on yields, as indicated by Galab et al. (2020) & Kumar et al. (2020) point towards a net increase in income for farmers, compared to prevalent practices. The next section discusses some possible directions for policy analysis to evaluate and then popularize agroecological practices in India.

VII

POLICY IMPLICATIONS

Based on the discussions in this paper, a broad set of policy directions can be distilled to provide direction for further academic research to fine tune the policy recommendations. At the outset it must be recognised that any paradigm shift is likely to cut across various functional areas. Furthermore, these implications represent the starting area for policy deliberations, not the final policy recommendations themselves. Overall, the implications for policy have been designed on the basis of the goals of both increasing productivity and ensuring sustainability.

1. FROM FOOD TO FOOD SYSTEMS

India has focused on improving access to cereals and achieved significant results. In the quest to double farmers income, diversification of farm incomes has been cited as an important strategy. With intercropping and multi-cropping at its core, natural farming could scientifically contribute to the solution. There are also calls to diversify the diets provided by the National Food Security Act and the Mid-Day Meal Scheme (TCI, 2020). India's experience is testament to the fact that public procurement can incentivise production of certain crops. Public procurement in the initial years can provide as an incentive towards diversification of farm produce. Preference to procurement from Natural Farming practising farmer organisations can be an incentive to popularise natural farming.

2. OVERHAUL OF INCENTIVES AND SUBSIDIES

As per the Union Budget 2020-21, Rs. 79,998 crores were spent on fertiliser subsidies by the Union Government in 2019-20. In comparison, the entire budget for the Department of Agriculture Research & Education (DARE) stood at approximately Rs. 7,500 crores in 2019-20. Similarly, the total transfers to States for agriculture extension services stood at Rs. 940 crores. Many state governments also provide power subsidies to farmers, making the input subsidy bill even bigger in reality. The transfer to states as part of the *Paramparagat Krishi Vikas Yojana (PKVY)*, was Rs. 300 crores in 2019-20. Therefore, funding for Natural Farming will have to be scaled up substantially. To give a larger push to agroecology, PKVY can be reoriented as a Central Sector Scheme, with funding scaling up as the area under Natural Farming increases. Promoting natural farming will reduce the reliance on inputs and hence the large subsidy bill for fertilisers, electricity, water and credit. This cost saving can then be translated to higher allocations under PKVY.

3. NEW MONITORING AND EVALUATION FRAMEWORK

A set of indicators, with clearly defined inputs, outputs and expected outcomes needs to be developed (Frison, 2016) to measure the performance of states. Funding allocation to the scaled up PKVY can be linked to the performance of states on this set of indicators. Third party validation of data should also be promoted, in partnership with either the private sector or the civil society. This will ensure robustness and transparency of data on the portal. These indicators are in turn bound to be in synergy with the sustainable development goals as well. Development of the initial framework could perhaps be undertaken by the Development Monitoring and Evaluation Office (DMEO), NITI Aayog. The framework can then be finalised in consultation with the relevant ministries and state governments.

4. DOCUMENTATION OF NATURAL FARMING PRACTICES IN INDIA

As mentioned earlier, agroecological approaches are highly context specific. Therefore, there is no one system of Natural Farming that can be propagated all across India. The need of the hour is to document and widely disseminate these practices, based on local conditions. At the same time, there is a need to develop some overarching principles, as the FAO HLPE Report has. Identification of these principles will also aid in the certification process, which is critical in commanding higher prices in terminal markets. Standards also need to de developed to grade and assay produce from natural farming.

5. FARMER HANDHOLDING

Since Natural Farming is a knowledge-intensive system, co-training and co-educating farmers on the benefits of agroecological approaches remains the key challenge. The success of Andhra Pradesh in popularising Natural Farming was in part due to long-term handholding of farmers. Government support and advocacy was critical as well. Therefore, increasing extension budgets, and reorienting extension services to promote Natural Farming is the need of the hour. The central government can take the lead in this aspect, through making PKVY a Central Sector Scheme to develop extension systems to popularise Natural Farming a cornerstone of the efforts. The role of farmer producer organisations (FPOs), self-help groups (SHGs) will be critical in these efforts as well.

6. PARTNERSHIPS WITH THE CIVIL SOCIETY AND PRIVATE SECTOR

Partnering with the Civil Society would help in reaching farmers for training and capacity building. These partnerships could also result in enabling a robust monitoring and evaluation framework as well. The private sector can have a role to play here as well. Whilst India lags behind in food processing, a large part of industrial agriculture products feed the food processing industry. The requirements of such industries are therefore based on the prevalent system of production. Partnering with the private sector, to develop processable varieties that can be used as inputs in the food processing industry, keeping in mind the principles of natural farming is another area to explore. Processed products based on organic inputs sell at substantial premiums.

7. COLLECTIVISATION OF FARMERS

Another way to reach a large group of farmers can be through collectivising them into producer organisations or cooperatives. The Government of India is already pushing for the creation of farmer collectives at a large scale. This push can be effectively leveraged to popularise Natural Farming. The Andhra Pradesh model showed that women organised through self-help groups (SHGs) enabled collective action and peer learning. These farmer collectives can then be connected to terminal markets, or partners in the food processing industry, as described above. This will boost their bargaining power.

8. TRANSFER PAYMENTS FOR ECOLOGICAL SERVICES RENDERED

As stated by Dorin et al. (2013, 2021), for agroecology to be popularised, farmers need to be compensated not just for their produce, but also the ecological services they render. India already has a mechanism to directly deliver cash to farmers' bank accounts. This system can be leveraged to transfer benefits directly to farmers for the ecological services they render. At present, there exists no such system where direct payments are being made to farmers for the ecological services they render.

While there have been some experiments, they usually exist in a single domain, eg. water management or are limited in scale. For instance, in the PES schemes reviewed by Drucker & Ramirez (2020), payments were made for biodiversity conservation, and limited to a single crop. Similarly, Von Thaden et al. (2021), explore the effectiveness on payments for hydrological services in Velacruz, Mexico. Jayachandran et. al (2017) explore the effectiveness of PES to conserve forests on private land in Uganda. While they find the payments reduced deforestation and degradation, such payments have not yet been demonstrated at scale. In the Indian context, a case has been made by Devi et al. (2021). Venkatachalam & Balooni (2018) also make a case for PES for participatory water management in Tamil Nadu.

In terms of measuring and valuing ecosystem services, the United Nations Statistical Commission (UNSC) in March 2021 adopted the System of Environmental Economic Accounting – Ecosystem Accounting (SEEA-EA) framework. In India, preliminary work on environmental accounting has been initiated by the Ministry of Statistics & Programme Implementation (MoSPI), under the Natural Capital Accounting & Valuation of Ecosystem Services (NCAVES) project. The first report was published in January 2021.

Based on the literature and the data available, moving towards PES in agriculture in India still remains some time away. However, it may be prudent to explore the contours of such a system, such as acceptable indicators, data required, payment level (farmer, by farm etc.). For instance, if payments are made by practice (eg. natural farming), then mechanisms of valuing these services still need to be evolved. Since the work still at a nascent stage, both in terms of global practices and data available, ideating on such a system will be an exercise that involves economists, statisticians, ecologists, policymakers, and other stakeholders.

9. INVESTMENTS IN THE COLD CHAIN

Regardless of the way it is produced, post-harvest management is critical as well. Annual wastage in excess of Rs. 90,000 crores have been estimated as a result of inefficient post-harvest management. Development of infrastructure at the farmgate, pre-processing facilities which are then linked to packhouses and cold storages, is critical in linking farmers to terminal markets, be they retail or exports. Despite claims that agroecological systems exhibit shorter value chains and produce is distributed locally, there still exists a requirement of an end-to-end cold chain to connect farmers to terminal markets. The Government of India has recently launched a Rs. 1 lakh crore Agriculture Infrastructure Fund, for development of infrastructure close to the farmgate, which can be leveraged by producer organisations.

10. LEVERAGING FRONTIER TECHNOLOGIES

The rising demand for organic products and the premiums paid for them are cited as a major reason for a shift towards organic or Natural Farming. However, without traceability and certification, this market cannot be served by most of India's farmers. A nationwide blockchain for quality certification and traceability may help solve this problem if such a blockchain does not consume too much fossil energy. This is another avenue for partnerships with the civil society and private sector. The Participatory Guarantee Scheme (PGS) for certification could be leveraged here. This is just one example of the potential frontier technologies carry. Further research and collaborations are needed to examine the use of such technologies in the popularisation of Natural Farming in India.

VIII

CONCLUSION

Conclusion

This paper has shown that the path of structural transformation India has taken is unsustainable. Land constraints are hampering India's agriculture labour productivity growth rates, leading to widening income gaps and greater inequality. Intensification of inputs has seen yields in India grow manifold over the past decades, allowing India to achieve cereal security and maintain sufficient buffer stocks for time of need. However, the intensification of inputs has led to severe environmental challenges. This creates a trade-off between the goals of increasing productivity and enhancing sustainability and resilience. In order to ensure the long-term health of India's agriculture sector and indeed, the economy, a new paradigm for agriculture in India has been mooted in this paper.

This new paradigm would embrace the principles of agroecology. While there is no definitive set of practices, there exist three characteristics which can be identified as agroecological: (i) reliance on ecological processes rather than purchased inputs; (ii) equitable, environmentally friendly, locally adapted and controlled and (iii) they adopt a systems approach. This agroecological approach can be seen in many parts of India. Natural farming in India is being promoted as the *Bharatiya Prakritik Krishi Paddhati* (BPKP) Programme. This programme seeks to promote agroecology based diversified farming system which integrates crops, trees and livestock with functional biodiversity and reducing a reliance on externally purchased inputs. The system is largely based on on-farm biomass recycling, stressing biomass mulching, use of on-farm cow dung-urine formulation and soil aeration. Clearly, this is in line with the characteristics of agroecological approaches discussed earlier. The need of the hour is to scale up such initiatives across India.

Agroecology carries with it the potential to convert this apparent trade-off in policy goals to mutually compatible goals. For this policy action will be critical. Extension services will need to be revamped, subsidies and incentives will need to be overhauled. A new monitoring and evaluation mechanism will be needed to track outcomes, defined in terms of both sustainability and productivity. Natural farming practices across India will need to be documented, verified and spread to the farm level using revamped extension services. Partnerships with both the civil society and private sector will be critical in spreading Natural Farming across India. In order to make natural farming more remunerative for small and marginal farmers, transfer payments for ecological services provided by farmers can be considered. However, certification will be critical in this endeavour. This relates to the goal of documentation and verification of practices as natural, as a set of practices must be identified prior to labelling a farm as natural. Public procurement may have an important role to play in demand generation, especially in the initial years.

At the same time, some existing policy thrusts must continue. Collectivisation of farmers through producer organisations is one thrust. Financial inclusion another. Investments across the cold-chain remain critical in connecting farmers to terminal markets, be they natural farmers or 'modern' ones. More research is needed in distilling actionable policy recommendations for a complete paradigm shift as mooted by this paper. The policy implications derived in this paper can serve as a starting point for policy deliberations.

This paper has established that not only is India's structural transformation incomplete, but it is on an unsustainable path. A paradigm shift is needed in India shifting towards agroecological principles. This would require a move away from the input intensification based agriculture in India today. It would also need a recognition that farm sizes in India are unlikely to get bigger, unless there is strong political will towards land consolidation. Rather than seeing our small landholdings as a weakness, policymakers must seek to leverage this into an opportunity, especially as small farms have been shown to be more productive and receptive to change. However, this shift must ensure protection of farmers' incomes, along with long-term handholding, to ensure the long-term health of India's agriculture sector as well as the economy.

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A NEW PARADIGM FOR

INDIAN AGRICULTURE

FROM AGROINDUSTRY TO AGROECOLOGY

The importance of agriculture in an economy usually declines as it climbs the development ladder. Raising agriculture productivity has been known to be an important precursor. Labour productivity in agriculture can either be increased by higher land productivity or higher land availability per farmer and mechanisation. In India, however, the dramatic increase in land productivity through industrial farming has caused severe environmental damage and did not boost agricultural labour productivity. Going ahead, India faces the challenges of both increasing farm productivity and increasing sustainability and resilience to climate change. These policy goals have the potential of creating a trade-off for policymakers. By showing that India's path of structural transformation is unsustainable, this paper calls for a new paradigm in Indian agriculture through the adoption of agro-ecological principles at scale.

Neelam Patel, Bruno Dorin & Ranveer Nagaich

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