AFRICA & INDIA

comparing countries' and states' economic and agrifood system developments and lessons for public policy

Editors
Joachim von Braun | Ashok Gulati

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ACADEMIC FOUNDATION
INDIA
www.academicfoundation.org

First published in 2025
by

AF PRESS
Plot No. 35, Sector 7,
IMT Manesar, Gurugram - 122050, India.

Tel: +91-124-4215070 / 71.
E-mail: booksaf@gmail.com
www.academicfoundation.org

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Africa and India – comparing countries' and states' economic and agrifood system developments and lessons for public policy

by Joachim von Braun and Ashok Gulati

ISBN 9789332706828 - Hardcover print edition
ISBN 9789332706873 - Kindle edition

Typeset, printed and bound at AF Press, Manesar, Gurugram, India.

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Foreword

Aggregate comparisons of agriculture between India and Africa are not meaningful due to substantial differences in natural resource endowments, production potential, agro-climatic zones, farming systems, agriculture's contribution to GDP, and the workforce share employed in agriculture. Similarly, comparing case studies in Africa and India are not providing a systematic picture of opportunities and constraints.

Instead, this book adopts a unique approach, using African countries and Indian states as units of analysis, matched based on various indicators, to draw actionable lessons for both regions. Interestingly, the quantitative assessments highlight that on some key indicators some Indian States are ahead, and on some indicators some African countries are ahead of Indian States.

By comparing the two regions in such disaggregated ways at state and national levels, it highlights critical lessons for boosting agricultural productivity, enhancing food security, and addressing malnutrition, fostering mutual South-South learning.

This book provides new insights into the patterns of structural change in Africa and India, examining the drivers of agricultural growth, the nutrition outcomes of structural transformation, and the role of public spending in shaping these dynamics.

Agriculture plays a vital role in driving economic growth, reducing poverty, and addressing food insecurity, particularly in rural areas where most of the poor reside. It outperforms other sectors in poverty reduction by creating jobs, raising wages, and boosting rural incomes, while also enhancing food availability and strengthening economies.

India and Africa have made significant progress in transforming agriculture. India, once food-insecure, is now the world's largest rice exporter and a leading producer of pulses, milk, jute, and cotton, thanks to the Green Revolution, which introduced high-yield crops, fertilizers, and modern irrigation. From 2000 to 2023, agriculture grew at 3.3% annually, lifting millions out of poverty. Africa's agricultural sector grew at 4.5% annually from 2000 to 2019, supported by initiatives like the Comprehensive Africa Agriculture Development Programme (CAADP).

Despite progress, India and Africa continue to face significant challenges with hunger, malnutrition, and poverty. In India, while the Green Revolution transformed agriculture, rural poverty persists, and child malnutrition remains high, with 32% of children under five stunted in 2022. In Africa, agricultural growth relies more on expanding farmland than improving productivity, hindered by limited access to modern inputs, weak infrastructure, and insufficient policy support.

Both regions face environmental and economic pressures, including climate change, pest outbreaks, and COVID-19 disruptions, threatening food security. Together, India and Africa account for two-thirds of the global undernourished population.

The book offers realistic recommendations for policies and investments to ensure agricultural growth effectively contributes to food and nutrition security in India and Africa. Investments in the development and scaling of locally relevant innovations will be key to sustainable intensification and value-addition in the agriculture sectors, including investments in irrigation, digitalization, climate-smart agriculture and value chain development. By supporting agricultural diversification into livestock and high-value crops which will empower smallholder farmers, improve nutrition and expand value chains. And by a balanced approach to public spending to ensure critical agricultural investments are not sacrificed for short-term social protection programs, as these investments are vital for long-term growth, poverty reduction, and improved food security and nutrition.

There is no question however, that India's ability to move vision and policies as one country provides a huge advantage and has implication for scale, trade and overall impact of programs that target rural poor and overall economic performance. It will be interesting to see how emerging global dynamics including Climate Change, the need to transform Food Systems, the opportunity for AI and global geopolitics and trade wars draw the two regions closer together or further apart. Each situation has major challenges, important transitions that must be thought through and great opportunities for positioning towards the future. The next generation will have a chance to be the judge but today; we do have an opportunity to learn, innovate, use the late comers' advantage, jump on the band wagon etc. Whatever the case maybe; what we can no longer afford, is to get lost or stuck in the complexity- as you will see throughout this book, there are enough lessons to help us shape a future in which most of our challenges are harnessed for different policies, new direction and new types of investments.

Dr. Agnes Kalibata

Former minister of agriculture and animal resources of Rwanda, past President of the Alliance for a Green Revolution in Africa (AGRA), and Special Envoy of the UN Secretary-General for the 2021 UN Food Systems Summit.

Acknowledgements

This study was jointly implemented by the Center for Development Research (ZEF), the Indian Council for Research on International Economic Relations (ICRIER) and their African partners in the context of the "Program of Accompanying Research for Agricultural Innovation" (PARI) and the Project, "Analysis and Implementation of Measures to Reduce Price Volatility in National and International Markets for improved Food Security in Developing Countries (Volatility)". We gratefully acknowledge the financial support provided by the Federal German Ministry for Economic Cooperation and Development (BMZ). We thank Gargi Dangwal, Khadeja Akter Konok and Patrick Shortall for their research and editorial support.

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Joachim von Braun and Ashok Gulati

Introduction and Overview

Agriculture plays a pivotal role in driving economic growth, reducing poverty, and addressing food and nutrition insecurity, particularly in rural areas where the majority of the poor reside. Empirical evidence highlights agriculture's superior impact on poverty reduction compared to other sectors, as it creates strong multiplier effects through increased labour demand, higher wages, and expanded rural incomes (Christiaensen et al., 2011; Klasen and Reimers, 2017). These effects enable households to consume more diverse diets, improving nutrition and overall well-being. Furthermore, agricultural growth directly enhances food availability while indirectly fostering economic linkages that benefit rural economies.

Despite significant global progress in reducing poverty and hunger, rural areas in regions such as Sub-Saharan Africa and South Asia continue to experience disproportionately high levels of undernutrition and poverty. For these regions, improving agricultural productivity is not only essential for food security but also represents a cornerstone for broader socio-economic development and poverty alleviation. This underscores the critical need for investments in agricultural research, infrastructure, and extension services to unlock the sector's transformative potential for growth and nutrition.

India and Africa have made significant strides in transforming their agricultural sectors. India has evolved from a food-insecure nation at independence to the world's largest rice exporter and a top producer of pulses, milk, jute, and cotton. The Green Revolution of the 1960s played a pivotal role, boosting wheat and rice production through high-yielding varieties, fertilisers, and modern irrigation techniques. As a result, agricultural growth averaged 3.3 per cent per year from 2000 to 2023, lifting millions out of poverty and turning India into a net food exporter. Agricultural development in Africa has shown promising progress, with the sector growing at 4.5 per cent annually from 2000 to 2019. Efforts like the Comprehensive Africa Agriculture Development Programme (CAADP) reflect increased policy focus.

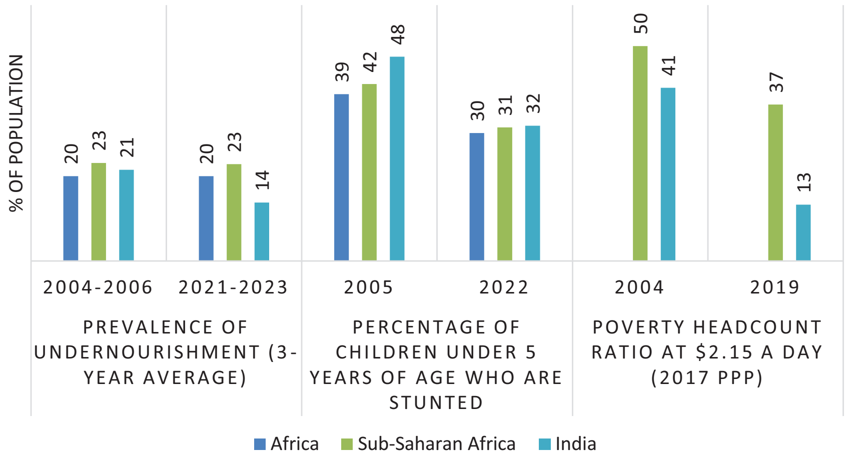
Despite significant progress, both India and Africa face persistent challenges, leading to high levels of hunger, malnutrition and poverty (Figure 1.1). In India, while the Green Revolution transformed the country into a global agricultural powerhouse, a large share of its workforce remains trapped in low-productivity farming, with rural poverty and high rates of child malnutrition still prevalent—32 per cent of children under five were stunted in 2022. In Africa, agricultural growth has been driven more by expanding farmland than by productivity improvements due to limited access to modern inputs, weak infrastructure, and inadequate policy support. Many African countries continue to depend heavily on food imports, and efforts like the CAADP have yet to fully meet investment targets. Additionally, both regions face environmental and economic pressures, including climate-induced droughts, pest infestations, and disruptions from the COVID-19 pandemic, threatening food security and sustainable agricultural development.

As a result, Africa and India together account for around two-thirds of the undernourished population while accounting for roughly 35 per cent of the world's population in 2022. Of the 722 million undernourished people globally, 27 per cent lived in India and 39 per cent in Africa (FAOSTAT).

While the share of undernourished people as a proportion of India's own population has declined from 21 per cent in 2004-06 to 14 per cent in 2021-2023, the share remained the same in Africa at 20 per cent. Due to the rapidly growing population in Africa, the actual number of undernourished people increased sharply on the continent (from 185 million in 2004-2006 to 284 million in 2021-2023), but decreased in India from 247 million to 195 million people during that period. India's population growth has slowed, but Africa's growth

Figure 1.1

Prevalence of poverty, undernourishment and stunting (%)



Source: World Development Indicators (World Bank - World Development Indicators. https://databank.worldbank.org/source/world-development-indicators. Accessed 23 Jan 2025); FAOSTAT.

remains high, underscoring the urgent need for its agricultural sector to expand rapidly to meet rising food demands and ensure diversified diets.

Fostering access to adequate and nutritious food is a multi-sectoral challenge that requires multi-sectoral solutions. Agricultural development and increasing food production cannot alone ensure food and nutrition security. Indeed, emphasis should be on differentiating between food availability and food access and shifting the focus from calorie intake towards delivering nutrition (Herforth et al. 2012; Viswanathan & Mishra, 2020). Africa and India need policies to develop not only the agriculture sector but also strengthen household resilience towards food insecurity and reduce inequalities in accessing a nutritious diet. Similarly, the two regions need strategies and innovative methods to improve nutrition through agricultural transformation.

This book offers valuable new insights on patterns of structural change in Africa and India to better understand the drivers of economic development, agricultural growth, nutrition outcomes of structural transformation and the role of public spending in shaping these dynamics. Comparing the two regions allows us to identify critical lessons for fostering agricultural productivity, improving food security and addressing malnutrition, thereby facilitating mutual South-South learning. However, comparing the agricultural sectors of India and Africa at an aggregate level would not be meaningful. Sectoral characteristics – such as natural resource endowment, production potential, agro-climatic zones, farming systems, the contribution of agriculture to GDP and the share of the workforce employed in agriculture – vary substantially within India and across Africa. Instead, this book focuses on African countries and Indian states as units of analysis. In doing so, we use a unique approach that matches Indian states and African countries based on a variety of indicators. This comparison serves to identify critical lessons for fostering agricultural productivity, improving food security, and addressing malnutrition facilitating mutual South-South learning.

The remaining book is structured as follows:

Chapter 2 provides a brief introduction to the growth trajectories of African countries and Indian states. Based on the analysis of a carefully selected set of indicators, the chapter identifies clusters of countries/states that are comparable across these indicators. Since 2000, both regions have seen significant agricultural growth alongside typical sectoral transformations, with declining shares of agriculture in GDP and employment. Agricultural productivity roughly doubled in many Indian states and African countries. Five clusters of Indian states and African countries can be identified that share similar agricultural, economic, and social characteristics, thus allowing for state-country comparisons.

Chapter 3 identifies potential drivers of agricultural growth African countries and Indian states and empirically assesses the role the different drives in influencing growth trajectories. While India's growth was driven by intensification, many African countries relied on area expansion. With rising population pressure, Africa must transition to sustainable intensification by adopting improved inputs like drought-tolerant seeds, fertilizers, and mechanization.

India's Green Revolution offers lessons in scaling innovations, rural infrastructure, and policy incentives, though environmental sustainability remains a challenge. Both regions need to strengthen agricultural credit markets, promote mechanization, invest in climate-resilient water management, and enhance agricultural extension services. Diversifying production toward high-value crops, improving market infrastructure, and ensuring energy access, road connectivity, and land tenure reforms are essential for linking farmers to markets, reducing post-harvest losses, and achieving sustainable growth.

Chapter 4 examines how structural transformation in India and Africa impacts nutrition, particularly child nutrition. The study shows that agriculture's share of employment and GDP is strongly correlated with child stunting and wasting, respectively. While higher agricultural income per capita reduces stunting, undernutrition is influenced by factors like poverty, women's education, gender equality, and access to clean water and sanitation. Urbanization and income growth shift diets toward nutrient-rich foods, while agricultural productivity improves dietary diversity. Policies supporting production diversity, infrastructure, and bio-fortification can combat undernutrition. Sustainable progress requires intersectoral efforts addressing health, hygiene, and maternal nutrition, alongside leveraging trends such as rising female education and income growth to improve food security.

Chapter 5 examines public spending patterns, particularly in agriculture, and evaluates their impact on development outcomes such as agricultural growth, social protection, and child malnutrition. The analysis reveals that high agricultural growth performers among Indian states and African countries allocate a larger share of GDP to agricultural spending, focus on infrastructure and direct support to producers, and achieve higher agricultural GDP growth, which correlates with reductions in child malnutrition. However, public spending on agriculture remains low in both regions, both as a share of total public spending and relative to agriculture's economic significance. Agricultural R&D, despite its high returns, is underfunded, and extension services in India receive minimal resources. Additionally, an overemphasis on input subsidies leads to inefficiencies, diverting funds from more impactful investments.

Chapter 6 summarizes key insights from the preceding chapters and offers recommendations for policies and investments to ensure agricultural growth effectively contributes to food and nutrition security in India and Africa:

1. Investments in the development and scaling of locally relevant innovations will be key to sustainable intensification and value-addition in the agriculture sectors, including investments in irrigation, digitalization, climate-smart agriculture and value chain development

2. Supporting agricultural diversification into livestock and high-value crops will empower smallholder farmers, improve nutrition and expand value chains.

3. African and Indian policymakers should increase public spending on agriculture, particularly in underfunded areas such as R&D and extension services, to boost productivity and drive technological adoption.

4. In African countries and Indian states, reforming inefficient input subsidy programs and reallocating resources toward public goods like agricultural infrastructure, R&D and extension services is essential for long-term growth and productivity.

5. In both regions, integrating nutrition-sensitive agricultural policies with social sectors, fostering innovation, replicating successful interventions like biofortification, and investing in agricultural infrastructure are crucial for reducing child malnutrition.

6. A balanced approach to public spending is crucial in African countries and Indian states to ensure critical agricultural investments are not sacrificed for short-term social protection programs, as these investments are vital for long-term growth, poverty reduction, and improved food security and nutrition

7. Development partners must consider the diverse growth trajectories, sectoral characteristics, and fiscal environments of African countries and Indian states to ensure their investments are targeted, aligned with local priorities, and tailored to regional capabilities.

2

Shyma Jose, Ashok Gulati, Joachim von Braun, Heike Baumüller, Lukas Kornher

Overview of India-Africa Comparison of Agricultural and Food Transformation

2.1 Introduction

India and Africa share several key characteristics that make them suitable for comparison when studying agricultural growth trajectories and transformation in both regions. Both have faced significant challenges with poverty and malnutrition. Although poverty rates have been declining, the number of people living in poverty has been increasing since 1990, largely due to population growth (World Bank, 2024). In fact, over three-quarters of the population in both regions live in poverty, defined as living below the $6.85 poverty line (87 per cent in Sub-Saharan Africa, 82 per cent in India in 2021). Sub-Saharan Africa accounts for just over two-thirds of the world's extreme poor, with 464 million people living on less than $2.15 per day in 2024, compared to 181 million people in India (or 26 per cent of the world's total).

Both regions also face significant demographic pressures. Together, India and Africa constituted just over a of world's population in 2024 (UN, 2025). India is already the most populous country in the world, while Africa's population is projected to exceed one-fourth of the global population by 2050. Both regions have a large youth population seeking employment and income opportunities, and are experiencing rapid urbanisation. In the agricultural sector, India and Africa benefit from abundant natural resources, production potential, and diverse agro-climatic zones and farming systems. The contribution of agriculture to GDP is similar in both regions: 15.3 per cent in Africa (2019) and 16.8 per cent in India (2019-20), while the share of the workforce employed in agriculture is only slightly higher in Africa (48.3 per cent in 2019) than in India (45.6 per cent in 2019-20) (FAO, 2022; PLFS, 2019-20).

However, it is also important to note the considerable heterogeneity within both India and Africa due to significant variations in factors such as natural resource endowments, production potential, agro-climatic zones, farming systems, and the proportion of the workforce employed in agriculture. Thus, comparing the agricultural sectors of India and Africa at an aggregate level could be misleading. Instead, we focus on identifying similarities between Indian states and African countries for a more meaningful country-state comparison. The current study explores economic, agricultural, and nutrition trends across Africa and India, identifying common typologies from 20 major Indian states[1] and 24 African countries[2] using cluster analysis. By identifying and characterising these clusters, the study aims to compare opportunities, identify best practices, and propose paradigms for transforming agrarian economies in both regions towards higher growth trajectories.

The study is organised as follows: Section 2.2 describes the secondary data sources and methodology used in the study. Section 2.3 gives an overview of Indian states and African countries in terms of economic, food and agricultural development. Section 2.4 explains the cluster analysis and throws light on the different clusters and their characteristics among the Indian states and African countries. The section also provides an assessment of development strategies and policy initiatives adopted by different African countries and Indian states within each cluster.

1. Indian states included in the study are Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jammu, Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Uttarakhand, West Bengal

2. African countries include: Algeria, Angola, Benin, Burkina Faso, Cameroon, Democratic Republic of the Congo, Cote d'Ivoire, Egypt, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mali, Morocco, Mozambique, Niger, Nigeria, Rwanda, Senegal, South Africa, Tanzania, Tunisia, Uganda

2.2 Data and methodology

2.2.1 Data sources

Secondary data related to Indian states was obtained from the Ministry of Agriculture and Farmers' Welfare, the Directorate of Economics and Statistics (DES) of the Government of India, the Census of India, National Accounts Statistics, Central Statistical Organization, Fertiliser Association of India and Tractor Manufacturer Association, National Family Health Survey (NHFS); Planning Commission and Periodic Labour Force Survey data.

For African countries, the principal data sources used are United Nation's Food and Agriculture Organization Database (FAOSTAT); United States Department of Agriculture (USDA); the World Bank's World Development Indicators (WDI, World Bank) and United Nations' World Population Prospects. Since different sources of data have been used to make comparisons between African countries and Indian states, we have ensured that the differences in the variables are small so that the conclusions drawn are not invalidated. The observation period for cluster analysis is restricted to two time periods: 2000 (financial year 2000 for India) and 2016 (financial year 2016 for India).

2.2.2 Methodology

In the present study, we use quantitative analyses and narrative studies to understand the differences and similarities in food and agriculture development between Indian states and African countries, including differences unexplained by quantitative methods. Various studies have used multivariate statistical techniques for creating common typologies and characterisation in cross-country analysis, farming strategies, agricultural transformation etc.. For instance, Laborde et al. (2019) identified typologies using global cluster analysis for 117 countries from Africa, Asia and Latin America; while Goswami et al. (2014) and Kuswardhani (2014), both used a combination of principal component analysis (PCA) and cluster analysis for India and Indonesia, respectively.

In the present study, we use a combination of six key steps for identifying the typologies across African countries and Indian states. These are: (1) choosing the appropriate variables to be used in the analysis, (2) reducing the dimension of the selected variables using a variable reduction strategy i.e. PCA, (3) characterising Indian states using the hierarchical clustering analysis, (4) selecting an appropriate multivariate distance matching method, (5) matching Indian states and African countries using a matching algorithm, and finally, (6) clustering African countries with Indian states based on one-to-one matching and clusters retained through cluster analysis. In this book we have identified clusters between Indian states and African countries at two points in time: 2000 and 2016. This will capture the intertemporal changes in clustering, for example, if there has been any movement across any Indian state or African country towards a higher growth trajectory. These six steps are discussed in detail:

2.2.3 Selection of indicators

A number of covariates were selected to perform the clustering. Studies have stated the importance of including a large set of indicators in clustering and matching techniques (Rubin and Thomas, 1996; Stuart, 2007). Instead of relying only on economic and agricultural indicators for classification of Indian states and African countries, we use multivariate statistics for identification of clusters and their characterisations. Apart from economic and agricultural parameters, socio-economic, nutrition, infrastructure, demographic, mechanisation and diversification indicators are included in the analysis. Description and measurement of the selected indicators for classifying clusters between Indian states and African countries is given in Table 2.1.

2.2.4 Data analysis

We employ PCA to reduce the number of dimensions by compressing the information while preserving the maximum possible proportion of the total variation in the original data set (Dunteman, 1989; Jolliffe, 1986). Thus, the original independent variables are reduced into a set of components using PCA which is later used in the cluster

Table 2.1

Selected variables in cluster analysis and characterisation, 2000 and 2016

Indicators	*Description in units*
Economic indicators	
GDP per capita	US$
Per capita Agricultural GDP	US$
GDP	billion US$
Agriculture GDP	billion US$
Share of Agriculture in GDP	Percentage share (%)
Employment in Agriculture	Percentage share (%) (Due to unavailability of employment data for the year 2000 and 2016-17, we have used 2004-05 and 2017-18 respectively for India)
Agricultural productivity and diversification	
GVOA per hectare (land productivity) (GVOA_ha)	US$/ha (Data for Africa and India are at constant 2011-12 prices)
Share of Livestock in GVOA	Percentage share (a measure of diversification) (%)
Infrastructure	
Irrigation ratio	Percentage share (%)
Technological input and mechanisation	
Fertiliser Utilisation	kg/ha
Tractor intensity	per 1000 hectare (For India, we have used tractor intensity data of 2005 for the year 2000)
Social and demographic indicators	
Underweight	Prevalence of underweight (We used underweight data of the year 2005-06 and 2015-16 for the year 2000 and 2016 respectively) *
Poverty	Head count ratio (In percentage share (%)) (We used poverty data of the year 2004-05 and 2011-12 for the year 2000 and 2016 respectively) *
Population density	per sq km (Due to unavailability of population data for 2000 in India, we have used 2001 Census data for India)
Total population	Total count (Due to unavailability of population data for 2000 in India, we have used 2001 Census data for India)

* To match with the period of observation in the Indian states, we interpolated data for African countries.

Source: Author's compliation

analysis. Kaiser-Maier-Olkin (KMO) test and Bartlett's sphericity test are used to check the appropriateness of the data set. The factors are selected using the varimax method (orthogonal rotation) which maximally correlates with one principal component and a near-zero association with the other components. All the factors with an eigenvalue of 1 or more are retained for further analysis as per the Kaiser Criterion (Kaiser, 1970). Notably, this criterion holds only if the number of variables in PCA is less than 30 (Field, 2005). Since we have used sets of 14 and 9 variables to construct components using PCA for 2000 and 2016, respectively, this criterion holds for our analysis.

Next, these derived principal components are used in cluster analysis for identifying the typologies across Indian states and African countries. Cluster analysis is a useful tool to partition a large data set into meaningful subgroups of the subject according to a set of specified characteristics (Cutillo, 2019). These clusters are relatively homogenous within themselves and heterogeneous between each other.

For clustering, we have used Ward's hierarchical method to minimise the variation of each cluster and determine the clusters using the agglomerative method. Hierarchical clustering analysis identifies groups of samples that are similar or exhibit similar characteristics and helps to quantify the structural characteristics of the sample or variable. In this method, the variables are compared between subjects and the clusters are derived in such a way that the difference (measured by Euclidean distance) between the members are minimised within a group while maximising the differences between members of different groups. This method of clustering is more appropriate for smaller data sets, particularly when the number of clusters is unknown a priori (Cutillo, 2019; McIntosh et al, 2010).

A hierarchical tree or dendrogram is used to structure the data which mainly provides a graphical representation of the hierarchy of nested clusters. After constructing a dendrogram, the optimal number of clusters is identified. We then classify Indian states into different clusters based on the optimal number of clusters retained from Ward's hierarchical method.

After clustering Indian states, we find the closest match for Indian states from the selected African countries using Mahalanobis distance (a multivariate-distance matching measure). The Mahalanobis distance (D_{ij}) on covariates X between units i and j is given as:

$$D_{ij}{}^2 = (x_i - x_j)^T \sum^{-1} (x_i - x_j)$$

where ∑ can be true or estimated variance-covariance matrix in the treated group, the control group or in pooled sample (Stuart, 2007, pp 11). In other words, we find the closest match in the control group (African countries) with similar characteristics for each observation in the treatment group (Indian states). The main objective of matching is to compare a group with a control group with or without reduced confounding and selection bias. A similar example of using Mahalanobis matching techniques can be drawn from studies such as Baltar et al. (2014) in Brazil which used propensity score, Mahalanobis distance and Mahalanobis within Propensity Calipers to match control groups.

After defining the distance using Mahalanobis distance measure, the next step is to match the samples between Indian states and African counties. For the present chapter, we use nearest neighbour (NN) matching which selects k-matched controls for each traded unit (where k=1 generally) (Rubin, 1973). As summarised by Stuart (2007, pp 12), the NN matching "uses a 'greedy' algorithm, which cycles through each treated unit one at a time, selecting the available control unit with the smallest distance to the treated unit".

Another concern while using NN matching is whether to use matching 'with replacement' or 'without replacement'. First, we match the states and countries based on NN matching 'without replacement' where 20 Indian states were matched with corresponding 20 African countries. This method increases the average quality of matching, reduces the bias and increases the variance of the estimator (Smith and Todd, 2005; Caliendo and Kopeing, 2008). We then use NN matching 'with replacement' for the rest of the African countries where Indian states can be used more than once as a match. However, this form of matching reduces the variance and increases the bias due to the use of "more information to construct the counterfactual for each participant" (Caliendo and Kopeing, 2008, pp 9).

After matching the samples the final step is to classify African countries across the Indian clusters (identified using hierarchical clustering as discussed above) based on one-to-one nearest neighbour matching between Indian states and African countries.

2.3 Comparison of selected economic indicators for Indian states and African countries

Agriculture and food transformation is affected by a host of agro-ecological, economic, social and demographic factors. The present section documents the major transformation in economy-wide and demographic characteristics. Our premise is that studying these trends will give a deeper understanding of typologies and clustering across Indian states and African countries crucial to determine the best feasible development trajectory for both regions to accelerate agricultural growth and overall development.

2.3.1 Demographic structure

In 2022, Africa accounted for 1.43 billion people, roughly 17.9 per cent of the world population. The share of the African population is projected to double by 2050 as per UN population projections (WPP, 2019). The population growth within Africa has considerably outpaced the other regions in the world. During 2000 to 2022, the African population increased at an annual growth of 2.55 per cent per annum (WPP, 2022). Africa's pattern of demographic transition is characterised by a decline in the death rate, particularly child mortality, rising life expectancy, and no comparable decline in birth rate as per the Africa Agriculture Status Report (2016).

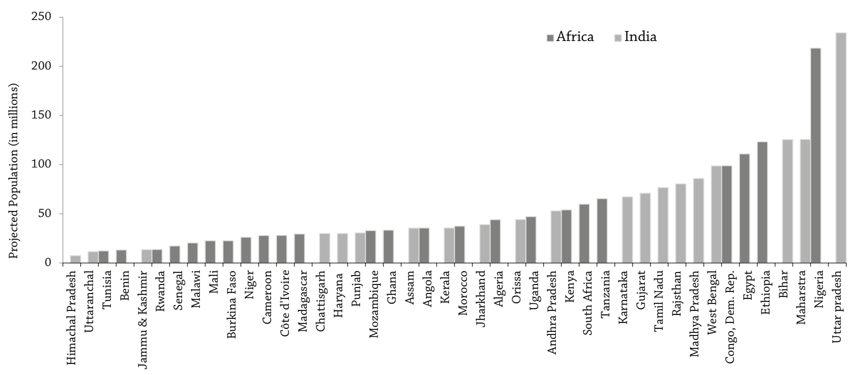
Increasing population growth has several significant implications for Africa. First, the high population growth has increased pressure on land, pastures and wood resources which have resulted in conflicts in certain parts of the continent such as in Cote d'Ivoire, Kenya, and Rwanda (Devèze, 2011). Second, food demand is rising exponentially, resulting in high pressure on African food systems. The continent is also becoming heavily dependent on global markets for staple cereals, livestock products, and oilseeds leading to a scenario where most of the food products in African countries are priced at import parity.

Across the sub-regions, Nigeria (with a population of 219 million), Ethiopia (123 million) and Egypt (111 million) together account for 31.7 per cent of the total population in Africa while Tunisia (12 million), Benin (13 million) and Rwanda (14 million) were the least populated African countries (among the countries selected for the present study) in 2022 as per the WPP (2022) (Figure 2.1).

Meanwhile, over the same period, the population in India increased at an annual growth of 1.4 per cent per annum with current population standing at 1.42 billion in 2022 (WPP, 2022). Uttar Pradesh (234 million), Maharashtra (126 million) and Bihar (126 million) account for 34 per cent of the total population in India in 2022 (MoHFW, 2019). In fact, these three Indian states i.e., Uttar Pradesh,

Figure 2.1

Projected population, India and Africa, 2022 (in millions)



Source: World Population Prospects (WPP) 2022, Report of the Technical Group on Population Projections, 2019, GoI

Maharashtra and Bihar have a larger population than the three most populous countries in Africa.

2.3.2 Economic structure in India and Africa

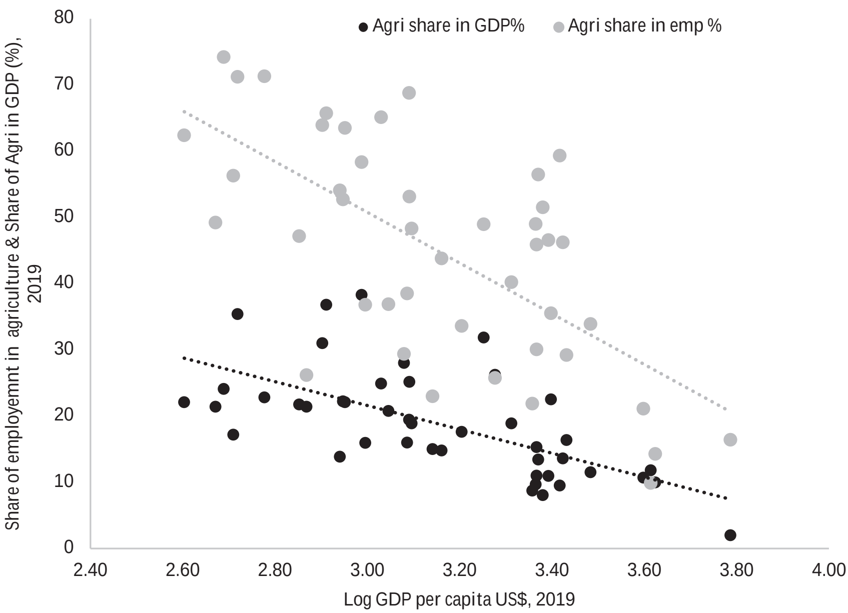
Economic transformation encompasses fundamental change in the structure of the economy with changes in drivers of growth and development. While substantial differences exist across the regions, the agricultural sector influences economic structure in most of the African countries. As highlighted, the agricultural sector contributes around 15.3 per cent of GDP in Africa; but the share varies across the African countries from 36.8 per cent in Mali to 2.0 per cent in South Africa in 2019 (FAO, 2022). Over the two decades, between 2000-2019, the share of agriculture to GDP has declined considerably across African countries except Mali, Niger, Benin, Nigeria, Algeria and Angola which experienced a reverse trend. Despite the declining agriculture's share in GDP, most of the African countries still have a high proportion of the workforce in agriculture except for Algeria (9.9 per cent) and Tunisia (14.3 per cent) in 2019. Some countries such as Niger, Mozambique, Mali, Tanzania, Ethiopia, Malawi and Madagascar have more than two-third of the population employed in the agricultural sector.

Meanwhile, agriculture's contribution to GDP in India declined from 21.6 per cent to 16.8 per cent during the period. Across states, it ranged from 38.3 per cent in Madhya Pradesh to 8.05 per cent in Uttarakhand in 2019-20. The experience of the agricultural sector in Africa and India in the last few decades have shown similar structural transformation in terms of agricultural GDP share declining much faster than agricultural employment share. Incidentally, a large gap between the share of agriculture in GDP and the share of agriculture in total workforce reflects a slow occupational transformation from agriculture to the non-agricultural sector (Byerlee et al., 2009).

An indicator of how far structural transformation has advanced is how strong the sectoral composition of income and GDP changes across income levels. Specifically, a relatively stable share in agricultural GDP and agricultural employment level across income levels

Figure 2.2

Log GDP per capita by the share of agriculture in GDP and employment in agriculture (%)



Note: India's figures for GDP per capita is at 2011-12 INR prices converted to US$ using 2019 exchange rate from OECD.

Source: Central Statistical Organisation (GoI), World Development Indicators, various years & PLFS (2019-20), Report of the Technical Group on Population Projections, 2019, GoI.

suggest a more productive agricultural sector. Figure 2.2 depicts the level of structural transformation by GDP per capita across Indian states and African countries. Although India and Africa share a similar economic and occupational structure, the process of structural transformation is unfolding at different paces. Within Africa, the pace of transformation has been uneven across the different regions. For instance, the gap between the share of agriculture in GDP and share of the workforce in agriculture is narrowing at a faster pace for countries with high GDP per capita such as Egypt, Tunisia, Algeria and South Africa. At the same time, Ethiopia, Rwanda and Ghana also manifested rapid economic transformation with a fall in workforce engaged in the agricultural sector (McMillan and Harttgen, 2014). Evidence suggests that the agricultural sector has become more intensified in regions with high population density, particularly in Rwanda, Nigeria, Uganda, Malawi, Ghana and Ethiopia according to the report by the New Partnership for Africa's Development (NEPAD) (2013).

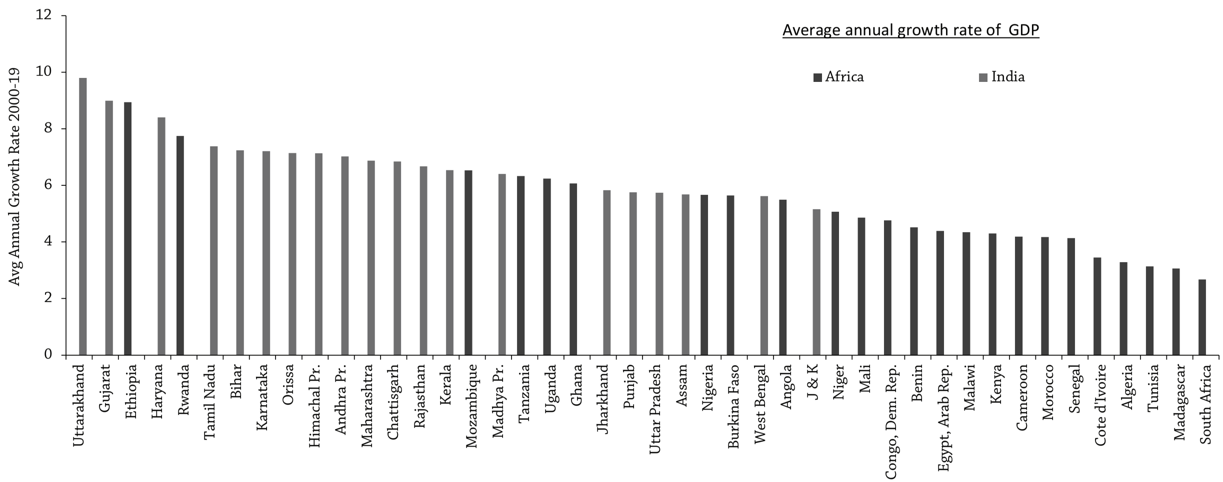
The same trend is not evident for Indian states where there exists a substantial gap between the share of the workforce employed in the agricultural sector and the share of GDP generated by that workforce. For instance, Punjab, Haryana, Andhra Pradesh and Gujarat, which have a high GDP per capita and a low share of agriculture in GDP, do not have low employment shares in the agricultural sector. Thus, African countries, particularly with high GDP per capita, achieved a more rapid decline in agricultural GDP share as compared to other developing countries (Badiane, 2014). Evidently, the prospects of the agricultural sector still significantly influence economic development in most of the African countries and Indian states.

2.3.3 Economic performance post-2000

After decades of stagnation, much of Africa entered into a period of sustained and remarkable economic growth at the turn of the millennium. In fact, the African economy as a whole was growing at a modest rate of 4.4 per cent annually during 2000-2019 (FAOSTAT). Today, most economists would agree that this has provided optimism for the continent's prospects for poverty alleviation and overall development; however, many African countries are behind other developing countries in terms of overall development. The recent development in African economies makes it necessary to look deeply at the nature of this growth in Africa and the factors that can lead to sustained long-term economic growth in the continent. According to the World Bank report (2015), Africa Pulse, the key factors that led to sustained growth in African economies were investments in public infrastructure, acceleration in the agricultural sector and an expansion in the service sector.

Figure 2.3

Average annual growth of GDP (2000 to 2019) (In %)



Source: MOSPI, GoI, World Development Indicators, World Bank, various years

Within Africa, economic growth continues to vary across the sub-regions. In addition, Africa's GDP has remained concentrated in the five major economies – Nigeria, South Africa, Egypt, Algeria and Morocco. During 2000-2019, the economic growth in these major economies has been higher than the average economic growth rate of the continent such as Ethiopia, Rwanda, Mozambique, Tanzania, Uganda, Niger, Burkina Faso, Nigeria, Mali, Democratic Republic of the Congo (DRC), and Benin (see Figure 2.3). In recent years, East Africa has been the continent's fastest-growing region, largely driven by Ethiopia (8.9 per cent), Rwanda (7.7 per cent), Mozambique (6.5 per cent) and Tanzania (6.3 per cent). However, North Africa comprising Egypt, Algeria, Morocco and Tunisia has been growing rather slowly.

Meanwhile, during the same period, the Indian economy grew at 6.5 per cent per annum. As pointed out by the World Bank (2018), India has been one of the world's fastest-growing economies which is supported by "prudent macroeconomic policy such as a new inflation targeting framework, energy subsidy reforms, fiscal consolidation, higher quality of public expenditure and a stable balance of payment situation". The five major states that contributed to more than half of India's GDP are Maharashtra, Gujarat, Tamil Nadu, and Karnataka and Uttar Pradesh. Uttarakhand, a state carved from Uttar Pradesh in 2000, achieved the highest annual average economic growth during the past two decades (2000-01 to 2019-20). Another state that performed well was Gujarat that grew 9.0 per cent for the same period.

2.4 Clustering comparable Indian states and African countries

So far, we have discussed the trends across India and African countries based on demographic, economic and agricultural indicators. Since there are numerous indicators within each dimension, we identify typologies between Indian states and African countries by using a combination of variable reduction strategy (PCA) and cluster analysis (on the derived principal components) for 2000 and 2016.

To examine the applicability of the PCA on the selected variables, KMO and Bartlett test of sphericity were applied. The estimates showed that the overall KMO measure was 0.71 and 0.65 (higher than 0.5) for the years 2000 and 2016, respectively, while the Bartlett test of sphericity was highly significant ($\rho < 0.00$) for both years. This confirmed that the selected variables are related and can be used for PCA. For brevity, we discuss the results of the PCA for the year 2016 only. The results of PCA for the year 2000 are given in Table A1 (see annexure).

In total, 9 indicators were included in the PCA, of which 2 principal components with an eigen value greater than 1 were retained for further analysis for 2016. The rotated factor (varimax) of the independent variables with factor loading for each variable for 2016 is shown in Table A2 in the annexure. These two components together explained 59 per cent of the total variance in the data set. The results revealed that the first component (PC1), which explains 36.3 per cent of the variance, is correlated with poverty, irrigation, gross value of output in agriculture per hectare and employment in the agricultural sector. The second derived component explains 22.5 per cent of the variance and is correlated with the prevalence of underweight and population.

For clustering, we used hierarchical clustering using Euclidean distance as distance measure and Ward's linkage clustering to identify the clusters among Indian states. Importantly, the number of clusters chosen should be realistic and best fit the data set to ensure meaningful classification. By using a dendrogram[3] , we found that five clusters were appropriate and most representative to classify Indian states. Figure A3 represents the distribution of Indian states in two-dimensional space defined by the first two principal components after orthogonal rotation (Varimax rotation).[4] As mentioned earlier, we classified Indian states into five different clusters where states circled together signify similarity in terms of a host of indicators. However,

3. The dendrogram (also called cluster trees) illustrates graphically the possible sequences for grouping Indian states into clusters using hierarchal cluster analysis. We cut dendrogram at a specified (dis) similarity value to arrive at an appropriate number of clusters.

4. The dissimilarity measured by Euclidean distance is equal to the distance between the positions of the states.

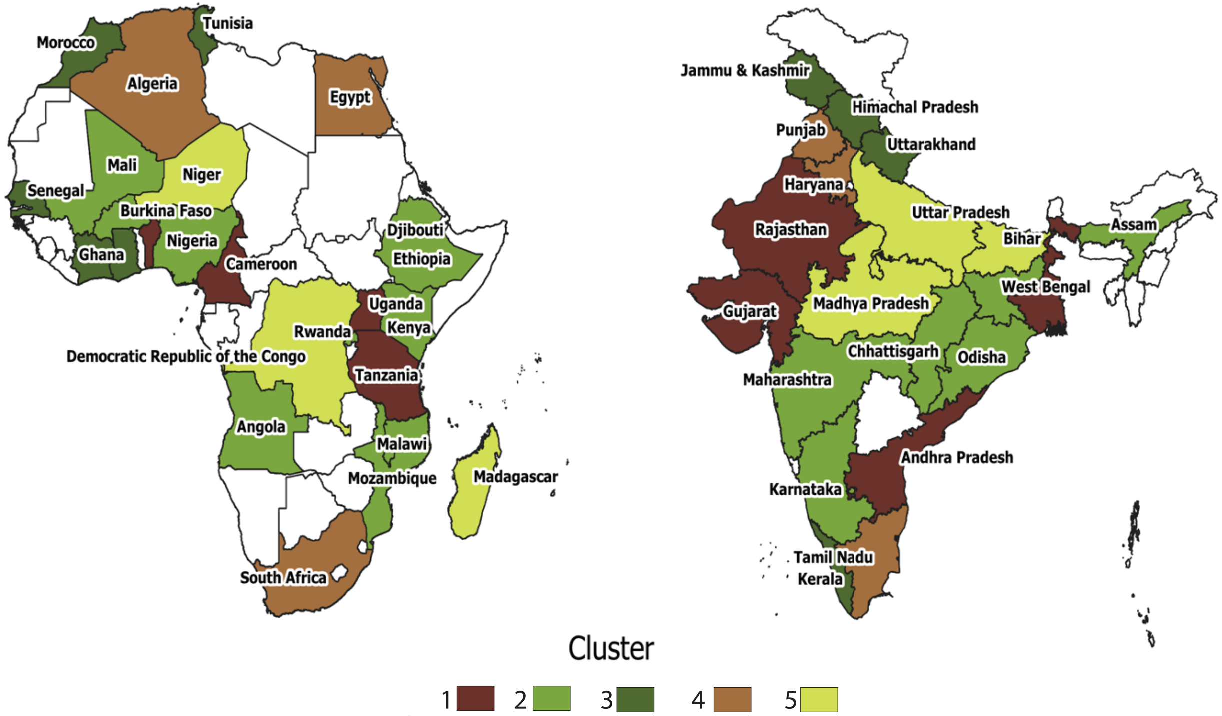
some states are scattered through the score plot reflecting a higher variability among these states.

After estimating clusters among Indian states, we matched the African countries to the respective Indian states using NN matching. In NN matching, the individuals from the comparison group, (African countries) are chosen as a match for a treated individual (Indian states) that is closer in terms of distance measure. The matching between Indian states and African countries for 2000 and 2016 is depicted in Table A4 (see annexure). Although NN matching with replacement may result in better matches, the controls that are similar to the treated unit can be matched multiple times. This type of matching may yield matched pairs using only a few controls. In addition to that, matching 20 states with 24 African countries, using one-to-one NN matching without a replacement would leave us with 4 unmatched units. For these remaining four African countries, we use the NN matching with a replacement to find their most representative Indian states. Thereafter, based on one-to-one NN matching, we classify African countries across the five Indian clusters identified using Ward hierarchical linkage for the year 2016 (Figure 2.4).

Within each matched cluster, we compare development path and agricultural transformation among Indian states and African countries. Analysing the policies and strategies of Indian states would give important insights to accelerate agricultural growth and overall economic development in Africa. Moreover, it could provide lessons for policymakers in African countries to respond to several critical issues related to drivers of agricultural growth, food security, poverty reduction and rural development. For the sake of parsimony, we will discuss the characteristics of the clusters for the year 2016 in this section (Table 2.2). See Figure A5 (in Annexure) for clusters for the year 2000.

Figure 2.4

Clusters based on hierarchical clustering, 2016



Source: Authors' compilation based on the cluster analysis.

Table 2.2

Characteristics of clusters based on a range of economic agricultural, nutritional and demographic indicators

CLUSTERS (2016)	*Average Agri growth*	*Agri productivity (GVOA per ha)*	*Agri intensification (Access to Input, Irrigation)*	*Diversified Agri sector (High share of Livestock)*	*Malnutrition*
CLUSTER 1: Gujarat, Rajasthan, Andhra Pradesh, West Bengal Cameroon, Uganda, Benin, Tanzania	High	Mixed	Mixed	Mixed	High
CLUSTER 2: Karnataka, Assam, Odisha, Chhattisgarh, Maharashtra, Jharkhand Burkina Faso, Rwanda, Mozambique, Mali, Malawi, Kenya, Ethiopia, Angola, Nigeria	High	High	Low	High	High
CLUSTER 3: Himachal Pradesh, Uttarakhand, Jammu and Kashmir, Kerala Cote d'Ivoire, Senegal, Morocco, Tunisia, Ghana	Moderate	High	Low	Mixed	Low
CLUSTER 4: Madhya Pradesh, Bihar, Uttar Pradesh Democratic Republic of the Congo, Niger, Madagascar	Moderate	Low	Mixed	Low	High
CLUSTER 5: Tamil Nadu, Punjab, Haryana Algeria, South Africa, Egypt	Low	High	High	High	Moderate

Note: Clusters based on Principal Component Scores of nine variables: Per capita Agricultural GDP, Employment in agriculture, Population, Irrigation ratio, GVOA per hectare, Share of Agriculture in GDP, Share of Livestock In GVOA, Underweight, Poverty

Source: Authors' calculation based on the cluster analysis.

Cluster 1: States are characterised by high agricultural GDP per capita, high agricultural value of output per hectare, average agricultural intensification and low poverty

Cluster 1 includes Indian states of Rajasthan, Gujarat, Andhra Pradesh and West Bengal. The contribution of agriculture to GDP in this cluster ranged from 13.6 per cent in Gujarat to 31.9 per cent in Andhra Pradesh in 2019-20. Gujarat, Andhra Pradesh and Rajasthan have roughly half of the population engaged in agriculture. Among these states, Gujarat, Andhra Pradesh and Rajasthan achieved high annual average agricultural growth of more than 6 per cent between 2000-01 and 2019-20. The strong agricultural performance in these three states is unprecedented, as both states have surpassed even the growth rate registered by Punjab's agriculture during its heydays of the Green Revolution. However, despite a high agricultural value of output per hectare and high per capita income, all the Indian states in this cluster have a high prevalence of malnutrition with a third of children being stunted in 2019-21 (IIPS, 2021).

The states in this cluster have a diversified agricultural sector. The value of output in the agricultural sector is dominated by cereals, fruits and vegetables, spices, oilseeds, fisheries and livestock in Andhra Pradesh; cotton, cereals, oilseeds, spices, and livestock in Rajasthan; cotton, fruits and vegetables, livestock and oilseeds in Gujarat and cereals, fisheries and fruits and vegetables in West Bengal. Complementarities of public policies and private initiatives coupled with better productivity and adequate access to marketing and agro-processing facilities played a significant role in influencing the agricultural diversification in Andhra Pradesh and Gujarat. For instance, in Gujarat, private sector participation in the development of dairy value chains provided a more profitable avenue for the dairy farmers through AMUL model outlets. To sustain the high growth, these states may need programmes of training and providing extension services to empower small and marginal farmers as self-reliant agri-entrepreneurs.

Tracing the agricultural transformation of these Indian states and the African countries of this cluster: Cameroon, Uganda, Benin and Tanzania, can provide valuable insights. Among these African countries, agriculture contributed about a quarter of GDP except Cameroon where the share of agriculture in GDP was only 14.8 per cent as per the latest data (FAO, 2022). However, the share of agriculture in employment ranged from 29.4 per cent in Benin to 65.1 per cent in Tanzania. Unlike the Indian states of this cluster, agricultural growth in these African countries was way below achieving the target of 6 per cent set under the Maputo Declaration. In contrast, during the last two decades (2000 to 2022), population growth in these countries was much higher compared with Africa's average population growth (2.55 per cent). Therefore, prioritising agricultural policy in these countries towards increasing yield and self-sufficiency in food crops is essential to meet the demands of a growing population.

For example, the Tanzanian government has been investing in agriculture and promoting agriculture intensification. To improve access to agricultural input, the National Agricultural Input Voucher Scheme (NAIVS), which included input vouchers for inorganic fertiliser and improved maize and rice seeds, was implemented in 2009. The scheme targeted approximately two million farmers and was able to increase the fertiliser use to around 16 per cent of the farms (Wineman et al, 2020, Diao et al, 2016). However, this scheme was scaled back in 2014 and has been replaced with a Fertiliser Bulk Procurement System (FBPS), which aimed at regulating fertiliser prices (Wineman et al, 2020; Kasumuni, 2018). Studies have shown that the NAIVS increased agricultural productivity in Tanzania (United Republic of Tanzania, 2016). Further, the Tanzanian government has promoted tractor usage by increasing agricultural credit through the Agricultural Inputs Trust Fund (Diao et al, 2016).

While the public expenditure earmarked for agriculture ranged from 7 per cent each in Benin (2017) and Tanzania (2012) to 5 per cent in Uganda (2013), it was well below the 10 per cent target under the Malabo/Maputo Declaration (as per the latest year data available from SPEED, IFPRI 2019). In fact, agricultural expenditure in these countries is mostly in the form of support to producers, such as input subsidy programmes, rather than investments in agricultural research, value chain development or marketing infrastructure. However, the literature highlights that public expenditure on agriculture research, extension and education tends to yield social returns substantially greater than costs (Fan et al, 2000).

Agricultural policies in these countries also favour the production of specific crops through massively subsidised inputs, encouraging specialisation. For example, in Benin, agricultural policies have been favouring cotton production (which accounts for more than half of agricultural export value) through the provision of subsidised inputs. However, the lack of subsidised input[5] for other high-value crops such as fruits and vegetables deter crop diversification. Essentially, to achieve agricultural transformation, these countries need to diversify towards non-traditional agricultural exports and production.

For sustaining growth and adding value to products in the agricultural sector, there is a need to develop value chains with stronger links with the private sector and to promote agricultural diversification towards high-value agriculture. Private investments in agro-processing and value addition can promote agri-entrepreneurship and thereby, profitability in the agricultural sector. For instance, Uganda, like several Indian states (Rajasthan and Gujarat), has increased the share of livestock in agricultural output providing a profitable avenue to empower small and marginal dairy farmers and creating jobs along the dairy value chain. Simultaneously, the Ministry of Agriculture, Animal Industries and Fisheries of Uganda has made agribusiness development a top priority, and promotes the export of agricultural products. In this regard, the farmer producer organisations (FPOs) can integrate small farmers and increase their market power. In Cameroon, the agricultural reforms have privatised most of the state-owned procurement and marketing agencies to create competition in the market and increase agricultural production.

Another challenge faced by smallholders in Africa is the insecure land tenure which hinders investments in agriculture intensification and climate-smart practices for sustainable agriculture development.

5. In 2008-09, the government of Benin has subsidised certified seeds for rice and maize. Cotton and rice growers are provided market support measures by fixing floor prices annually at farm gate.

A priori findings indicate that insecure land tenure lead not only to land degradation but also inadequate diets, which has serious consequence on nutrition among women and marginalized groups (Holden and Ghebru. 2016). In recent years, several countries in Sub-Saharan Africa – including Benin and Tanzania have implemented some form of systematic land formalisation programme. In Benin, for example, empirical studies have shown using randomized control trials how the land formalisation tends to shift investment decisions from subsistence crops to long-term and perennial cash crops (Goldstein et al, 2015), increasing profitability for farmers.

Cluster 2: States are characterised by high poverty, high malnutrition, low GDP per capita, low agricultural GDP per capita, low agricultural intensification and low irrigation coverage with higher agricultural share in employment

Cluster 2 includes the Indian states of Karnataka, Assam, Chhattisgarh, Maharashtra, Odisha and Jharkhand. All these states are predominantly agrarian with roughly half of the population still dependent on agriculture in Maharashtra, Karnataka, Jharkhand and Odisha while Chhattisgarh has more than 68.8 per cent employed in agriculture (PLFS, 2019-20). In contrast, the contribution of agriculture to GDP ranged from 19.4 per cent in Chhattisgarh to 10.9 per cent in Karnataka in 2019-20.

There exists huge inter-state variability in agricultural growth among these Indian states, varying from 5.7 per cent per annum in Jharkhand and Chhattisgarh to 2.7 per cent per annum in Assam between 2000-01 and 2019-20. Evidence suggests that agriculture is an engine of economic growth and development, crucial for food security and poverty alleviation in these states. However, low seed replacement rate, low level of fertiliser utilisation, low irrigation coverage and low level of mechanisation are some of the major challenges faced by the agricultural sector in these states, leading to serious gaps in agricultural productivity.

It is noteworthy that, even with all these challenges, Chhattisgarh and Jharkhand have been on a path of high agricultural growth trajectory with the right mix of policy and government efforts. Further, most of these states have diversified their agriculture towards high-value. For example, the agricultural value of output is dominated by cereals, fruits and vegetables, sugarcane and livestock in Karnataka; cotton, sugarcane, cereals, fruits and vegetables, and livestock in Maharashtra; fruits and vegetables, livestock, spices and floriculture in Assam; and spices, cereals, livestock, fisheries and fruits and vegetables in Chhattisgarh and cereals, spices, livestock and fruits and vegetable in Jharkhand.

Since high-value agriculture such as fruits and vegetables, fisheries and livestock, has a relatively short shelf life, these states need public investments in cold storage infrastructure along with reliable power in rural areas. In addition, facilitating long-term investment in agricultural sectors (on-farm as well as off-farm) both by the private, public sector and private & public partnership (PPP), particularly for post-harvest management, marketing, agro-processing and value addition, among others, will go a long way to boost agricultural growth. In addition, linking FPOs to the agricultural export market can provide smallholder farmer's access to the export market and create avenues to earn remunerative prices, for example, similar initiatives in Maharashtra's horticulture, particularly in pomegranate and grapes exports, have achieved some success.

Initiatives have been taken by the state governments to support small and marginal farmers to shift from subsistence to profitable commercial agriculture. For instance, the Odisha government passed the State Agricultural Policy (2013) for enhancing seed replacement rate, integrated nutrient and pest management, water management, farm mechanisation and technological transfer. The Odisha state government also launched the KALIA (Krushak Assistance for Livelihood and Income Augmentation) scheme, a direct benefit transfer scheme, to provide financial assistance of Rs.10,000 per year to farm families from 2018-19 onwards. The income transfer scheme will not only encourage farmers to invest in productivity-enhancing agricultural inputs but will also have a positive effect on improving agricultural growth and poverty alleviation. Remarkably, Odisha (3.1 per cent) attained the highest decline in poverty per year from 2004-05 to 2011-12.

Given the development trajectories of these Indian states, we now delineate the agricultural pathways among the agrarian African countries of this cluster - Burkina Faso, Rwanda, Mozambique, Malawi, Kenya, Ethiopia, Mali, Angola and Nigeria. In fact, about two third of the population are employed in agriculture, particularly in Ethiopia, Mali, Malawi, Mozambique and almost half in Rwanda.

Some of the major challenges for the agricultural sector in this cluster are: low resource utilisation, low irrigation coverage, low access to modern farming techniques, and inappropriate agrarian policy (e.g., land tenure). Evidence suggests that uncertainty in rainfall coupled with low irrigation coverage tends to make agricultural intensification (using fertiliser and improved seeds) financially infeasible and risky (McCann, 1995, Taffesse et al, 2012). During the last two decades, most of the African countries in this cluster recorded higher population growth than the continent's average population growth of 2.55 per cent per annum (WPP, 2022). The rapidly growing population with low agricultural yield will have a significant impact on food security in these countries.

As a result, the governments of these countries have been focusing on increasing staple production, improving access to land and climate change mitigation strategies. For example, Mali's Agricultural Land Policy adopted in 2014 ensures equitable and secure access to land for all producers. In 2005, Rwanda passed a Land Law to establish a private market for land titles and abolished customary land tenure systems. However, these land reforms need to be accompanied by increased access to public credit, allowing farmers to realise the full productivity potential of their land.

The agricultural sector in these African countries needs to shift production from subsistence farming to commercial farming. The land-use structure in these countries is characterised by small landholdings, growing staples such as maize (mostly grown by small farms), cassava and potatoes in Malawi; teff, wheat, maize, sorghum in Ethiopia; cassava, potatoes, sweet potatoes, maize, and beans in

Rwanda; rice, cassava, corn, beans, potatoes, and sweet potatoes in Angola; cassava, sugarcane and maize in Mozambique; paddy, millet and maize in Mali and sorghum, maize and millet in Burkina Faso. Aside from small-scale subsistence farming, the important cash crops (with high export earning) grown are tobacco, sugar, tea, cotton lint and groundnuts in Malawi; coffee, tea and sugarcane in Ethiopia; maize, wheat, beans, coffee and potatoes in Kenya and tea and coffee in Rwanda. Essentially, these countries need to diversify towards non-traditional agricultural exports for agricultural transformation. For sustaining growth and adding value to products in the agricultural sector, there is a need to develop value chains with stronger links with the private sector to encourage agricultural diversification towards high-value agriculture.

Most of these African countries need to reform agricultural marketing to provide better access to smallholders and increase competitiveness in the agricultural sector. For example, the Kenyan Government, like most African countries, still controls agricultural outputs marketing with negligible participation by private players. Additionally, the Kenyan government has been providing price support to maize farmers at a premium above the price determined by market forces. Such price support schemes result in increasing not only the fiscal pressure but also discourage private investments. According to the World Bank (2019a), structured commodity trading is a feasible method to minimise these inefficiencies of price support mechanisms and also transform smallholders from subsistence agriculture to agribusiness.

To encourage agricultural intensification, various input subsidy programmes have also been implemented in these countries. For instance, the Government of Rwanda started the Crop Intensification Programme in 2007 to provide fertiliser subsidies for the cultivation of six priority crops. In Malawi, the input subsidy programmes (called Farm Input Subsidy Program) resulted in increasing the fertiliser usage higher than in neighbouring countries. According to FAO 2015a), around 80 per cent of agricultural households benefited from this programme during 2010-11. Similarly, the government of

Mozambique piloted a two-year subsidy programme, which targeted around 25,000 rice and maize producers over 2009-10 to 2010-11. However, this limited input subsidy programme in Mozambique has not been able to increase fertiliser utilisation at a national scale, which is much lower compared to other African countries.

In Mali, the Rice Initiative was started by the government, in response to the global good crisis during 2008-09, to provide farmers with subsidised seeds and fertilisers, as well as agricultural credit for farm machinery and extension services. In 2009, the scheme was extended to maize, wheat, millet and sorghum, to increase production through fertiliser subsidies (FAO, 2017a). Unlike other Sub-Saharan African countries, Ethiopia has continued state-led policies in the input market and extension services. In 2000, private companies were withdrawn from fertiliser markets, and thereafter, the Agricultural Input Supply Enterprise and cooperative unions engaged in fertiliser imports, regional input supply and extension system (Welteji, 2018). As a result, Ethiopian farmer's adoption of fertiliser remains high among the African countries in this cluster.

Notably, the examination of public expenditure on agriculture among these countries reflects that Malawi (11 per cent in 2017) and Mali (12 per cent in 2017) were some of the African countries that achieved the target of allocating roughly 10 per cent of public expenditure to agriculture, while Burkina Faso (8 per cent in 2017), Nigeria (2 per cent in 2016), Angola (1 per cent in 2013), Ethiopia (3 per cent in 2017), and Rwanda (9 per cent in 2016) were still way behind the target (SPEED, IFPRI, 2019). Despite expanding public expenditure on agriculture due to the commitments made under the Maputo Declaration, a large share of budgetary allocation focused on input subsidies rather than capital formation in agriculture which includes investments in R&D as well as extension services. Therefore, the continued public investments in the input market need a smart subsidy programme accompanied by private investment to promote competition in the input market (Baltzer and Hansen, 2011).

At the same time, most African countries in this cluster have agricultural polices encouraging production of specific crops. For instance, much of Burkina Faso's budgetary allocation in agriculture is concentrated in the cotton industry.[6] Consequently, food production has not kept pace with population growth, resulting in rising food imports. To reverse this trend, this group of countries needs to prioritise agricultural policy towards self-sufficiency in food crops. For example, the President of Angola, under the Production Support Programme Diversification of Import Export and Replacement has listed import substitution in food production to encourage local production. Indeed, the policies promoting food security should be accompanied by nutritional sensitive programmes, particularly since many countries in this cluster have a high level of undernourishment. Between 2004-06 and 2020-22, the prevalence of undernourishment in Nigeria has increased from 7.0 to 15.9 per cent while Rwanda reported 31.6 per cent of undernourished people in 2020-22 according to the State of Food Security and Nutrition Report (2023). In Mali, 23.8 per cent children under five were stunted in 2022. Owing to chronic food insecurity and undernutrition, the governments in these countries have been implementing cash transfer schemes, food distribution at subsidised rates and public works programmes. For example, the Malian Government along with the World Bank has implemented an unconditional cash transfer programme 'Jigisemejiri –Tree of Hope' which mainly targets poor and chronically food-insecure households and provides a monthly transfer of CFAF 10000 (US$ 20) per household (FAO, 2017a). In addition, the government of Mali adopted the National School Feeding Programme in 2009 to improve the nutritional status of school-going children. While the programme has increased the school enrolment among girls, increasing community-based participation and linking the feeding programme to local agricultural production remain major challenges.

6. The Government of Burkina Faso has been providing subsidies to cotton farmers and fixing the prices of cotton seeds to sustain cotton production.

Cluster 3: States are characterised by high GVOA per hectare, low agriculture share in GDP, average input access and irrigation coverage with low level of poverty

The Indian states in this cluster include Himachal Pradesh, Uttarakhand, Kerala and Jammu and Kashmir. The most striking features of these Indian states are that they are characterised by a low level of poverty and low malnutrition among children. Although the contribution of agriculture to GDP is low in these states, they are better off in terms of the value of agricultural output per hectare. These states are endowed with agro-climatic zones and natural resources conducive for diversification towards high-value agriculture such as spices, livestock and fruits and vegetables. For instance, the value of output in the agricultural sector is dominated by fruits and vegetables and livestock in Jammu and Kashmir; cereals, fruits and vegetable, livestock, forestry and logging in Himachal Pradesh; oilseeds, spices, fruits and vegetable, livestock and fisheries in Kerala and cereals, fruits and vegetables, livestock and forestry and logging in Uttarakhand.

Notably, in Uttarakhand, the GDP grew by 9.8 per cent annually from 2000-01 to 2019-20 rendering the state to be the fastest-growing state in India. The separation and establishment of Uttarakhand from the parent state of Uttar Pradesh in 2000 helped realize its potential for better development and governance for sustained growth. However, agriculture growth in Uttarakhand (2.21 per cent annually) was lower than the all-Indian average of 3.3 per cent per annum during the period from 2000-01 to 2019-20. Jammu and Kashmir (3.00 per cent per annum) and Himachal Pradesh (4.77 per cent per annum) achieved moderate agricultural growth during the period. By contrast, Kerala recorded a negative growth rate of -0.41 per cent per annum. Kerala's agriculture has been highly volatile due to global price shocks owing to high dependence on cash crops. This partly reflects the volatility in agricultural growth in the state.

Policy solutions exist that can help these states to make agriculture profitable and improve farmer's income. Given all four states have diversified towards high-value agriculture, the states need to facilitate investments in marketing and agro-processing infrastructure. Moreover, these states should encourage private investments to establish value chains similar to AMUL model outlets (a milk product cooperative dairy company in Gujarat) for procurement and distribution of high-value agriculture products to make agriculture inclusive, sustainable and profitable. In addition, the state governments need to promote training programmes as well agricultural extension services to empower small and marginal farmers as self-reliant agri-entrepreneurs.

Unlike the other states in this cluster, Kerala's government's excessive intervention in agricultural credit, pricing, procurement and marketing has resulted in distorting the agriculture market. Moreover, the restrictive government policies in input markets, namely, land and irrigation as well as output markets such as price and procurement have made agriculture unprofitable in the state. For instance, the land-use control policies for incentivising paddy farming have created disincentives to small and marginal farmers for paddy cultivation, which resulted in declining paddy cultivation (Nair & Dhanuraj, 2016).

Drawing on a range of policies and strategies from these Indian states, we outline broad priority areas and best practices among the African countries of this cluster - Ghana, Tunisia, Cote d'Ivoire, Senegal and Morocco that will help to accelerate agricultural productivity and growth in both regions.

In these African countries, the contribution of agriculture to the economy is lower than the African average, ranging from 18.9 per cent in Ghana to 10.0 per cent in Tunisia. Still, the sector remained the primary means of livelihood for roughly 45.9 per cent of the population in Cote d'Ivoire, well over one-third of the population in Morocco and a quarter in Senegal in 2019. Even though Tunisia is an industrialised economy, agriculture is still of vital significance, employing 14.3 per cent of the workforce.

These countries need to increase agricultural productivity, particularly of staple crops to meet the growing food demand and build a diversified, competitive and sustainable agricultural sector. The agricultural policies in these countries encourage the cultivation of cash crops for export rather than staple crops for domestic consumption. Therefore, in Senegal, the Accelerated Programme for Agriculture in Senegal (PRACAS) was implemented to improve self-sufficiency in food. Launched in 2004, PRACAS aimed for "self-sufficiency of rice and onion by 2017 and 2016, respectively, along with optimising the performance of the groundnut sector and developing the off-season fruits and vegetable sector" (FAO, 2015b pp. 2). Similar programmes in line with PRACAS can be designed to improve food security in other countries of this cluster.

Agricultural intensification including fertiliser utilisation and tractor intensity, particularly in Morocco, Tunisia and Senegal is relatively higher than in other African countries. The governments in these countries have been encouraging agricultural intensification through national programmes to improve agricultural productivity and competitiveness. However, rather than the universal subsidies, a smart subsidy programme would be more effective, that is, specifically targeted at smallholders, poorest and vulnerable farmers who do not have access to agricultural inputs (Baltzer and Hansen, 2011). Further, the schemes could build upon the existing private input supply network for the development of a competitive input market. For instance, Ghana's Fertiliser Subsidy Programme implemented in 2008 utilised extensively the existing private sector for input supply, distribution and retailing. The programme included a market-oriented voucher system that allowed farmers to choose freely between different suppliers, thereby increasing competition among the existing businesses. The government of Senegal, within the context of CAADP commitments, elaborated the National Agricultural Investment Programme during 2011-2015, which focused on input production and productivity, development of agricultural value chain and processing facilities, and increasing market access for agricultural products. Since most of the agricultural equipment and inputs are imported, the provision of subsidised credit for the rural producer would have a positive impact on the agricultural transformation.

The countries in this cluster, located in West and North Africa, are faced with the adverse impacts of climate change coupled with low agricultural productivity and food insecurity, resulting in rising food imports. Not only that, agriculture, particularly in Morocco and Ghana, needs to be more resilient to climate change such as droughts to boost agricultural production. For these countries, investment in innovative irrigation technology like drip irrigation and the use of drought-resistant crops are some feasible solutions to increase agricultural productivity.

Importantly, the provision of input without the transfer of technical know-how will not be able to enhance the resilience of smallholders to climate and market-related risks. Therefore, increasing agricultural extension services along with targeted policies for training subsistence farmers will encourage them to diversify towards high-value agriculture and thereby, create employment opportunities and stimulastimulate income in rural areas (Hazell, 2013).

Adding value to the wide range of cash crops, cultivated in these countries through investments in agro-processing can accelerate farm income. In addition, reforms are required in agricultural marketing since a well-functioning market, be it input, output or factor market is crucial for smallholders to diversify towards high valued commodity. In Tunisia, for example, the government is now prioritising private investments in niche markets such as organic food, bottled olive oil, processed fruits and vegetables, which can be developed into new agribusiness sub-sectors in the country.

Cluster 4: Agrarian states with slow structural transformation, high poverty, widespread malnutrition level and poor agricultural productivity although endowed with adequate access to technological input and irrigation coverage

Indian states in cluster 4 include Madhya Pradesh, Uttar Pradesh and Bihar. These states are densely populated with a high share of agricultural GDP. Further, these states also have a high share of the labour force employed in agriculture which ranged from 47.15 per cent in Uttar Pradesh to 58.35 per cent in Madhya Pradesh (PLFS, 2019-20). Despite being well endowed in natural resources, a vast network of road and high irrigation coverage, the productivity of major crops in these states was lower than the all-India average. In addition, these states have the lowest farm income in the country, particularly Uttar Pradesh and Bihar, according to NABARD's Financial Inclusion Report (2018). Studies indicate that low farm income deters farmers from investing in agricultural inputs, which prevents these states from increasing agricultural productivity.

Clearly, agriculture will remain a major part of the economic structure of these states for another decade or so. All three states need to focus on agricultural growth along with the right mix of policies for structural transformation and poverty alleviation. It is noteworthy that Madhya Pradesh attained a high agricultural growth of 6.0 per cent annually (during 2000-01–2019-20), almost double the all-India average, in spite of a low level of agricultural intensification in the state. Improving access to irrigation facilities and all-weather roads to connect farmers to markets with a robust procurement system for wheat (which included a bonus over the minimum support price (MSP)) are some of the important policy interventions adopted by the Madhya Pradesh government to accelerate agricultural growth. The agricultural transformation in Madhya Pradesh can offer policy lessons for low-income African countries.

Over the last two decades, the states in this cluster have been making strides to increase investment in creating marketing and agro-processing infrastructure to diversify towards high value agriculture for accelerating agricultural growth and alleviating high poverty rates. Food processing is crucial for all these states as the high-value segment dominates the agricultural output, particularly in Bihar. Bihar was one of the first states in India to bring reforms in agricultural marketing in 2006, thereby, liberalising the agricultural markets from the gambit of the Agricultural Produce Marketing Committee (APMC). Although the liberalised regime in the post-APMC era seems to have been a mixed experience for different stakeholders in Bihar, they tend to favour processing industries as they now have increased sourcing options without paying mandi (market) taxes. However, the state requires huge investments in storage, cold chain and warehousing facilities to earn remunerative prices for the high valued produce.

The challenges and opportunities faced by Uttar Pradesh, Bihar and Madhya Pradesh can provide insights to low-income African countries of these clusters i.e., Democratic Republic of the Congo (DR Congo), Niger and Madagascar and simultaneously, learn from their agricultural pathways.

Agriculture in Niger, a landlocked country in West Africa, employs more than 71.2 per cent of the population while Madagascar's and DR Congo's agriculture employs roughly 74.2 and 56.3 per cent, respectively in 2019 (FAO, 2022).[7] The major cultivated crops are rice, maize, sweet potato, potatoes, groundnuts, beans and cassava in Madagascar; pearl millets, sorghum, cowpeas, cassava, sweet potato, rice, maize and wheat in Niger; and cassava, sugarcane and maize in DR Congo. The main export cash crops are vanilla, cloves, coffee, cotton, cocoa, sugarcane, and sisal in Madagascar; coffee, cotton and groundnut in Niger; and tobacco and coffee in DR Congo.

African countries in this cluster are characterised by limited access to agricultural inputs, low irrigation coverage, seasonal supply shifts, and inadequate storage infrastructure coupled with climate-related hazards including inconsistent rainfall patterns and drought, and pest infestation, resulting in low yield per hectare and food shortages. Consequently, this has serious repercussions on the price variability of staple food commodities and on food and nutritional security in these subsistence-based agrarian countries. On top of that, the prevalence of undernourishment in Madagascar has increased from 33.7 to 51.0 per cent during 2004-06 and 2020-22. In DR Congo, where the agricultural production covers only one-third of food consumed in the country, the child stunting rate was as high as 40.3 per cent in 2022 (FAO et al., 2023).

For this cluster, agricultural growth has enormous potential to catalyse structural transformation, increase food security and promote sustainable, equitable economic development. However, large food production deficits have prompted the governments to focus on increasing the production of staple crops through productivity gain

7. Agriculture employs the majority of the population, but mining contributes the most to Congolese GDP.

to promote food security and self-sufficiency, which in turn, depends upon the following key factors.

First, agricultural policies that promote sustainable agricultural intensification through increased access to technological inputs and farm machinery are important for agricultural growth. For instance, in Niger, the Integrated Production and Pest Management (IPPM) programme seeks to promote balanced fertilisation for healthy crop growth, help farmers adopt sustainable agricultural practices, reduce the use of harmful pesticides and support climate-smart technology. In fact, Niger is one of the few African countries to allocate more than 10 per cent of public expenditure to agriculture during some of years in the last two decades (9 per cent in 2013), achieving the target under CAADP commitments (as per the latest data available by the Statistics of Public Expenditure for Economic Development (SPEED) database 2019). This could have been a plausible factor for Niger attaining robust agricultural growth of 5.8 per cent for the period 2000 to 2019.

Second, agricultural diversification, particularly towards livestock, is one of the key factors to increase profitability in the agricultural sector as well as improve access to nutritionally diverse food. For this, governments should encourage private and public participation to integrate farmers/cooperatives into the value chains that can enhance farmer's technical know-how on mobilisation and the judicious management of resources. In addition, private sector value addition could support inclusive business models to increase rural employment and farm income. For instance, in Madagascar, the Agricultural Diversification Program, created in tandem with USAID, has encouraged the farmers to adopt efficient sustainable agricultural practices while providing business development services, thereby generating more profit and employment.

Thirdly, the high food insecurity and undernutrition in these countries also call for leveraging agriculture policies to be more nutrition sensitive. For instance, in DR Congo, Feed for Future (FFF) value chain development activities and Food for Peace (FFP) agricultural development activities under USAID work in tandem with the health and nutritional programmes to increase participation of smallholders in the agricultural market and ensure nutritional security. Furthermore, in countries with food shortages like Niger, market linkages between neighbouring countries can also play a significant role to ensure price stability and food security. For instance, trade between Niger and Nigeria has been critical for household food security, particularly during the lean season. Nonetheless, a heavy reliance on inter-regional trade among African countries can also aggravate food insecurity due to political conflicts or economic shocks in neighbouring countries.

Fourthly, these countries need strategies resilient to climate change, including rising temperature, droughts and extreme weather conditions, which poses a serious threat to food and nutrition security. Investment in irrigation systems like drip irrigation and precision farming technique will help to make agriculture more climate-change resilient and increase agricultural productivity.

Cluster 5: States with high per capita income, high per capita agricultural income, high agricultural intensification and diversified agricultural output towards livestock with a low level of poverty and agricultural growth

Cluster 5 includes the Indian states of Haryana, Punjab and Tamil Nadu. These states have been the front-runners in economic and agricultural performance with fast structural transformation. From 2000-01 to 2019-20, Haryana and Tamil Nadu recorded on average more than 7.0 per cent per annum of GDP growth while Punjab's GDP grew at 5.8 per cent per annum. Noticeably, these states have performed well in reducing poverty. In 2011-12, poverty dropped to less than 10 per cent in Punjab while it stood at 11 per cent in Haryana and Tamil Nadu. Looking at the agricultural transformation of these states could give us a better understanding of how these states achieved high growth trajectories.

Agriculture contributed one-tenth of GDP in Tamil Nadu while a quarter in Punjab in 2019-20. However, all three states still have more than a quarter of the workforce in the agricultural sector. Even though these states have achieved structural transformation, agricultural growth ranged between 4.1 per cent in Tamil Nadu to 1.96 per cent in Punjab from 2000-01 to 2019-20. Note that Punjab, was a front-runner in the agricultural sector, particularly during the Green Revolution period with an agricultural growth rate of 5.7 per cent during 1971-72 to 1985-86, more than double the all-India average growth rate (2.31 per cent). Today, the state has lost its top position of recording the highest GDP per capita and is also experiencing a deceleration in agricultural growth, although it is endowed with the highest irrigation cover and best road infrastructures with an increasing holding size. Exploring Punjab's agricultural strategy and policies can provide policy lessons for African countries to recognize what mix of demand-driven policies and incentives are required to sustain agricultural growth in the long term.

Even with the predominant rice-wheat system, these states have diversified towards high-value agriculture, particularly the livestock sector which accounts for more than one-third of their agricultural value of output. These states have recorded high GVOA per hectare, especially in Tamil Nadu. For these states to sustain agriculture growth and increase farm income, the state governments have been investing in the food processing sector, value chain along with creating forward-backwards linkages with the rural nonfarm sector to absorb the surplus labour force.

Agricultural growth in these states is influenced by a host of supply-side factors such as technology (fertiliser and farm mechanisation); infrastructure (irrigation, road and electricity) and incentives (price support). Rural infrastructure particularly rural roads, power, irrigation, and access to technological inputs provided significant drive to agricultural transformation in these states. Moreover, high procurement of rice and wheat at MSP especially in Punjab and Haryana has played a significant role in transforming their agricultural sector. Procurement at MSP ensures remunerative prices to the farmers for their produce which works as an incentive to increase production and productivity. But today, the two states need to bring down the area under paddy from 4.7 mha to just 2.5 mha and diversify the production base to other high valued commodities

(Gulati, 2023), since the region is experiencing high depletion of ground water table, environmental degradation as well as high greenhouse gas (GHG) emissions.

Algeria, Egypt and South Africa are the African countries of the cluster. In 2019, the share of agriculture to GDP ranged from 11-12 per cent in Algeria and Egypt to 2.0 per cent in South Africa. Structural transformation has been rather slow in Egypt as compared to the other two African countries with the share of agriculture in total employment ranging from 21.1 in Egypt to 9.9 per cent in Algeria in the same year.

Within the cluster, there is high variability in agricultural growth. Algeria was the only country that was close to achieving the target of 6 per cent agricultural growth under CAADP while Egypt and South Africa were lagging behind in agricultural growth at 3.2 and 2.5 per cent per annum, respectively, during the period 2000-2019. Despite being well endowed with high irrigation coverage and adequate access to technological inputs such as fertilisers and farm machinery, Egypt's agricultural growth was much lower than the continents' average. Besides, the agricultural growth has stagnated in the country, quite similar to Punjab's agricultural trajectory.

Various studies have shown that the Egyptian agricultural sector is characterised by traditional agricultural production and harvesting techniques, inadequate infrastructure for storage and transportation, poor management of water resources and scarcity of arable land, which, in turn, have limited diversification towards high-value agricultural exports (Tellioglu & Konandreas, 2017). Moreover, the country is still dependent on food imports to meet domestic food demand. In fact, more than 50 per cent of food is imported in Egypt which results in persistent food inflation. Unlike Egypt, Algeria is poorly endowed with land with a semi-arid climate and marked annual variations in rainfall. In addition, Algeria's agricultural imports including food accounted for almost 21.1 per cent of total value of merchandise imports in 2019 (FAOSTAT, 2022). Agricultural policies in these African countries should strive to increase agricultural productivity, particularly of staple crops to meet the growing food demand and build a diversified, competitive and sustainable agricultural sector.

Egypt, due to its unique climate and ecology, has potential for increasing production and export of high valued commodities such as fruits and vegetable (Tellioglu & Konandreas, 2017). The governments in these countries can strengthen agricultural performance through increased public investments as well as public private linkages in research and development (R&D), extension services, marketing and agro-processing infrastructure which are vital to increases agricultural productivity and meet the growing food demand.

Moreover, the livestock sector is prominent in the agricultural value of output in these countries. However, the sector has been facing constraints such as low productive breeds, low-value addition and lack of processing facilities and modern inputs. Integrating livestock and mixed cropping system provides a feasible solution not only to increase climate-change resilience but also contribute to stable and higher farm income in these countries. Priorities for sustainable agricultural production in these countries should also encompass water conservation techniques along with updating the efficiency of irrigation through digital farming techniques.

3

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Drivers of Agriculture Growth in Africa and India

Lessons for South-South Learnings

3.1 Introduction

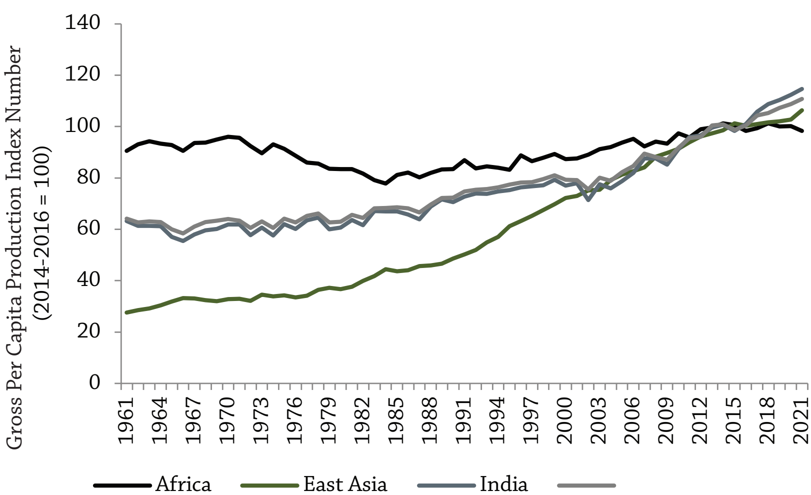
Studies have estimated that agricultural growth is approximately 2-3 times more effective in poverty reduction than growth in non-agricultural sectors (Christiaensen et al., 2011; Klasen and Reimers, 2017), especially for long-term and pro-poor economic development in Africa (Diaz-Bonilla et al, 2014, Dawson et al, 2016; Barrett et al, 2017; Goyal and Nash, 2017). It is also regarded as superior to overall economic growth in terms of enhancing child nutrition (Mary and Shaw, 2020). Agricultural growth has played a significant role in transforming economies and absorbing surplus labour through the expansion of the rural non-farm sector (Memfih, 2015; Suttie and Benfica, 2016; Badiane and Collins, 2016). This evidence has been well-established empirically by experiences in Asia and Latin America over the past few decades (High-Level Panel of Experts (HLPE) Report, 2013) and the same approach could be applied to African countries, as indicated by Diao et al. (2010).

India and Africa together constituted around 36 per cent of the world population in 2023 (World Population Prospects (WPP), 2022). In 1980s, the population growth in India was 2.3 per cent but came down to 1.4 per cent during 2000 to 2022, whereas in Africa, it was 2.9 per cent and only reduced to 2.55 per cent. Africa's population has already surpassed India's in 2022. The African agricultural sector needs to grow sufficiently to address the fast-growing demand for food with diversified diets.

Unlike Asian countries, which successfully increased agricultural yields through the adoption of Green Revolution technology, African counterparts faced limited success for various reasons, including the restricted utilisation of modern inputs such as fertilisers, improved seeds, agricultural machinery, and irrigation systems (Dawson et al., 2016; Memfih, 2015). Consequently, the progress achieved in agricultural development in Asian and Latin American countries could be replicated in Africa. It is worth noting that during the 1960s, the continent had a significantly higher gross per capita production index than South and East Asia. However, the per capita agricultural production index in Africa has been on a declining trend since the 1960s, with some improvements observed around the early 2010s. In

Figure 3.1

Trends in gross per capita agricultural production index



Source: FAOSTAT, various years.

recent years, the index has continued to decline in Africa and is now lower than that of South and East Asian economies (Figure 3.1).

Considering the continent's internal diversity, economic structure and income level, Africa is hardly comparable to any other region. However, Africa's current conditions are quite similar to the conditions that existed in India during the past decades. Additionally, India with internal heterogeneity and diverse agricultural practices could be compared with Africa as both the regions face similar challenges.

Apart from similarity in demographic characteristics, India and Africa have similar landholding structures with small landholdings (less than two hectares) constituting around 80 per cent of total landholdings in Africa (Viswanathan and Mishra, 2020) and 86.2 per cent in India (Agricultural Census, 2015-16). Even the contribution of agriculture to GDP is similar in Africa (15.3 per cent) and India (16.8 per cent), however, the share of the workforce employed in agriculture is slightly higher in Africa (48.3 per cent in 2019) (FAO, 2022) than India (45.6 per cent) (PLFS, 2019-20).

In this context, this chapter aims to identify the patterns and drivers of agricultural productivity that can accelerate agricultural transformation in the African countries and Indian states while ensuring sustainability.

Given the heterogeneous agro-climatic zones and different farming systems in Africa, the pertinent question is if the Indian Green Revolution, based on high yielding cereal varieties, agricultural inputs and intensive use of labour, can be replicated to transform Africa's agriculture? Therefore, the examination of the different drivers of agriculture growth including technological breakthrough as well as institutional reforms and policies that were adopted in India, will provide a valuable lesson for the success of the second Green Revolution in African countries. Similarly, gauging the agricultural trajectory of African countries to meet the food needs of an ever-increasing population in the face of climate change can provide insights for India to deal with challenges of sustainability. Hence, in the following section, we discuss the proximate drivers of agricultural growth in Africa and India.

This chapter is structured as follows. Section 3.2 describes the agricultural performances in both regions with regard to agricultural growth, agricultural productivity and sectoral composition. Section 3.3 describes the methodology, conceptual framework, empirical approach and data sources used in the chapter. Section 3.4 reviews the potential drivers of agricultural growth in Africa and India and discusses some empirical findings based on the different regression tools. Section 3.5 offers a discussion and conclusions.

3.2 Trajectory of African and Indian agricultural sector

3.2.1 Agricultural growth

Africa is well endowed with abundant arable land and labour. However, the progress towards increasing agricultural production and making the continent food secure has been rather slow. Africa constitutes 18.15 per cent of the world's arable land and 7.98 per cent of the global value of agricultural production in 2021 as per FAOSTAT, yet growth in agricultural production in the continent has been slower than population growth, due to which the continent has remained a net food importer (Waha et al., 2018; FAO, 2011). Agriculture in Africa is dominated by smallholders cultivating less than 2 hectares with traditional modes of farming (Oluwatayo and Ojo, 2016). Moreover, under-capitalisation, small and fragmented landholding, inadequate access to irrigation coupled with adverse climate change further constrained agriculture in Africa (AGRA, 2018).

For many decades, African agriculture lagged far behind other developing regions. In this regard, the African Union (AU) and the New Partnership for Africa's Development (NEPAD) jointly established the Comprehensive Africa Agriculture Development Program (CAADP) in 2003. Under CAADP agricultural productivity growth was recognized as important for addressing issues such as hunger, poverty reduction, food security, and expanding exports (Brüntrup, 2011; NEPAD, 2013; Myeki et al., 2022).

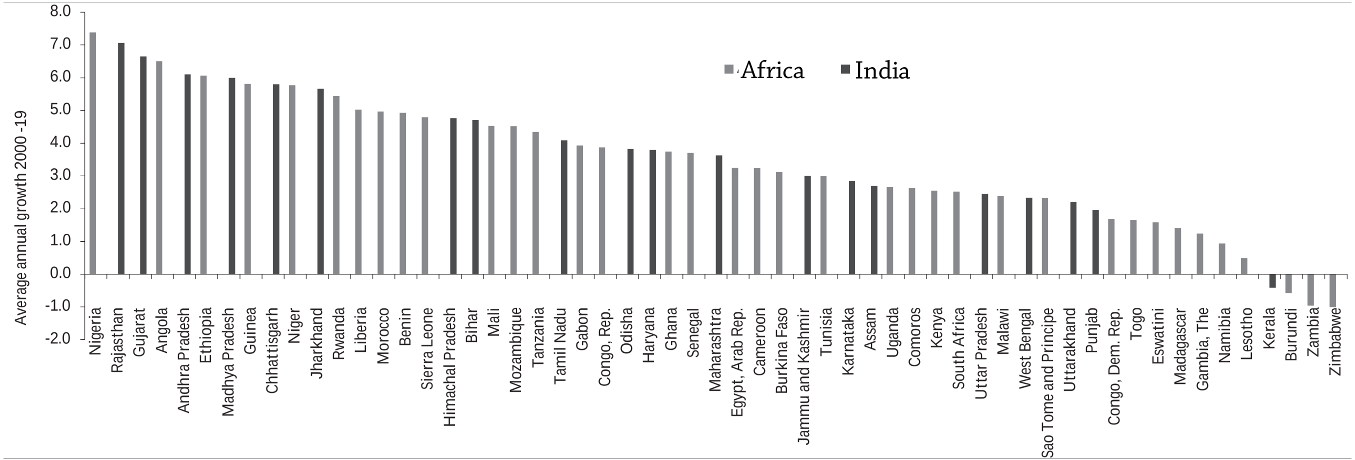
With the great impetus to increase agricultural investments in the past decade, with initiatives such as CAADP, NEPAD and Alliance for a Green Revolution in Africa (AGRA), the continent is undergoing remarkable recovery (Badiane and Collins, 2016). Between 2000 and 2019, Africa's agriculture entered into a period of sustained and remarkable growth with the sector growing at 4.5 per cent annually. The average agricultural growth variability (measured by the coefficient of variation of annual growth rates) was 0.4 for Africa as a whole. Low variability is important to maintain growth momentum while coping with aberrant weather conditions, droughts, and desert locust upsurge. However, it was still below the target of 6 per cent as stated under CAADP.

Despite robust agricultural growth in Africa, there are large fluctuations in different parts of the continent (Figure 3.2). Some African countries recoded a higher agricultural growth than the continents' average and surpassed the 6 per cent target under CAADP such as Nigeria (7.4 per cent), Angola (6.5 per cent) and Ethiopia (6.1 per cent). However, countries like Burundi, Zambia and Zimbabwe registered negative agricultural growth rate during the same period. In absolute terms, the highest agricultural GDP was recorded by Nigeria followed by Egypt and Ethiopia while Rwanda and Malawi had the lowest agriculture GDP in 2019 (within the selected African countries for our study).

Meanwhile, during the same period between 2000-01 to 2019-20, India's agricultural sector recorded a much lower growth rate than Africa at 3.3 per cent annually with a growth variability of 1.2. We observe a significant spatial variation in agricultural growth performance. Among the major Indian states, Rajasthan reported growth rate of 7.1 per cent per annum, more than double of the all-India agricultural growth during the same period. Punjab, a front-runner in agriculture during the Green Revolution with high agricultural intensification and farm mechanisation, has experienced lower agricultural growth during the same period (1.96 per cent). Another state that performed poorly was Kerala. In absolute terms, Uttar Pradesh attained the highest agricultural GDP followed by Andhra Pradesh and Maharashtra in 2019. However, in terms of

Figure 3.2

Average annual growth rate of Agricultural GDP (%) (2000 to 2019)



Source: MOSPI (GoI) and World Development Indicators, World Bank.

growth rate, Uttar Pradesh attained only a moderate agriculture growth rate of 2.5 per cent between 2000-01 and 2019-20.

3.2.2 Agricultural productivity

The examination of agricultural productivity in both the regions can give valuable inputs on the key sources of agricultural growth as well as on constraints affecting sustainable agricultural growth. Studies have shown that countries with the highest agricultural growth per worker experienced the greatest rate of rural poverty reduction (Byerlee et al., 2009). Increasing agricultural productivity is important not only for reducing poverty but also increasing agricultural and food production for a growing population. Agricultural Total Factor Productivity (TFP) is a comprehensive measure which quantifies the amount of agricultural output produced using the combined resources of land, labour, capital, and materials employed in farm production. Unlike partial productivity measures, such as labour or land productivity, TFP measures changes in agricultural productivity due to technological advancements which in turn are influenced by enabling environment factors, such as infrastructure, political stability, and sound economic policies. Furthermore, it has been prioritised by policymakers as well as under CAADP for enhancing African agriculture (Benin and Nin-Pratt, 2016).

Figure 3.3 illustrates the TFP index across India, Sub-Saharan Africa, North Africa since 1961. TFP growth was nearly stagnant for Sub-Saharan Africa during the 1960s and 1970s. However, there was a noticeable improvement in the region's average productivity in the mid-1980s. During 1981 to 2000, TFP in the Sub-Saharan Africa region has been consistently growing at an annual rate of approximately 1 per cent.

While TFP growth in India and North Africa was around 1.5 per cent each during the same period. Since then, TFP growth in India improved to around 2.3 per cent during 2000 to 2019. While in Sub-Saharan Africa and North African countries, it fell to 0.2 and 1.4 per cent respectively during the same period. Agricultural research plays a crucial role in achieving these goals. In 2019-20, India allocated approximately 0.47 per cent of its agricultural GDP to agricultural research and development (Gulati and Thangaraj, 2023), whereas many African nations allocate less than half of that amount. As a result, despite substantial efforts in policy development, the endeavour to increase agricultural TFP in Africa and narrow the gap in TFP growth across the continent has not been successful.

Agricultural productivity can also be gauged through land productivity (output per hectare). In terms of average cereal yield, Africa is nearly half of that in South Asia and India, and approximately one-third of that in East Asia (see Figure 3.3.b). The limited success of the Green Revolution in the African continent during the 1980s has led to deceleration in cereal productivity compared to developing countries including India over the decades. Even within the continent, there are large variations in land productivity. Central and West African regions have cereal yields much below the global benchmark. Agricultural growth in both these regions is driven by area expansion which is in sharp contrast to other regions where productivity gains have been the main driver of the increase in agricultural production. West Africa is the most extensively cropped region cultivating traditional cash crops such as cocoa and cotton along with yams, cereals and other root crops. East and Central Africa's land use pattern is dominated by the highland temperate mixed system and maize mixed system which extends to southern Africa. In terms of agricultural yield, Southern and North Africa have performed remarkably well as compared to the other regions (Figure 3.3.b). One reason could be that Southern African countries such as South Africa, Angola, Mozambique, Namibia, Eswatini etc. have a large commercial and smallholder system (Wood et al, 2016). Comparing the cereal yield per hectare with Indian states shows that the majority of Indian states have higher cereal yield compared to African countries with Egypt being the only exception.

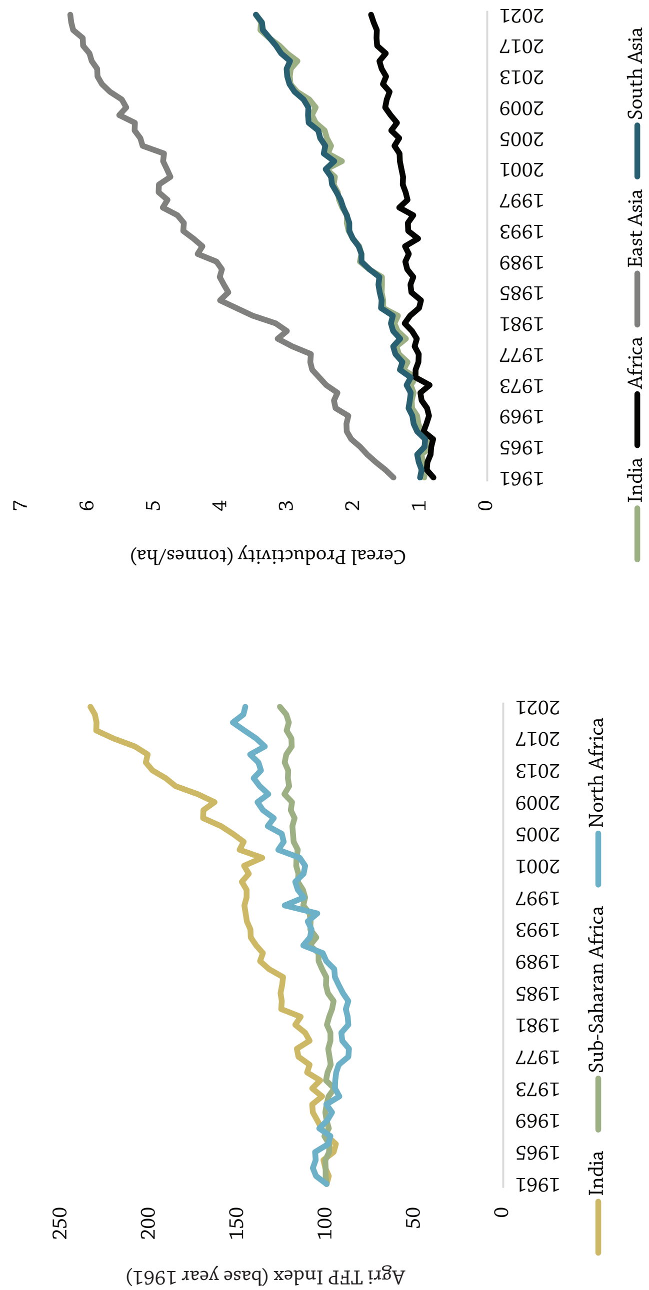
Unlike TFP growth and land productivity, African agriculture has shown promising signs of progress in labour productivity (output per worker) (AFDB, 2021). Comparing the labour productivity across the continent and states as illustrated in Figure 3.4, it is clear that African counterparts (Eswatini, Tunisia, Egypt etc.) have performed

Figure 3.3

Agricultural productivity gap across Africa and India

a. Agri Total Factor Productivity

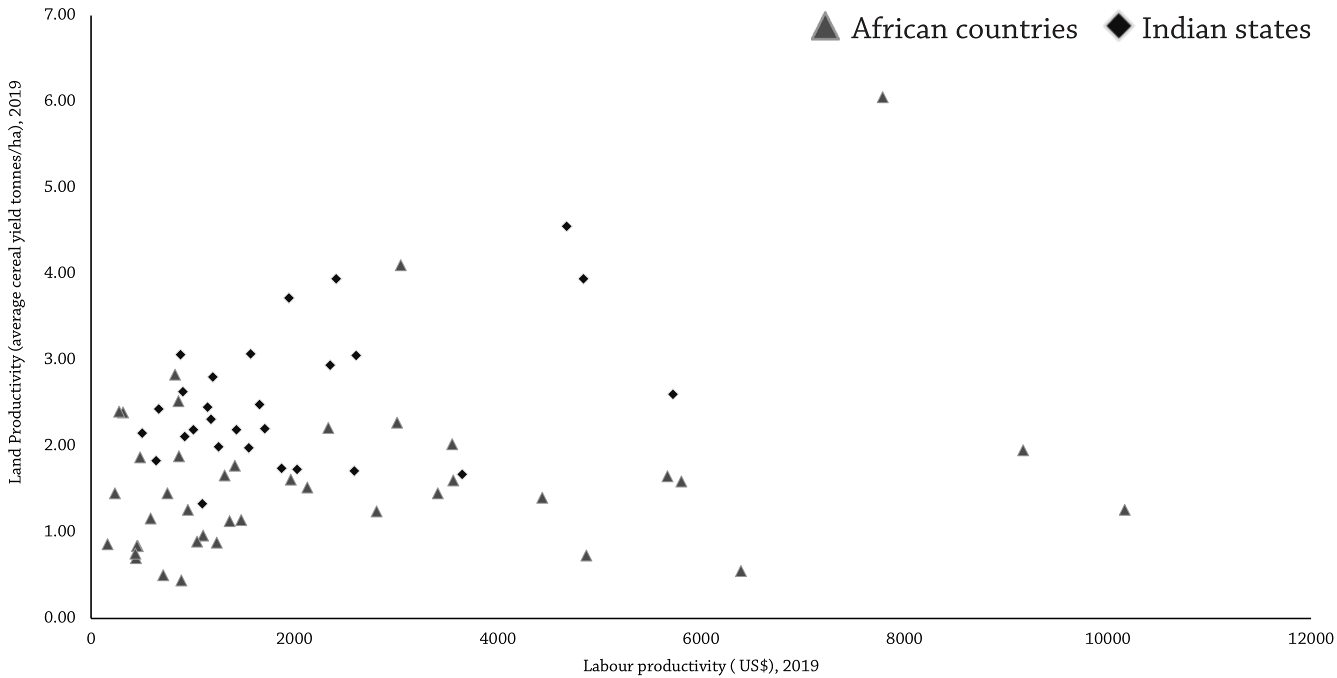
b. Land Productivity (average cereal yield)



Source: FAOSTAT, USDA, various year

Figure 3.4

Land and labour productivity across African countries and Indian States



Source: FAOSTAT, ILO Modelled Estimates, MOSPI, PLFS, DES, GoI. Note: Data for Africa's Agriculture, forestry, and fishing, value added is at constant 2015 US$. India's figures for Gross State Value Added in agriculture is at 2011-12 INR prices converted to US$ using 2019 exchange rate from OECD.

remarkably well compared to Indian states. Several studies have shown that labour productivity differences between developed and developing countries are much larger in agriculture than in non-agriculture (Blanco and Raurich, 2022). The use of new technologies and resources increase production per worker along with food availability per worker, accelerating pro-poor growth in poor agrarian economies (Dorward, 2013). This is because higher labour productivity releases agricultural labour from food production to production of other goods and services (as fewer workers are needed to produce the food that society requires) which in turn helps in structural and rural transformation.

During the early 1950s, Indian agriculture was characterised by subsistence farming, low productivity and primitive techniques (Kumar, 2019; Parayil, 1992) similar to the African agricultural sector. Although food grain cultivation was dominant in the land use pattern in India, food shortages could not be eliminated and in many parts of the country, drought and famine were frequent. The popular proclamation was that India was heading towards a Malthusian catastrophe[8] with stagnant agricultural productivity and a rapidly increasing population (Lerner, 2018). The stagnant decades of the 1950s and 1960s in India before the onset of the Green Revolution look remarkably similar to Africa during the 1980s[9] and 1990s with low agricultural productivity, poor land rights, low investments in agriculture, lack of access to market and poor remuneration and incentives.

3.2.3 Sectoral composition

Figure 3.5 shows that the structural composition of the agricultural sector in Africa has changed significantly over the last decade.[10]

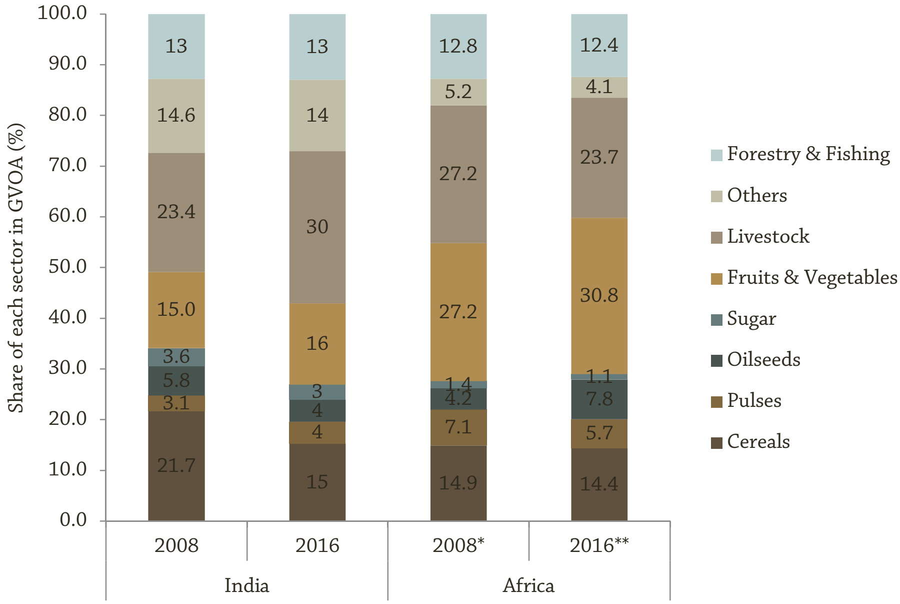
8. The classical Malthusian argument stated that a country's "population when unchecked grows at a geometric ratio," whereas its food production in "an arithmetic ratio" (Malthus, 1798). In other words, a nation's food production grows linearly while the population grows exponentially , which would lead to a Malthusian catastrophe.

9. Incidentally, India and Africa started diverging on the economic front during the 1980s and the reason was the difference in the performance of the agricultural sector (Fujitia, 2010).

10. For evaluating the sectoral composition, the share of the value of the output of different segments as a percentage of the total value of output from agriculture and allied activities

Figure 3.5

Shares of each sector in the agricultural value of output



Note: GVOA for India includes all states included in the analysis. * Africa's GVOA for 2008 includes Kenya, Niger, Uganda and Tanzania ** Africa's GVOA for 2016 includes Kenya, Nigeria, Uganda, Senegal, Niger and Tanzania

Source: Government of India, State-wise Estimates of Value of Output from Agriculture and Allied Activi ties and FAOSTAT, various years

In Africa, the sector-wise composition of the agricultural sector has changed significantly between 2008 and 2016. In 2008, livestock and fruits and vegetable accounted for 27.2 per cent each of the value of agricultural output; however, the share of fruits and vegetables has increased to 30.8 per cent while that of livestock had declined to 23.7 per cent in 2016. Livestock, an important source of farm income for smallholder farmers in Africa, has declined considerably in Africa's GVOA. The share of oilseed has increased considerably over the period

(GVOA) are estimated for the years 2008 and 2016. Note that the data for GVOA was available for only a few African countries; nonetheless, we have computed the composition of GVOA to show the share of each sector in agriculture's value of output in Africa. As the data for Africa's GVOA was unavailable for 2000, we have analysed the composition of GVOA for 2008.

from 4.2 per cent to 7.8 per cent. During the same period, the shares of cereals, sugar and forestry and fishing have remained stagnant while the share of pulses has declined (from 7.1 to 5.7 per cent), although it remains important.

Like Africa, the agricultural sector in India is also diversified. In recent years, although agriculture (crop) continues to be the largest sector, the share of livestock in the total value of output in agriculture has increased from 23.4 per cent in 2008 to 30 per cent in 2016. During the period, the share of oilseeds, cereals and sugarcane in agriculture's value of output has declined while that of fruits and vegetables and pulses has slightly increased from 15 to 16 per cent and 3.1 to 4 per cent, respectively.

3.3 Data and methodology

3.3.1 Conceptual framework

In evaluating the factors that impact agricultural growth in Africa and India, we start from a classical agricultural production function, for instance, Hayami and Ruttan (1970), and employ a cross-country Cobb-Douglas production function of the form:

$$Output_j = Aw^{\alpha} l^{\beta} \tag{1}$$

Where w and l are variable and fixed inputs used for the production of good j with $0<\alpha,\beta<1$. A is the total factor productivity. We now assume a country i produces several agricultural products at current price p_j. Therefore, the log transformed agricultural gross domestic product (AGDP) of country i in a fixed effect specification can be written as:

$$\ln(AGDP)_{it} = \Sigma_j \ln \mathrm{p}_j \ \ln(A) + \alpha\ln(w) + \beta\ln(l) + u_{it} \tag{2}$$

From equation (2), we can see that AGDP is a function of the (and increases in the) production inputs w and l and the price of the individual agricultural products which lead to two hypotheses:

1. In presence of the diminishing marginal returns with respect to the individual inputs, AGDP will be higher for a diversified agricultural sector that produces at a steeper slope of the production function.
2. Under the assumption that resource allocation between agricultural products is inelastic in the short-run, AGDP will be higher if a greater share of high value products (high p_j) is produced.

The remaining part of equation (2) is A, the TFP, defined as the ratio of total output to total inputs. TFP measures how efficiently agricultural inputs are used to produce a country's agricultural output: that is TFP growth measures technological progress in production processes equivalent to an upward shift in the production function. Yet, TFP is an intangible concept and is not observable but estimated as the unexplained component of equation (1). Dhehibi et al. (2015) list several factors as important sources of productivity change, and therefore, TFP growth in the agricultural sector: research and development (R&D) extension, education, infrastructure, government programs and policies, technology transfer and foreign R&D spill overs, health, structural change and resource reallocation, and sectoral terms of trade. Some of these factors, particularly agricultural R&D, are expected to have effects on TFP only in the very long-term, others (like education and health) may not change on an annual basis and could be considered as part of the country fixed effect. Therefore, we concentrate on the factors: infrastructure, structural change and resource reallocation, and sectoral terms of trade. Structural change and resource allocation are closely linked to the sectoral terms of trade, which express the price of agricultural products in relation to manufacturing or service products. Specifically, the sectoral terms of trade drive resource allocation across sectors as they represent the relative returns in the different sectors. Chanda and Dalgaard (2008) in their study show that TFP is largely driven by inter-sectoral resource allocation. To account for inter-sectoral resource allocation, we include previous year's agricultural terms of trade and hypothesize that through their associations with TFP:

3. AGDP will increase in the quality of agricultural infrastructure
4. AGDP will increase in the agricultural terms of trade

3.3.2 Data sources

Much of the data on macroeconomic and agricultural indicators for Indian states have been taken from the Ministry of Agriculture and Farmers' Welfare, the Directorate of Economics and Statistics (DES) of the Government of India; Ministry of Statistics and Programme Implementation, Central Statistical Organization; Fertilizer Association of India; FAOSTAT and Tractor Manufacturer Association.

For other indicators such as population, the labour force in agriculture, electricity index, transportation index and Information and Communication Technology (ICT) including telephone subscription (fixed, and mobile phone), we have used data from the Census of India, Periodic Labour Force Survey (PLFS, various years), Central Electrical Authority, Basic Road Statistics of India, Ministry of Road Transport and Highways and Telecom Regulatory Authority of India (TRAI), respectively. The rainfall data for Indian states have been taken from Rainfall Statistics of India, India Meteorological Department (IMD).

For African countries, we have taken the data from the United Nation's Food and Agriculture Organization database (FAOSTAT); United States Department of Agriculture (USDA); the World Bank's World Development Indicators (WDI) and United Nations' World Population Prospects. For data on African infrastructure including transportation, ICT, electricity etc., we have made use of the African Infrastructure Development Index (AIDI) published by the African Development Bank.

The detailed description of the variables used in the empirical analysis is given in Appendix Table B1. Since there are several caveats in using different data sources to make comparisons between African countries and Indian states, we have taken care to ensure that differences in the variables are small so that the conclusions drawn are not invalidated.

3.3.3 Empirical approach

In this section, we outline the econometric approach. Our econometric strategy consists of two parts. In the first part, we analyse the determinants of agricultural growth, specifically, the AGDP across Indian states and African countries in a dynamic panel framework to account for the persistence of agricultural growth and to accompany and distinguish between short and longer-term drivers of agricultural growth. The unit of analysis is country/state-year and possibly sector-country/state-year in our panel of 27 Indian states[11] and 41 African countries.[12]

The pooled regression model, including both Indian states and African countries, takes the following form:

$$In(AGDP) = \beta_1 In(AGDP)_{i,t-1} + \beta_2 In(input\ index)_{i,t-1} + \beta_3 In(ToT)_{i,t-1} + \beta_4 In(Area)_{i,t-1} + \beta_5 In(Specialization\ index\ H2)_{it} + \beta_6 In(Transport\ index)_{i,t-1} + u_{it} \quad (3)$$

where *i* reflects an Indian state or African country and *t* is the year subscript. u_{it} comprises the random error e_{it} and the time-invariant state/country fixed effect $\bar{u}_i$ that address endogeneity driven by any unobserved heterogeneity of the panel units. The observation period is restricted to the time between 2000 (2000-2001 for India) to 2019 (2019-2020 for India). This leaves us with N=68 and T=20. On that

11. Indian states included in the analysis are Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh, Uttarakhand and West Bengal.
12. African countries included in the analysis are Angola, Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Comoros, Congo, Dem. Rep., Congo, Rep., Cote d'Ivoire, Egypt, Arab Rep., Eswatini, Ethiopia, Gabon, Gambia, The, Ghana, Guinea, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia and Zimbabwe

account, we continue using econometric methodologies for so-called short panels.

The inclusion of the lagged dependent variable in a dynamic panel introduces a correlation between the error term lagged dependent variable known as the Nickel Bias (Nickell, 1981). In addition to that, even if an independent variable is exogenous in the static model, it may be correlated with the error term through the lagged dependent variable, and therefore, standard panel econometric estimators will be biased. In the specification in equation (3), the independent variable contains strictly exogenous variables as well as endogenous variables (current value associated with a past value or the error term). In the dynamic model, the regressors such as ToT (terms of trade between agriculture and manufacturing), rainfall index, transport index and specialization index H2 have been taken as exogenous instruments while the lagged dependent variable (AGDP), input index and agricultural area are endogenous.

In the presence of both Nickel Bias and endogeneity, Arellano and Bond (1991) suggested a Generalized Method Moments (GMM) estimation. The Arellano and Bond or difference GMM estimator takes the first differences and instruments the lagged dependent variables and the predetermined variables by their lagged differences:

$$\Delta In(AGDP)_{it} = \beta_1 \Delta In(AGDP)_{i,t-1} + \beta_2 \Delta In(input\ index)_{i,t-1} + \beta_3 \Delta In(ToT)_{i,t-1} + \beta_4 \Delta In(Area)_{i,t-1} + \beta_5 \Delta In(Specialization\ index\ H2)_{it} + \beta_6 \Delta In(Transport\ index)_{i,t-1} + \Delta u_{it} \quad (4)$$

The system GMM has advantages over the differences GMM estimator in terms of instrument relevance and efficiency, however, it implicitly assumes the data is mean stationary (Roodman, 2009). We test the stationarity of both the dependent and the independent variables using *xtfisher* test and cannot reject a unit root for the AGDP, input index, and transport index. Therefore, we apply one-step difference GMM estimator. One of the limitations with the GMM models is the possible issue of serial correlation which invalidates the instrument and renders the estimation unreliable (Baltagi, 2008). Further, for the validating GMM dynamic models, we use the Sargan test for over-identifying restrictions and the Arellano-Bond serial correlation AR (1) and AR (2) test, as developed by Arellano and Bond (1991). Failing to reject the AR (2) test renders the use of first differences as instruments possible, otherwise deeper lags need to be used for the instrumentation.

Given that the Arellano Bond estimator is designed for short panels that have a large number of panel units, the estimator is appropriate for the full sample of 68-panel units, however, appear to be ill-suited for the estimation for a sub-sample of countries. Therefore, we choose a standard first difference estimator when running the regression for African countries and Indian states separately. Specifically, we estimate the following model:

$$\Delta(AGDP)_{it} = \beta_1(AGDP)_{i2000} + \beta_2\Delta(input\ index)_{it} + \beta_3 In(Area)_{it} + \beta_4\Delta(Specialization\ index\ H2)_{it} + \beta_5 In(rainfall\ index)_{it} + \Delta u_{it} \quad (5)$$

Equation (5) differs from equation (4) in three aspects; first, *t* refers to a time interval of 3 years; second, we omit the lagged dependent variable and third, we add an additional regressor AGDP in the base year (2000) to test for convergence (Martin, 2019). By estimating a medium-term growth model with 3-year intervals, it is less likely that previous growth rates play an important role. Further, endogeneity as a result of predetermination can be ruled out. Therefore, we have applied a linear regression model using Ordinary Least Squares to estimate equation (5).

3.4 Results

3.4.1 Potential drivers of agricultural growth in India and Africa

Irrigation coverage

Irrigation development is a key component of agricultural intensification that has facilitated more rapid growth in overall agricultural production when compared to the expansion of cultivated land (FAO, 2021). The African continent is highly dependent on the rain-fed production system. According to the Report on Agriculture in Africa (2019), only 6 per cent of the continent's arable land is under irrigation.[13] With respect to agricultural land, the latest publication of FAO (2022) shows that only 1.5 per cent is under irrigation in 2019. A priori evidence suggests that rainfall in the African continent varies considerably, limiting agricultural production during dry season and droughts (Xie et al, 2014). Difficult agro-climatic conditions and the adverse impact of climate change exacerbates the vulnerabilities faced by farming communities due to negligible irrigation coverage in the continent.

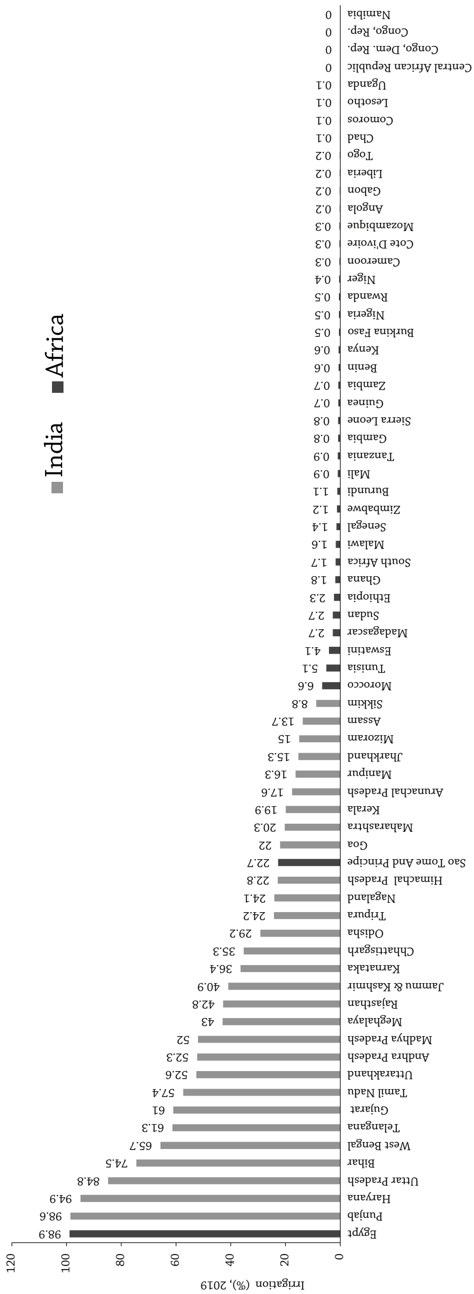
Expansion of both surface water (canal) and groundwater irrigation, particularly for small landholders, is important to boost agricultural productivity and farm income in Africa. Irrigation is also an important component for improving the efficiency of new seed-fertiliser technology. Much of the irrigation coverage in the continent is concentrated in only six countries, Egypt, Sao Tome and Principe, Morocco, Tunisia, Eswatini and Madagascar. In fact, the irrigation ratio ranges between 98.9 per cent in Egypt to being fully dependent on rainfall in Namibia, Central African Republic, Congo and Democratic Republic of the Congo (Figure 3.6).

On the contrary, India has done remarkably well in improving the irrigation coverage from 41.1 per cent to 55.1 per cent between 2000-01 and 2019-20. Arguably one of the key factors for the successful implementation of the Green Revolution in India was the diffusion of private tube wells (Fujita, 2010). Among the Indian states, Punjab recorded 98.6 per cent irrigation ratio followed by Haryana (94.9 per cent) and Uttar Pradesh (84.8 per cent). States such as Maharashtra, Kerala, Manipur, Mizoram Jharkhand and Assam reported the lowest irrigation coverage in 2019-20. Evidence suggests that the uncertainty due to low irrigation and high dependence on rainfall discourage farmers from investing in modern agricultural inputs and productivity-enhancing technologies.

13. According to the Malabo Montpellier Panel, the total area under irrigation in the continent increased by 1.5 per cent from 1990 to 2015 (The Report on Agriculture in Africa, 2019).

Figure 3.6

Irrigation coverage, India and Africa (%)



Source: DES, GoI; FAOSTAT, various years

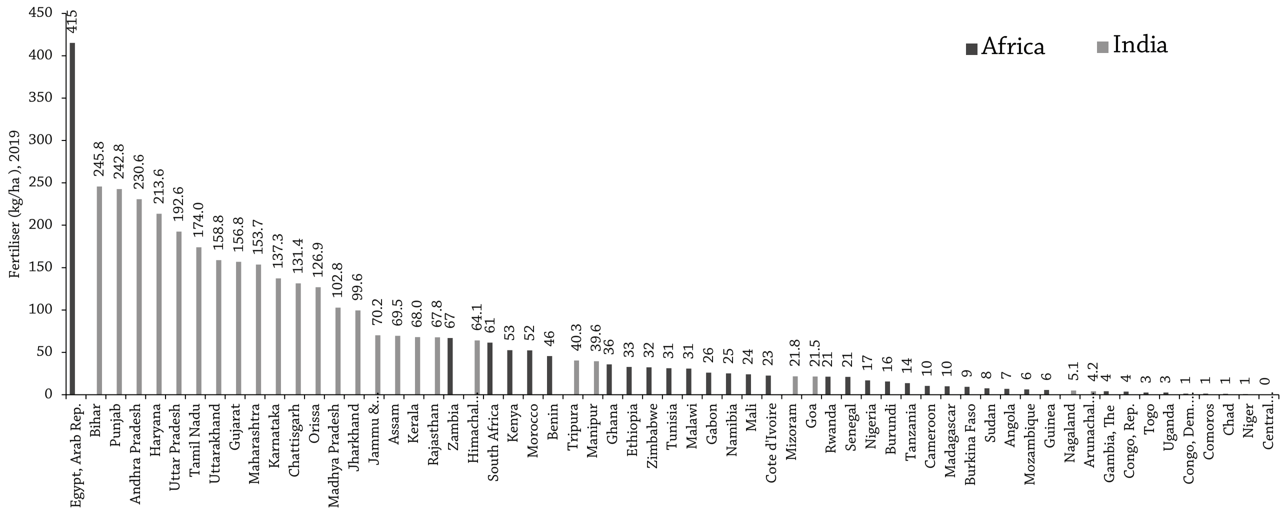
Access to technological inputs

Adoption and dissemination of improved and modern agricultural technology allow farmers to enhance productivity and get remunerative prices. Studies have shown that low-quality seeds, limited fertiliser application and mechanisation were some of the limiting factors that hindered the African Green Revolution from taking off (Pernechele et al, 2018; Voortman, 2013). According to the Report on Agriculture in Africa (2019), African farmers do not have access to necessary agricultural inputs in two-third of the total arable land. In addition, fertiliser usage remains inadequate in Africa, often benefiting medium or large farmers as compared to small landholders. The average fertiliser utilisation in Africa per hectare of cropland increased from 17.4 kg/ha in 2000 to 26.0 kg/ha in 2019 as per FAOSTAT (2021). During the same period, Egypt is the only African country to increase the average fertiliser utilisation per hectare of arable land from 382.8 kg/ha to 415.3 kg/ha which is far more than in comparison to all-India average of 143.44 kg/ha. In 2019-20, the fertiliser utilisation in Bihar (246 kg/ha), the state with the highest fertiliser utilisation in India, was almost half of Egypt. Other Indian states that have performed well in fertiliser utilisation are Punjab, Andhra Pradesh and Haryana (Figure 3.7).

The adoption of a universal fertiliser subsidy programme by the Indian government can explain the consistent rise in fertiliser usage in India. For example, between 2000-01 and 2019-20, fertiliser utilisation in India increased from 90 kg/ha to 143.44 kg/ha. However, the subsidisation is massively skewed in favour of urea/nitrogenous fertiliser which constitutes 75 per cent of the total fertiliser subsidy. Although increasing input intensities and subsidies have largely boosted agricultural growth in India, they have posed a considerable threat to the sustainability of the country's agriculture. Particularly the urea centric subsidisation policy is perpetuating the imbalanced utilisation of nitrogenous (N), phosphatic (P) and potassic (K) fertilisers (Gulati and Banerjee, 2019). In 2019-20, the NPK ratio in India was 7.3:2.9:1 which is undesirable both from a crop need point of view and from a sustainable productivity growth angle. At the same time,

Figure 3.7

Fertiliser utilisation (kg/ha), India and Africa



Note: Includes use of inorganic fertilisers only

Source: FAOSTAT, Fertiliser Association of India, various years there is wide variation in regional and inter-state fertiliser use and nutrient use ratios. These disparities in fertiliser use are also associated with farm size and irrigation facilities (which further depends on power subsidies). The negative externalities of agricultural intensification through power and fertiliser subsidies are contributing to the environmental problems with receding water tables, methane and nitrous oxide emissions, decline in crop response ratio and deterioration of soil fertility especially in the Green Revolution belt in India (Punjab, Haryana, western Uttar Pradesh). The government incurs substantial expenses through fertiliser subsidies, and it is crucial to revise the pricing policy and redirect these resources toward the promotion of balanced and efficient nutrient utilisation.

Like India, universal fertiliser subsidies were also common in Africa during the 1960s to 1980s. However, since the early 1990s, large inefficiencies associated with universal fertiliser subsidies and disproportionate fiscal costs against the benefits prompted a paradigm shift towards liberalising most of the fertiliser market, removing fertiliser subsidies and encouraging the development of private sector-led fertiliser markets in many African countries (Druilhe and Barreiro-Hurle, 2012). However, since the late 1990s, the policymakers in many African countries were of the view that stagnation in agricultural production and rising food insecurity requires supporting farmers through input subsidies to enhance agricultural productivity. Thus, the return of new subsidy programmes emerged in many African countries, after almost a decade of liberalised input markets. For instance, in Malawi, the government returned to a large-scale subsidy programme in 1998 and started providing free fertilisers to farmers. Nigeria, Tanzania, Kenya and Ghana also followed suit and promoted fertiliser subsidy programmes to enhance agricultural production. Moreover, the Government of Nigeria along with the African Union (AU) and NEPAD, hosted the Africa Fertiliser Summit in 2006, where two important action plans were proposed – implement smart subsidy programmes to improve access to fertilisers for small-holder farmers and increase fertiliser intensity to an average of 50 kg/ha by 2015. Likewise, Ethiopia has continued state-led policies in the input market. In 2000, private companies in Ethiopia were withdrawn from fertiliser markets, and thereafter, the Agricultural Input Supply Enterprise and cooperative unions were engaged in fertiliser imports, regional input supply and extension system (Welteji, 2018). As a result, Ethiopian farmer's adoption of fertiliser remained high, unlike other Sub-Saharan Africa countries.

Another important driver that has a direct correlation with productivity and agricultural output is farm mechanisation. Studies suggest that mechanisation helps in undertaking timely farm operation, reduces the cost of production in the long run, cuts down on post-harvest losses and enhances agricultural production and farm income (Gulati and Juneja, 2020). To measure penetration of farm mechanisation, we use tractor intensity per 1000 hectares measured as a ratio of the stock of tractors (assuming the average life of a tractor is 10 years in India) per 1000 hectares of the gross cropped area. According to USDA data, the tractor intensity (for tractors above 40 horsepower) ranged from 34.6 per 1000 hectares in Egypt to 0.01 per 1000 hectares in Niger, Chad and Central African Republic. Moreover, according to the Report on Agriculture in Africa (2019), only 5 per cent of cropped areas in Sub-Saharan Africa have access to tractors.

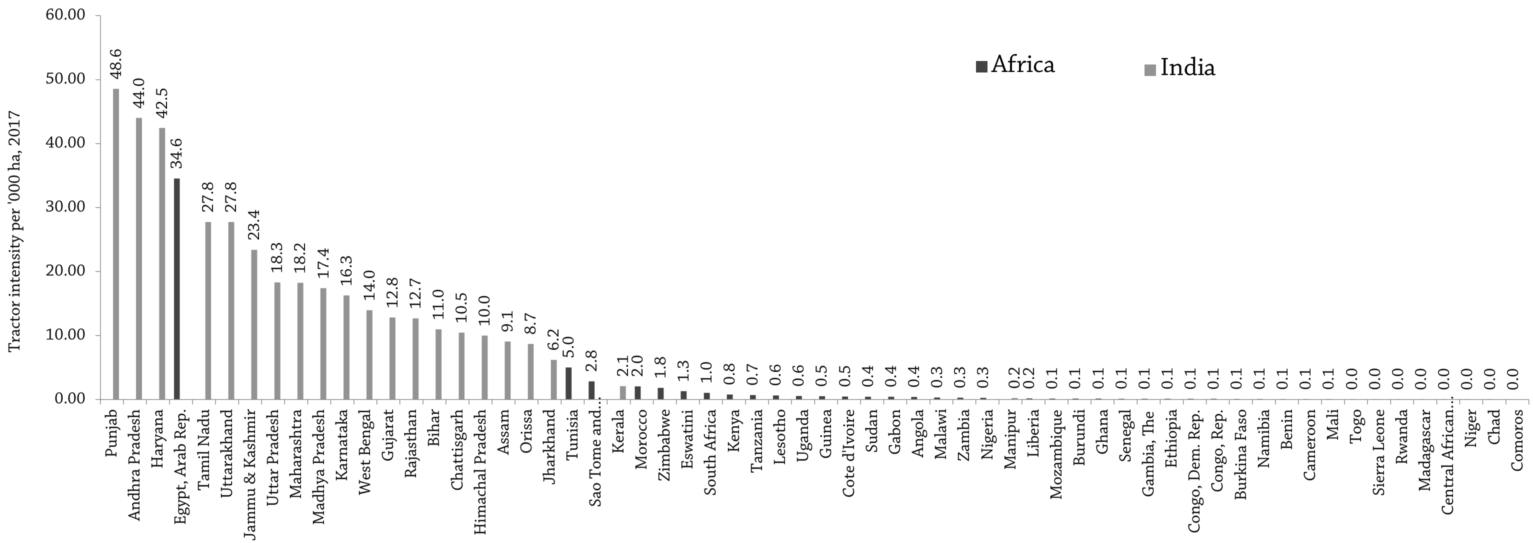
Unlike Africa, India, on the other hand, has done relatively well to increase the penetration of farm mechanisation over the years. The tractor intensity (above 40 horsepower) in India increased significantly from 3.4 to 17.7 tractors per 1000 hectares between 2005 and 2017. However, there is high inter-state variability in tractor intensity (see Figure 3.8). Punjab, Haryana, Andhra Pradesh and Tamil Nadu have performed well in tractor intensity while Odisha, Jharkhand and Kerala recorded the lowest tractor intensity in 2017. One of the main reasons for the high variation in tractor penetration across Indian states, particularly in Punjab and Haryana, was primarily due to the benefits accrued in the Green Revolution period.

Based on the above discussed drivers of agricultural input, we have constructed the input index[14] to measure input-use ratios among

14. First, we have normalised the three indicators, namely, irrigation ratio, fertiliser utilisation, and tractor intensity and then, aggregated the normalised indicators using the arithmetic

Figure 3.8

Tractor intensity (per 1000 ha)



Note: Tractor intensity for India has been calculated adding the domestic sales of tractor above 40 horsepower* between 2007 and 2017 and dividing it by the net sown area of 2017-18 (assuming that the average tractor life is 10 years). The tractor data for Africa from the USDA was available in sum of the equivalent of 1000CV horsepower which has been converted to 40 HP to compare it with India's figure. For the regression analysis, we have interpolated tractor data for India till 2019. Tractor intensity in Africa is given for tractors above 40 horsepower. To compare tractor intensity between India and Africa, we have calculated tractor intensity above 40 horsepower for India as well.

Source: Tractor and Manufacturing Association, DES, GoI; USDA various years

African countries and Indian states. Among African countries and Indian states, Egypt recorded the highest score in the input index followed by Punjab, Haryana and Andhra Pradesh. Among African counterparts, Sao Tome and Principe, Tunisia, Morocco and Malawi did well in terms of input index while Republic of Congo, Chad and Comoros recorded the lowest input index score in 2019 (see Figure 3.9). The low input index in most African countries reflects the low investment and undercapitalisation of agriculture that has hindered agricultural intensification. We also observe a significant gap in input index (whether fertiliser, irrigation type or tractors and machinery) between African countries and Indian states.

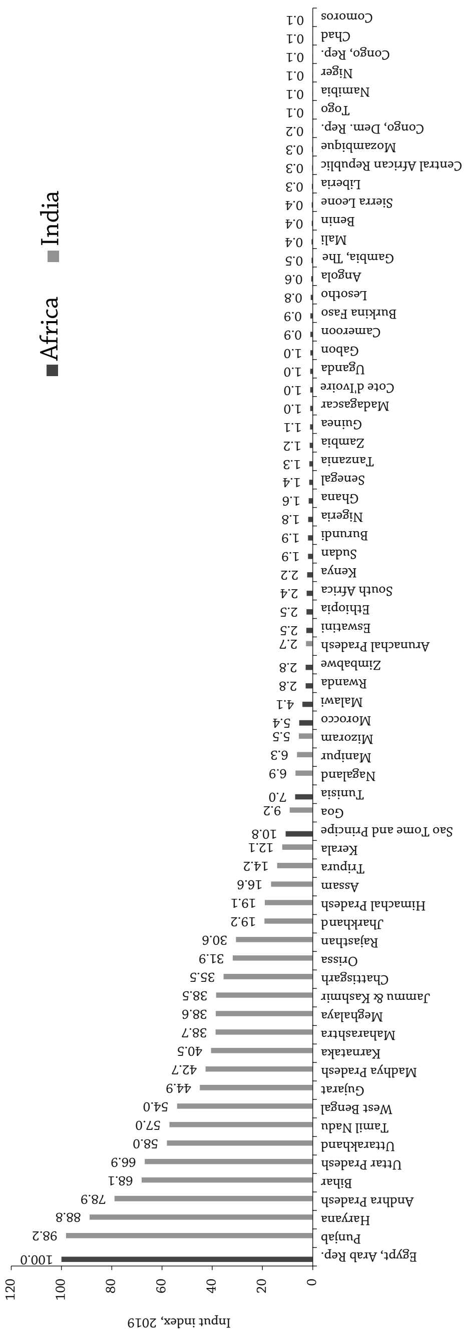
Access to infrastructure

Rural infrastructure can transform the existing traditional agriculture or subsistence farming into a modern, commercial and dynamic farming system. Thereby, accelerating agricultural productivity and marketed surplus, primarily by reducing costs of input delivery, facilitating trade flow, enhancing usage of agricultural input, and improving farmer's access to product-markets through better transportation and road networks (Adamopoulous, 2011; Gajigo and Lukoma, 2011; Pinstrup-Andersen and Shimokawa, 2010; Fan et al, 2002; Wu et al,2019). Similarly, the development of agro-industries plays a crucial role in diversifying the crop portfolio, spurring value addition and adopting modern agricultural technologies, and increasing hired-labour use (Fan et al, 2008). However, it requires adequate storage infrastructure and consistent power supply. In addition, information infrastructure such as ICT tools, geographic information system (GIS) technologies etc. are crucial for disseminating extension services and modern technology. With this view, in 2002, African governments in NEPAD's Action Programme in Africa on Infrastructure prioritised rural infrastructure as an essential element for the competitiveness of African agriculture, although very limited progress has been made in actioning it.

mean.

Figure 3.9

Input index in Africa and India



Source: Author's compilation

Most of the SSA countries are not well connected in terms of road networks, and they compare poorly not just with North African countries but also other parts of the world. For instance, a recent World Bank report (2018) states that the road density in SSA was only 0.09 km of road per sq km of land area in 2011, while it was around 0.47 and 0.14 km of road per sq km of land area in South Asia and the Middle East and North Africa, respectively (Calderón et al, 2018).

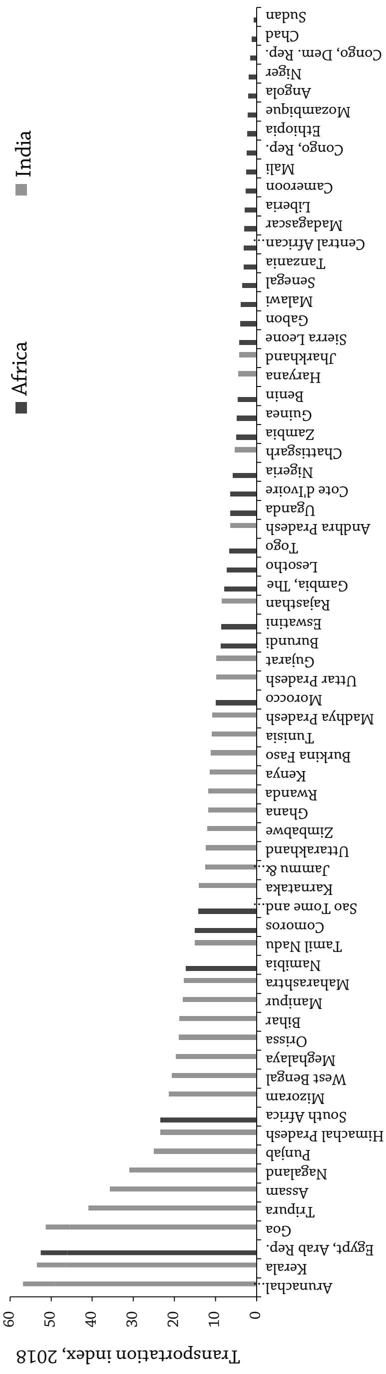
Using the transport index, a composite index measuring road connectivity in a country/state[15], we compare the major African countries with Indian states in Figure 3.10. In road infrastructure, some of the African countries have performed well and are at par with Indian states. For instance, Egypt has performed remarkably well in the transport index with a score of 53.1, followed by South Africa (23) and Namibia (17). While DR Congo. (1.9), Chad (1) and Sudan (1) have the lowest scores among the African countries in 2018. Comparatively, Indian states have performed better in the transport index relative to the African countries. In 2018, Arunachal Pradesh ranked the highest in the transport index with a score of 57, followed by Kerala (53) and Goa (51). Evidence from research studies in India also has corroborated that adequate road infrastructure and its access increase the mobility of agricultural workers by integrating labour markets across space, and facilitate adoption of labour-intensive production practices (Shamdasani, 2021).

As mentioned earlier, power supply to the agricultural sector is crucial for improving irrigation potential, post-harvest management of agricultural produce as well as farm mechanisation (Fan et al, 2008). Electricity generation in Africa, despite its vast natural resources, has been poor for decades and is less than half of that in either Asia or Latin America (FAO, 2002). In particular, the electricity generation capacity in Sub-Saharan Africa is 0.04 megawatts per 1000

15. The transport index is the weighted averages of the normalised values of two indicators: total paved roads (km per 10,000 inhabitants) and total road network (per km of exploitable land area). "The weights are based on the inverse of the standard deviation of each normalised component: $yt = (\sigma tot/\sigma x)*xt$; where σtot is given by $1/\sigma tot=\sum \chi (1/\sigma x)$ and σx is the standard deviation of the normalised component x. The rationale for step 2 is to reduce the impact of the most volatile components on the composite index and consequently the volatility of the rankings" (AIDI, 2020, p17).

Figure 3.10

Transport Index in Africa and India, 2018



Source: Basic Road Statistics of India, AIDI. Note: For the regression analysis, we have interpolated the data till 2019.

inhabitants in 2012, less than a third of that of South Asia (with 0.15) and less than one-tenth of Latin America and the Caribbean (0.43) (Calderón et al, 2018). The low level of power generation in Africa has significantly affected the overall performance of the region's economic and agricultural indicators. It has largely hampered the modernisation of smallholder agriculture in terms of irrigation as well as value addition to agricultural produce (African Monitor, 2012). Figure 3.11 illustrates the electricity index[16] for African countries and Indian states, which is the total electricity generation of a given country measured in kilowatt-hour (kWh) per inhabitant. In 2019, the electricity index in South Africa was 74.03 kWh per inhabitant, followed by Egypt (34.26 kWh per inhabitant) and Tunisia (28.9 kWh per inhabitant). In the same year, Liberia (0.36 kWh per inhabitant), Chad (0.28 kWh per inhabitant) and Burundi (0.25 kWh per inhabitant) ranked lowest in the electricity index. Davidson and Sokona (2002) in their study identified several constraints contributing to low energy generation in Africa including low population density in rural areas, the isolation of small villages from the electricity grid, and the high production, transmission, and distribution costs of electricity. These limitations are compounded due to low energy demand resulting from limited industrialisation and the limited financial allocation to the energy sector due to heavy reliance on external financing.

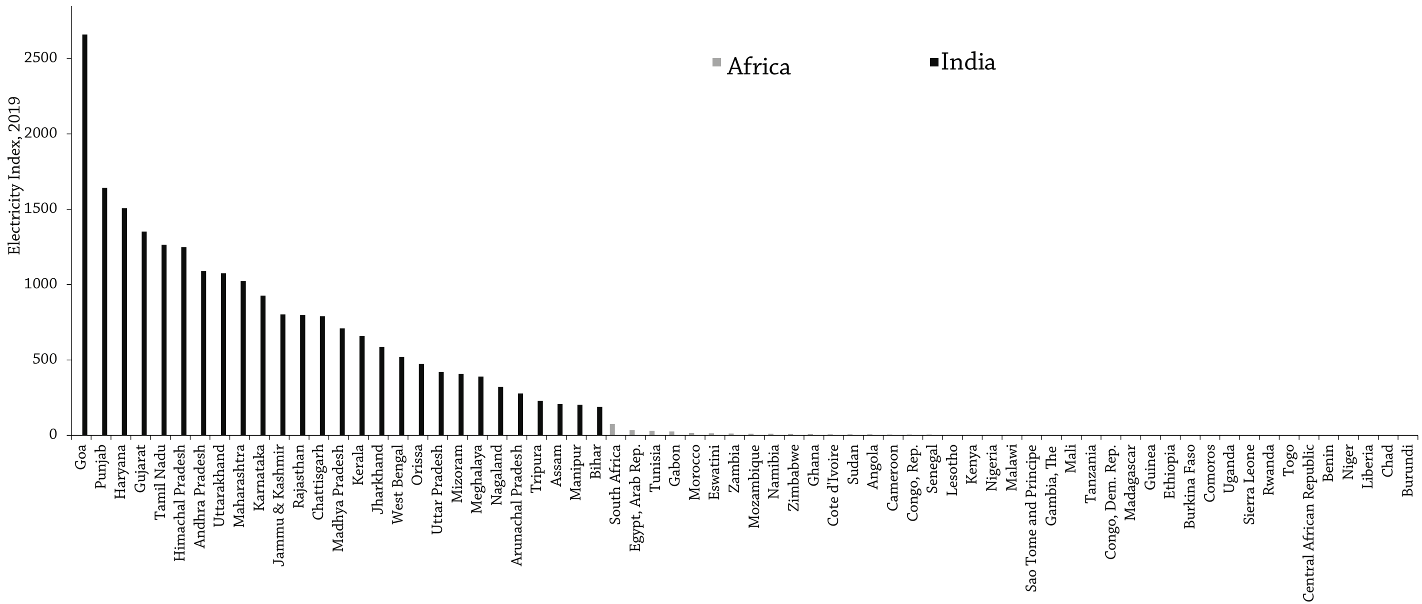
In the past few years, renewable energy has become an important source of energy in Africa — namely, solar, wind, and biomass (Suberu et al., 2013). Given that the continent is endowed with substantial renewable energy resources, augmenting investments in an innovative solution for sustainable, affordable and reliable energy for agriculture will accelerate the agricultural transformation towards a diversified agricultural sector. Further, inviting private sector investments in renewable energy will lead to a significant decline in the cost of renewable energy technologies.

Unlike African countries, the power generation in India has been noteworthy with the electricity index ranging from 2660 kWh per

16. For African countries, the electricity index has been taken from the African Infrastructure Development Index.

Figure 3.11

Electricity Index (kilowatts per hour and per inhabitant), Africa and India



Source: Central Electrical Authority, GoI; Source: Africa Infrastructure Development Index, various years inhabitant in Goa to 189.1 kWh per inhabitant in Bihar. In India, adequate and consistent power supply to the agricultural sector has been a key factor to improving irrigation potential and encouraging diversification towards high valued commodities, thereby, increasing the profitability of farmers.

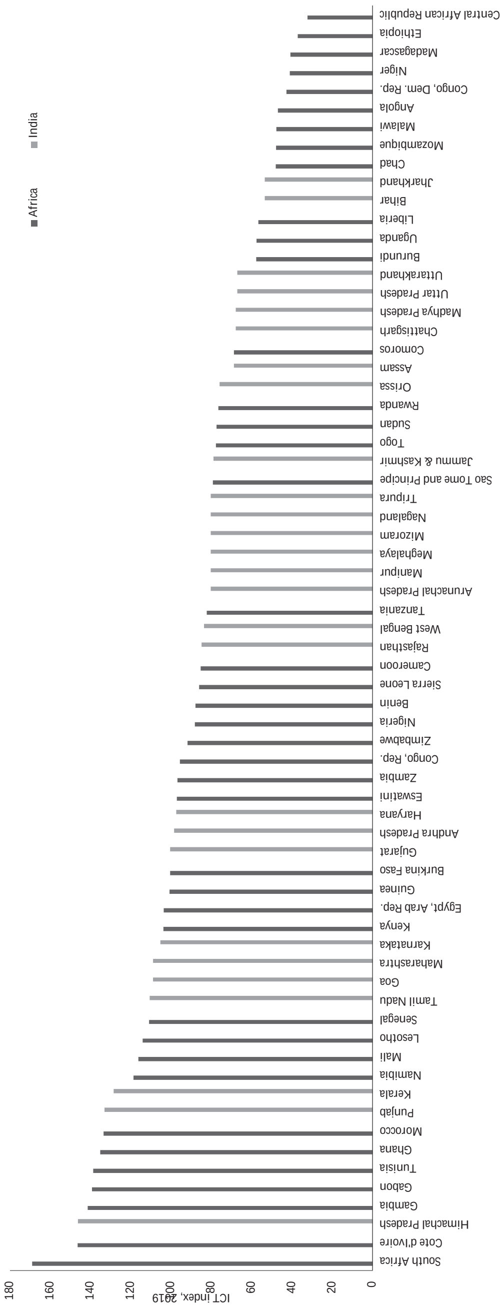
Information and communication technology (ICT) in the agricultural sector

Digital farming including ICT, remote sensing, artificial intelligence, drones and the Internet of Things (IoT) plays a critical role in transforming the agricultural sector. These tools reduce transaction cost through collecting and sharing accurate information on input, agricultural markets, price signals, and weather; by disseminating information to farmers and by connecting producers and consumers (FAO, 2017b). Through ICT, farmers along with farmer's cooperative organisations can be provided with a number of services including extension services. For instance, smallholder farmers in Africa, through the Esoko platform, receive agricultural extension services that provide critical information on current market prices, matching bids and offers, weather forecasts, news and tips through mobile phones and web services as well as advisory call centres. Similarly, in rural Niger, an estimate shows that timely information on agricultural prices obtained through mobile phones reduces search costs by 50 per cent (FAO, 2017b). Another platform, Croplife, in Uganda, validates the authenticity of agricultural inputs at the point of purchase to avoid counterfeited products. Innovative ICT tools that provide financial services including mobile money to formerly unbanked smallholders, for example, Agrinet in Uganda and M-Pesa in Kenya and others, can significantly improve their access to technological inputs.

Importantly, digital farming tools such as remote sensing, precision agriculture and ICT-based tools can facilitate in assessing the information about climate change, soil analysis, weather forecasting and more, which can mitigate the risks faced by smallholders due to climate change. For instance, Africa Adapt helps the vulnerable communities in Senegal to access information on climate change adaptation techniques.

Figure 3.12

ICT index across Africa and India



Source: Africa Infrastructure Development Index, and TRAI, various years

Figure 3.12 captures the ICT penetration across African countries and Indian states. To measure ICT penetration, we have constructed an ICT index (calculated using the total phone subscription, both fixed telephone lines and mobile cellular telephone subscriptions, given in a year per 100 inhabitants). Evidently, Africa is making positive progress in ICT. In 2019, South Africa, Cote d'Ivoire, Gambia, Gabon and Tunisia performed remarkably well in access to ICT. In contrast, Madagascar, Ethiopia and Central African Republic reported lower access to ICT per 100 inhabitants. Comparatively, access to ICT tools was lower in Indian states in relation to African countries. In 2019, the Indian states that performed well in the ICT index per inhabitants are Himachal Pradesh, Punjab, Kerala and Tamil Nadu while Bihar and Jharkhand performed poorly in the ICT index. There are many ICT tools developed for farmers in India that are making significant inroads. For example, *e-Choupal,* covering 4 million farmers, offers a trading platform along with crop agnostic integrated solutions. At the same time, the platform disseminates real-time information and customised knowledge on scientific farm practices and risk management and facilitates the sale of farm inputs. Also, recently innovative tools such as *e-locust tab* and *e-locust* M, which uses precise location through Global Positioning System (GPS), were used by the Indian government to control locust attacks in Rajasthan.

Agricultural diversification and marketing: Diverging agricultural polices

Several empirical studies have shown that diversification plays a major role in stabilising food production as well as ensuring food and nutritional security (Waha et al, 2018; World Bank, 2019b). However, in most African countries, the agricultural sector has been dominated by a narrow range of staple crops, aggravating the risk for agricultural production, food insecurity and income variability due to market volatility and climate risks. For instance, maize, groundnut and cassava dominate the agricultural production in most Sub-Saharan Africa countries.

Diversifying farming systems by cultivating different agricultural products (horizontal diversification) and engaging in multiple value-added activities (vertical diversification) is an important strategy to boost livelihoods enhance climate change resilience and promote income diversification (Barghouti et al, 2004). Often, agricultural policies and public expenditure in African countries encourage the production of primary staple crops, constraining agricultural diversification. In Africa, input subsidies incentivise the production of specific staple crops, for example, a recent study by Goyal and Nash (2017), based on six Eastern and Southern African countries, found that input subsidies that targeted production of specific crops accounted for one-third of total public spending, ranging from 30 per cent in Kenya to 70 per cent in Malawi.

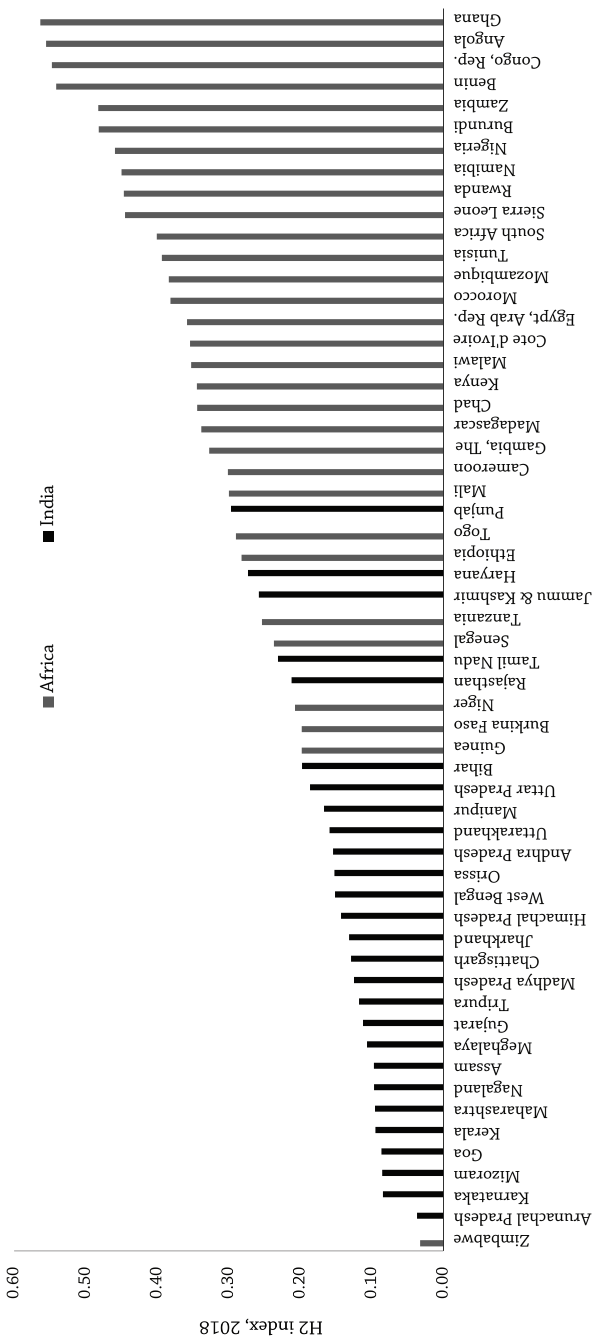
Apart from public expenditure incentivising specific crop production, there are other important factors essential for diversification. Firstly, access to a well-functioning market, be it input, output or factor market is crucial to diversify towards high valued commodities. Secondly, higher agricultural investments are required to diversify African agriculture by addressing the challenges of poor infrastructure, inadequate market institutions (Diao et al, 2012; von Braun et al., 2008), inaccessibility to productivity-enhancing inputs and poor price incentives (Benin et al, 2011).

Further, agricultural marketing reform and institutional changes such as the liberalisation of input markets are needed for increasing competition in the input market. In African countries, there is a high government involvement in agricultural marketing which restricts trade and results in high marketing and transportation costs. For example, the Kenyan Government controls agricultural outputs markets with negligible participation by private players. Additionally, the Kenyan government has been providing price support to maize farmers at a premium above the price determined by market forces. Such price support schemes result in increasing not only the fiscal pressure but also discourage private investments.

Figure 3.13 shows the trend of agricultural diversification in African countries and Indian states. As mentioned earlier in the methodology section, we have used the Herfindahl-Hirschman Index (H2) to capture diversification in the farming systems. H2 is used in

Figure 3.13

Diversification of agricultural sector in Africa and India



Note For the regression analysis, we have interpolated the data until 2019.

Source: FAOSTAT, MOSPI

microeconomics to measure market concentration or specialisation; however, in this study, we adopt the same framework to measure diversification in the agricultural sector. It is calculated by squaring the share of cereal, livestock and fruits and vegetables in the gross value of output in agriculture and allied activities. A higher value of H2 signifies a more concentrated or specialised agricultural sector and the inverse means a more diversified agricultural sector. The figure shows that Republic of Congo, Angola, and Ghana recorded higher H2, demonstrating a more concentrated agriculture sector. Further examination of the composition of agricultural output highlights that, in these countries, more than three-quarters of GVOA is dominated by fruits and vegetables. On the contrary, Zimbabwe, Guinea, Burkina Faso and Niger have a less concentrated (more diversified) agricultural sector in 2018. Comparatively, most Indian states are more diversified as compared to Africa countries.

3.4.2 Empirical analysis

Hitherto, we have discussed key drivers of agricultural growth and their trend across African countries and Indian states. Evidently, structural differences in population density, the supply of labour and land, as well as the returns to agricultural intensification have resulted in differences in agricultural productivity. As discussed in earlier sections, disparities in the use of production inputs, development of rural infrastructure, irrigation coverage, accessibility to mechanisation and ICT, and climate change within as well as across both the regions impact overall agricultural performance and structural transformation.

To determine the significant drivers for accelerating agricultural growth in India and Africa and its dynamics for the period from 2000 (2000-01) to 2019 (2019-20), we employ a dynamic modelling approach using the GMM estimation since some of the independent variables are not strictly exogenous. The dependent variable used for regression analysis is agricultural gross domestic product (AGDP). Further, using the rule of thumb, we check the stationarity of the dependent variable to choose between system or difference GMM.

Based on the stationarity test, we apply the dynamic regression model - one step difference GMM[17] as suggested by Arellano and Bond (1991) that captures the endogeneity problem in the regression estimation by adopting appropriate instrumental variables.

The estimated results show that the lagged dependent variable ($lnAGDP_{i,t-1}$) has a positive and statistically significant relationship with the current AGDP ($lnAGDP_{it}$) (see Table 3.1). It indicates that one per cent incremental change in AGDP in the last year will increase the current AGDP by 0.96 per cent. Further, we found that lagged input index and lagged terms of trade ($lnToT_{i,t-1}$) for agriculture in relation to manufacturing have a positive and statistically significant effect on $lnAGDP_{it}$, implying that a one per cent increase in lagged input index and lagged $lnToT_{i,t-1}$ will increase the agricultural income by 0.06 and 0.02 per cent, respectively.

Further, H2 (specialisation) has a negative and statistically significant relationship with AGDP. Statistically, a one per cent increase in specialisation/concentration of the agricultural sector decreases agricultural gross domestic product by 0.09 per cent. Alternatively, it implies that increasing diversification in the agricultural sector will have a positive impact on the agricultural income. However, the coefficients of lagged agricultural area ($lnAgri\_Area_{i,t-1}$) and transport index ($lnTransport\_Index_{i,t-1}$) are statistically insignificant in the dynamic regression.

To empirically validate the regression model and to check the validity of the instruments, we have used the Sargan test for over-identifying restrictions of the instrument and the Arellano-Bond test for autocorrelation. The result reveals that our dynamic model specification is free from over-identification restrictions and has no second-order autocorrelation (AR2) (see Table 3.1). Overall, the dynamic model using one-step difference-GMM specification is valid and substantiates that adequate access to agricultural inputs including modern technological inputs (fertiliser utilisation, tractor density),

17. The Difference GMM dynamic model is applied in a scenario with fewer time periods (T) and many groups (N), a linear functional relationship where the dependent variable is dynamic and independent variables are not strictly exogenous (Roodman 2009).

irrigation and agricultural diversification coupled with increasing terms of trade in agriculture are critical for agricultural growth in India and Africa.

Next, we identify which agricultural drivers work in India and which in Africa. As mentioned earlier, for examining the drivers of the agricultural sector in India and Africa, we could not use dynamic modelling (one-step difference GMM) due to a low number of cross-sectional units. To take care of endogeneity in our model, we transformed the data into a three-year growth rate for Indian states and African countries covering the period 2000-2019 under the assumption that it is less likely that previous growth rates play

Table 3.1

Dynamic panel-data estimation, one-step difference GMM

Explanatory variable	*Coefficient*	*Robust S. E*
$lnAGDP_{i,t-1}$	0.96***	0.02
$lnInput\ Index_{i,t-1}$	0.06**	0.02
$lnToT_{i,t-1}$	0.02***	0.01
$lnH2_{it}$	-0.09***	0.03
$lnTransport\_Index_{i,t-1}$	-0.00	0.01
$lnAgri\_Area_{i,t-1}$	-0.08	0.13
N	899	
No. of groups	56	
No of instruments	74	
Arellano-Bond test for AR(1) in first differences (Z)	-4.64 (p-value = 0.00)	
Arellano-Bond test for AR(2) in first differences (Z)	1.28 (p-value = 0.22)	
Sargan test of overid. restrictions: chi2(60)	211.43 Prob> chi2=0.0	
Hansen test of overid. restrictions: chi2(60)	53.56 Prob> chi2=0.93	

Note: ***, **, * denotes the level of significance at 1, 5, and 10 per cent, respectively

Source: Author's estimation

an important role. For each country/state, the observation has been computed for five different periods over time: 2003, 2006, 2009, 2012, 2015 and 2018. Since we have a pooled data set at six points of time, we can use Ordinary Least Squares (OLS) estimation since the estimates are likely to be unbiased and consistent.

Table 3.2 presents results for the OLS regressions for India and Africa with three yearly growth rates of agricultural GDP as the dependent variable. To capture convergence or divergence in growth rates within African countries and Indian states, we have used the AGDP in the base year (2000).

In the regression estimation for Indian states, the coefficient of AGDP in the base year (2000) in relation to the growth rates of AGDP was insignificant. In our model, H2 (specialisation or a proxy for diversification) shows a negative and statistically significant relationship with agricultural growth. This means a one per cent decrease in H2 increases agricultural growth by 0.19 per cent. In other

Table 3.2

OLS estimates of growth regression for the drivers of agricultural growth in India and Africa

Explanatory variable (three-year growth rate)	*India*		*Africa*	
	Coefficient	SE	Coefficient	SE
GDP in 2000 (base year)	-0.003	0.00	0.54**	0.17
Growth rate of input index	0.10*	0.06	0.08	0.06
Growth rate of agri area			0.44***	0.26
Growth rate of H2	-0.19***	0.05	-0.14***	0.06
Growth rate of rainfall index	0.19***	0.05		
Constant	13.58***	1.94	6.96	1.55
N	157		135	
R square	0.2		0.12	
Adjusted R square	0.2		0.11	

Note: ***, **, * denotes the level of significance at 1, 5, and 10 per cent level, respectively

Source: Author's estimations

words, diversification in the agricultural sector significantly improves agricultural growth. The rainfall index also depicts a positive and significant relationship with the growth rate of AGDP. Importantly, the growth rate of the input index is statistically significant and has a positive impact on agricultural growth. The regression estimates for India provide evidence that corroborates a priori literature that agricultural intensification, consistent rainfall and a diversified agricultural sector especially towards high valued commodities have a significant and positive effect on agricultural growth.

In Africa, the coefficient of AGDP in the base year (2000) has a significant and positive relation with growth of AGDP, signifying divergence in agricultural growth from the initial period. We find that area expansion significantly increases agricultural growth in Africa. Precisely, one per cent increase area expansion increases agricultural growth by 0.44 per cent. Further, the OLS estimates show that the growth of H2 has a negative impact on agriculture growth. This implies that a one per cent decrease in H2 would increase the agricultural growth in Africa by 0.14 per cent. That is, a diversified agricultural sector is crucial for accelerating agricultural growth in Africa. Interestingly, the growth rates of input index are statistically insignificant with no effect on agricultural growth in Africa.

3.5 Discussion and conclusions

While both India and Africa are at different stages in their agricultural development, the study tries to find the best possible techniques that can be utilised for accelerating agricultural growth in both regions. The study draws on similarities and differences in factors of agricultural growth such as agricultural resources, landholding structures, population size, agricultural production diversification, input intensification, rural infrastructure, and digitalization between the two regions. The lessons drawn from empirical analysis and the synthesis of agricultural experiences in Africa and India could foster mutual south-south learning for transforming agriculture and food sectors to provide affordable and nutritious diets for all. Based on comparative analysis between 27 Indian states and 41 African countries, the study explores opportunities, challenges and potential drivers that could accelerate agricultural growth and productivity in both regions.

The factors for accelerating agricultural growth in Africa differ significantly from that of India. In India, agricultural growth is driven largely by intensification, irrigation and rural infrastructure (GoI, 2016; Gulati et al, 2021). By contrast, several studies have highlighted that the recent acceleration in agriculture growth in the African continent accrued due to areas expansion as opposed to agricultural intensification or increase in agricultural yield (NEPAD, 2013; Jayne et al, 2021; OECD/FAO, 2016; AEB, 2017; Bjornlund et al., 2018). To accelerate agricultural growth, African economies need to intensify land use by increasing cropping intensity, which, in turn, requires huge investment to improve access to modern agricultural technologies, agricultural intensification (through use of the improved seed, fertiliser, agro-chemicals and mechanisation) and rural infrastructure (Barrett et al, 2017) along with price support and institutional reforms. In addition, public investment in agricultural R&D along with extension services are the key component to enhance agricultural productivity, profitability, and sustainability in African agriculture (Dewbre and de Battisti, 2008; Fan et al, 2000, Fatunbi et al. 2020). Low productivity coupled with weak infrastructure such as poor road networks, inadequate storage facilities and underdeveloped marketing infrastructure discourages diversification towards high-valued agriculture (Martin and Fukase, 2018).

African countries, in the coming decades, are going to face more severe population pressure compared to India, reducing availability of uncultivated land and exacerbating food security challenges. In such a situation, the pressing challenge for most African countries is raising the level of agricultural productivity. In recent decades, the growth in Africa's agricultural productivity can be attributed to improvements in factor use efficiency, particularly through area expansion, rather than agricultural intensification and technological advancements (Benin et al., 2011; NEPAD, 2013). Consequently, African nations must transition towards achieving food security by emphasizing innovation and sustainable intensification.

The empirical results from the dynamic model regression suggest agricultural inputs have a significant effect on accelerating agricultural growth. With a few exceptions such as Egypt, Morocco, South Africa and Tunisia, most African countries are characterised by limited access to technological input and mechanisation. The use of yield-enhancing inputs especially improved drought-tolerant seeds and fertilisers is essential to sustainably increase agricultural productivity and meet the increasing food demand. For the past decades, agricultural area expansion has been the key factor for augmenting agricultural and food production in Africa, however, the policy approach needs to focus on agricultural productivity growth through the supply of modern inputs.

In the case of India, during the Green Revolution period, agricultural policies prioritised the scaling of innovations and the infusion of technological inputs. Additionally, these policies were complemented by substantial investments in rural infrastructure, including an extensive road network for connecting farms to markets, irrigation facilities, and rural electrification. At the same time, appropriate incentives and institutional reforms aimed at achieving food grain self-sufficiency and accelerating agricultural performance were also implemented. For example, Indian government's adoption of a price policy, ensuring minimum support prices for farmers' produce, served as an incentive for increased productivity and investment in technological inputs. While a one-to-one replication of India's agricultural trajectory in Africa may not be feasible due to variations in agro-ecologies and climate change, it is essential to adapt and implement specific essential changes - encourage sustainable intensification practices while prioritising environmental sustainability.

India's longstanding agricultural policies promoting intensification through input subsidies, including power and fertilisers, have succeeded in increasing agricultural production, but they have come at the cost of environmental degradation. Today, India needs a corrective policy design to ensure the long-term sustainability of the agricultural sector. To tackle the inefficiencies associated with universal fertiliser subsidies, India could consider following the institutional reforms of the 1990s undertaken by African counterparts. These could include removing fertiliser subsidies, liberalising the fertiliser market, and encouraging the development of a private sector-led fertiliser market. Furthermore, the recent Indian government decision to experiment with the direct benefit transfer (DBT) of subsidies to farmers in selected districts, with the aim of increasing the coverage to the entire nation, is a positive move. Such policy changes can enable the industry to focus its workforce and resources on developing more effective fertiliser products and improving farmers' awareness on fertiliser best management practices (FBMPs) (FAI, 2017). Similarly, African countries with universal fertiliser subsidy programs should take science-based approaches to mitigate environmental degradation, paying special attention to ecological vulnerabilities, particularly in water management innovations. Supporting soil testing-based applications of customised fertilisers and promoting the use of fertilisers fortified with micro-nutrients is a step forward in this regard.

Another significant challenge faced by African countries and some Indian states is the low level of agricultural mechanisation. One key factor inhibiting mechanisation and input utilisation is the underdeveloped and weak agricultural credit market, particularly in Africa. To address this issue, enhancing the financial infrastructure in rural areas and implementing ICT-enabled money transfer platforms and mobile phone payment systems can expand access to agricultural credit and improve input availability for smallholders. For example, the Tanzanian government promoted the use of tractors by increasing agricultural credit through the Agricultural Input Trust Fund (Diao et al., 2016). Similarly, Indian states with low levels of mechanisation could encourage tractor usage by providing production-linked incentives and credit opportunities to smallholder farmers. Another viable solution is to establish community-level rental and sharing schemes to facilitate the adoption of tractors and mechanisation in both regions.

While the input and rainfall index were not significant in the OLS regression analysis for Africa, it is essential to consider the potential impact of climate change when implementing and formulating agricultural programs and policies for the sustainable development of the African agricultural sector. Additionally, African countries could invest in local water management and water conservation practices to enhance water supply efficiency, thereby bolstering farmers' resilience to increasingly erratic rainfall.

In water-scarce African countries and Indian states, innovative approaches to maximise agricultural output with minimal water usage are crucial. Substantial investments are required in technologies like precision irrigation, including variable rate irrigation (an innovative technology for optimising irrigation application), irrigation sensors, monitoring systems, and automated irrigation systems. These technologies can significantly reduce water wastage, evaporation, surface runoff, and leaching. Beyond capital investment, establishing regulatory mechanisms and appropriate irrigation policies, including land and water tenure, is important to make irrigation accessible and equitable for smallholders. Recent studies, such as Wren-Lewis et al. (2020), highlight the positive impact of land tenure formalisation in Benin in terms of climate mitigation and increased profitability for smallholders. Indian states could benefit from vibrant land lease markets to enhance land productivity and land use efficiency.

To maximise spillover effects of technological inputs and increase the returns from agricultural intensification, it is essential to complement them with agricultural extension services. Providing inputs without the transfer of technical knowledge is insufficient to enhance smallholders' resilience to climate and market-related risks. Therefore, offering advisory services and timely information on improved farming practices, yield-enhancing seeds, and locally suitable techniques can contribute to agricultural productivity growth. Furthermore, strengthening FPOs is crucial to improving access to agricultural extension services, which can provide tailored advisory support based on the specific needs of farmers.

Our dynamic and OLS regression models for both regions indicate that agricultural diversification has a significant impact on agricultural growth in Indian states and African countries. Shifting towards high-value commodities necessitates substantial investments in market infrastructure, processing and storage facilities such as warehouses and cold storage, along with a well-connected road network to establish an efficient and reliable value chain. Encouraging private investments and public-private partnerships (PPPs) within the agricultural supply chain can efficiently link farmers to markets, thereby removing financial and technical barriers among smallholders in Africa. Additional investments are required in technological innovations that reduce food loss and wastage of high-value perishable products, including low-cost storage solutions like hermetic bags and reusable plastic crates for transportation.

While the regression analysis may not have captured the impact of roads on agricultural growth, it's important to note that poor road networks in African countries can hinder access to markets (World Bank 2017). This limitation results in inefficient distribution of agricultural inputs, exacerbates post-harvest losses, and indirectly impacts food prices and input costs. Ensuring adequate access to energy, which was a cornerstone of India's agricultural growth, is essential to enable agricultural mechanisation, support post-harvest handling, and improve transportation and distribution. As noted by Baumüller et al. (2020), this should be prioritised as a key investment area in African countries.

4

Muhammed Usman, Lukas Kornher

Impact of Structural Transformation in Agriculture on Nutrition Outcomes in Africa and India

4.1 Introduction

This chapter examines the effects of agricultural transformation on food and nutrition security. Structural transformation in agriculture is the gradual process of reallocation of economic resources across the broad sectors of the economy, that is, from less efficient sectors to the more efficient ones. It encompasses the movement of labour forces from rural to urban centers or from agriculture to non-farm sectors. More broadly, "Structural transformation is the process by which low-income societies, in which agriculture absorbs most labour and generates most economic output, become high-income societies characterised by a relatively smaller but more productive agricultural sector" (Barrett et al., 2017, p. 1). Agricultural structural transformation involves technological change and innovations that accelerate productivity growth and efficiency.

Structural transformation in agriculture is needed to reduce poverty and hunger, and to achieve food and nutrition security, which are part of the Sustainable Development Goals (SDGs). Since the majority of the population depend on agriculture for their livelihood, growth in agriculture can play an important role to reduce poverty and improve well-being among the poorest people (e.g., Christiaensen et al., 2011; Christiaensen and Martin, 2018; Ligon and Sadoulet, 2018). Recent studies suggest that agricultural growth is more effective in reducing poverty than an equivalent amount of growth in non-agricultural sectors (Christiaensen and Martin, 2018). Given that the world's extreme poverty is concentrated in Africa and South Asia regions (Castañeda et al., 2018), the agricultural sector plays an important role in accelerating the reduction in poverty and undernutrition (Mary et al., 2019).

African economies are heterogeneous, but many African countries have registered sustained economic growth including a shift from primary activities to tertiary and to a lesser extent to the secondary sector, showing signs of an early stage of structural transformation (Barrett et al., 2017; Diao et al., 2017). Structural transformation is accompanied by higher labour productivity and greater opportunities for income diversification among rural households, however, poverty and food insecurity are pervasive in many African countries and Indian states. Many African countries, for example, experienced unprecedented overall economic growth, yet, the contribution of agriculture is generally low (Barrett et al., 2017). More importantly, nutritional indicators are less responsive to overall economic growth. India is one of the countries that achieved strong economic growth over the last two decades but saw little improvement in the nutritional status of the population (e.g., Kadiyala et al., 2014; Singh, 2014; Smith, 2015; Subramanyam et al., 2011; Vollmer et al., 2014). This is partly explained by the lack of inclusive growth, that is, the benefits of economic growth often do not reach the poor (African Development Bank, 2012). On the other hand, a few studies suggest that growth in GDP per capita is associated with lower child undernutrition prevalence (e.g., Biadgilign et al., 2016; Mary, 2018; Mary et al., 2019; Smith and Haddad, 2002, 2015). Such mixed results call for additional research to further examine the link between economic growth and change in nutritional indicators. There is also a lack of rigorous empirical evidence on the linkages between agricultural growth and nutritional outcomes (e.g., Leroy and Frongillo, 2007; Masset et al., 2012; Ruel and Alderman, 2013).

There is extensive empirical work, although results are mixed, on the impact of agriculture intervention on nutrition and poverty at the microlevel (e.g., Gulati et al., 2012; Masters et al., 2018; Webb and Block, 2012). The role of agriculture in improving nutrition outcomes is highly contentious because its effect depends on many socioeconomic characteristics (Gillespie et al., 2019). Moreover, longitudinal country analyses on nutrition outcomes are constrained by data limitations (e.g., Masters et al., 2018) in that observed indicators of nutritional status from Demographic and Health Surveys (DHS) data is only available on an irregular basis.

This chapter builds on the previous two chapters by Jose et al. that examine agricultural growth and transformation across African countries and Indian states and inform appropriate policy choices to accelerate the process. The main contribution of the current study is that we addressed the data limitation problem by considering Indian states as observations. India as a country is as large as a continent and Indian states are as diverse in their economic state as African countries. So, we pooled 27 Indian states and 41 African countries into a country/state-year data set to conduct a rigorous econometric analysis. We also considered all child undernutrition indicators in our analysis.

4.2 Structural transformation and nutrition

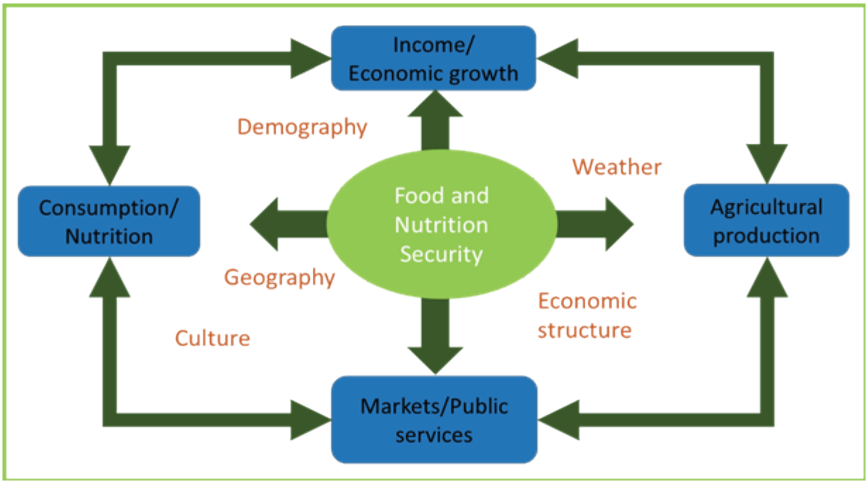
Agriculture is one of the primary sources of income and food supply. Agriculture has a huge potential to shape and influence food systems and nutritional outcomes. Improving nutrition involves more than just increasing agricultural production because the entire food system plays a role in the nutritional status of the population and the pathway towards food and nutrition security. The "Food System" concept is a framework that enunciates the relationships between the various activities in the food supply chain associated with food security and nutrition outcomes, and several socioeconomic and environmental constraints and their impact on food security (Interacademy Partnership, 2018).

The food system framework puts into perspective the interconnections - with short or long-term time lags - between agriculture production, income and employment, markets, and public services, that is, investments, with food security. As depicted in Figure 4.1, the framework entails six critical linkages that are important in the discussion of addressing hunger and undernourishment, with the linkages being bi-directional relationships. In addition, food system characteristics (demography, geography, weather, economic structure, and culture), that are exogeneous in the short term, mediate the effects of these relationships (von Braun et al., 2023).

The empirical evidence suggests that income growth improves children's nutritional status: underweight, wasting, and stunting (Kornher, L., Z. Kubik, B.B. Chichaibelu, M. Torero Cullen (2023).

Figure 4.1

Food system framework



Source: Adapted from von Braun et al. (2021).

The aid-nutrition link–Does targeted development assistance related to food systems matter?. World Development 162, 106127, DOI: 10.1016/j.worlddev.2022.106127; Smith and Haddad, 2002, 2015) but only moderately (Mary, 2018). Economic growth will lead to increases in average income which in turn leads to increases in food consumption expenditure and improvements in access to health services, both eventually contributing to improved nutritional status and health. This can be reinforced by growth-facilitated public investments in markets, infrastructure, and institutions. Micro-level studies from Africa also provide evidence for more diet diversity with increasing income (Colen et al., 2018). However, the impact pathways to better nutrition are many and complex and often depend on the particular stage of structural transformation in the country of concern (Pingali and Sunder, 2017). Although income increases the accessibility of food, it might not improve food availability and utilisation. Demographic characteristics and the economic structure of a country determine the extent that poor and undernourished households benefit from economic growth and trigger rural-urban and sectoral growth disparities. For instance, Vollmer et al. (2014) do not ascertain positive growth effects on nutritional outcomes of children from the lowest wealth quintile.

The link between agriculture production, mediated by food system characteristics, and nutrition can be rather short-term, for instance, in situations of acute food security problems but increased food production will not be sufficient for sustainable and nutritious diets. On the other hand, productivity-driven agricultural growth can have sustained positive effects on agricultural production and income in the sector. Agriculture employs most of the labour forces in Africa and India and the majority of the poor are either smallholder farmers or work in the sector. Therefore, growth in agriculture is more likely to benefit the poor than growth in non-agricultural sectors. Growth in agriculture will also spill over to non-agricultural sectors. Agricultural growth could also stimulate multiple pathways to improved nutrition by reinforcing several positive linkages. Gillespie and Haddad (2001) and Haddad (2000) categorise these pathways linking agriculture to nutrition into the generic effect (links nutrition to agriculture through employment and income generation), and the specific effect through increased production (availability of and access to food, consumption of own production, household food acquisition).

Several empirical studies affirm that agriculture affects nutrition and poverty in several ways but only a few studies provide empirical estimates on the extent of the agricultural growth and nutrition linkages. Specifically, growth-nutrition elasticities, similar to what Smith and Haddad (2015) and Mary (2018) provide for overall economic growth, are scarce. The degree of leverage agricultural growth has on nutrition depends on the characteristics of the food system. Additionally, countries can substantiate agricultural sectors through policy to achieve a rapid reduction in undernutrition (e.g., Adjaye-Gbewonyo et al., 2019; Webb and Block, 2012). This linkage considers structural issues such as access to markets, availability of resources, and multifactor issues that affect the resilience of communities which would affect societal cohesion.

It is important to note that agricultural growth needs to originate from productivity gains, instead of pure intensification, to have sustained impacts on food and nutrition security. The reallocation of resources between agricultural value chains and across economic sectors stimulates economic growth. In other words, structural transformation in agriculture is a key driver of the growth in other sectors of the economy. Agricultural productivity growth is the primary driver of structural transformation. Productivity growth increases the incomes of smallholders, which can change consumers' diets and consumption diversity. Therefore, agricultural policies and programs that target productivity growth need to be leveraged to be more "nutrition-sensitive" and reinforce diet diversification. A clear synergy is crucial between agricultural policies and the nutritional quality of food supply (Pinstrup-Andersen, 2012; Ruel and Alderman, 2013) to improve health through diets. Overall, understanding the underlying process of agricultural structural transformation and its impacts on the nutritional status of the population will help policymakers to identify the problems and associated solutions to optimally utilise agricultural policies.

4.3 Data and methodology

4.3.1 Data

The analysis combines various data sources to construct a panel for 1,264 country/state-year observations between 2000 and 2018. The sample consists of 41 African countries and 27 Indian states. Data for African countries are publicly available and taken from the

World Bank's Development Indicators (WDI) (available at https://datatopics.worldbank.org/world-development-indicators) and the FAOSTATA (available at http://www.fao.org/faostat/en/#data). The nutrition data were obtained from the UNICEF/WHO/World Bank joint child malnutrition estimates (available at https://data.unicef.org/resources/dataset/malnutrition-data). Data on macroeconomic and agricultural indicators for Indian states have been taken from the Ministry of Agriculture and Farmers' Welfare, the Directorate of Economics and Statistics (DES) of the Government of India; Ministry of Statistics and Programme Implementation, Central Statistical Organization; and FAOSTAT. For other indicators such as population, the labour force in agriculture, and nutrition, we have used data from the Census of India, Periodic Labour Force Survey, and National Family Health Survey, respectively. The rainfall data for Indian states have been taken from Rainfall Statistics of India, India Meteorological Department (IMD). The list of observations (country/state and years) can be found in Table C2 in the Appendix.

Anthropometry is the most frequently used method to assess nutritional status. As outcome variables, we use the national/state-level percentage headcounts (prevalence rates) of child undernutrition for under-five years of children. A child is considered stunted, underweight, or wasted if the child is at least −2 standard deviations below the median of the WHO child growth standards adjusted for age and gender. The WHO child growth reference values are assumed to reflect normal child growth under optimal socioeconomic and environmental conditions.

Stunting measures the long-run cumulative effects of malnutrition and repeated infectious, and its effect is often irreversible, while wasted children are too light for their height, which could be as a result of recent rapid weight loss or a failure to gain weight. Wasting is more sensitive and more likely to fluctuate seasonally. Although socioeconomic indicator variables are largely available for the study countries, the nutritional indicators are more limited and restricting the overall matched samples for the nutritional analysis to 305 country/state-year observations. In line with most recent empirical studies, for the dependent variable, we use stunting, underweight, and wasting as child nutrition indicators across the selected countries/states.

In addition to the standard under-five child nutrition indicators (stunting, underweight, and wasting), we use a normalised child malnutrition index, closely following Gulati et al. (2012). To compute the normalised malnutrition index, we first normalised each nutrition indicator using the following formula:

Normalised indicator = (actual values – minimum value) / (maximum value – minimum value)

The normalised malnutrition index is then computed as simple arithmetic means of the normalised values of the three indicators.

There are many indicators to capture structural transformation in agriculture. In this chapter, we focus on three indicators to measure agricultural transformation in the study countries, namely: growth in agricultural incomes, reduction in the share of agricultural employment, and value-added to GDP.

4.3.2 Empirical approach

To investigate the effect of agricultural transformation on nutritional outcomes, we employ a semi parametric regression approach. Semiparametric regression is useful to capture complicated relationships between the independent and the response variable for which parameter models fit poorly. We estimated the following model.

The first model is a standard fixed-effect model and can be written as:

$$\boldsymbol{y_{it}} = \boldsymbol{\beta X_{it}} + \boldsymbol{f(Z)} + \boldsymbol{u_{it}} \tag{1}$$

where i stands for each Indian state and African country and t for the respective year, X is a vector of control variables that enter linearly, and $f(.)$ is an undefined function relating the dependent variable to the key variable of interest (Z) in a given model. Since this method relaxes the assumption of a linear relationship between undernutrition and agricultural transformation indicators, the nonparametric regression results are robust for functional form misspecification. Nonparametric regression is still consistent but less efficient if the linear regression assumptions are true. The current analysis is closely related to earlier works (e.g., Webb and Block, 2012) that show structural transformation helps to reduce prevalence of undernutrition in low-income countries, and that GDP per capita is a good predictor of health outcomes indicators.

4.4 Results and discussion

4.4.1 Descriptive analysis

When a structural transformation is underway, the share of agriculture in GDP and labour employment gradually declines while agricultural income per capita grows, albeit the speed and pattern of structural transformation differ across regions. As shown in Figure 4.2, agriculture value added (% GDP) and share of employment in the sector showed persistent downward trend, while GDP (or agricultural income) per capita has been growing during the study period.

GDP and agricultural income per capita growth is greater in India than in African countries between 2000 and 2019. Both agricultural per capita income and GDP per capita income are growing faster in India than in Africa (Figure 4.2). In Africa, growth in agricultural income is stagnant over the period while the rate of GDP per capita income growth is declining. For example, between 2000 and 2019, Indian's GDP per capita growth averaged around 5 per cent while in Africa the average growth rate is much smaller (1.85 per cent). Agriculture's share of GDP in Africa declined from 25.4 in 2000 to 21 per cent in 2019. Relatedly, the share of agricultural employment fell during the study period by 11.4 percentage points in Africa and by 17.1 percentage points in India.

The descriptive statistics presented in Table 4.1 indicate that child undernutrition prevalence is generally high in both Indian states and African countries, although the prevalence rates in Indian states are much higher compared to African countries' average. Our data also suggest that although child malnutrition has slowly declined in both regions over the study period, there is a large disparity within African countries and Indian states.

Figure 4.2

Income per capita, the share of agriculture in GDP and employment between 2000 and 2019

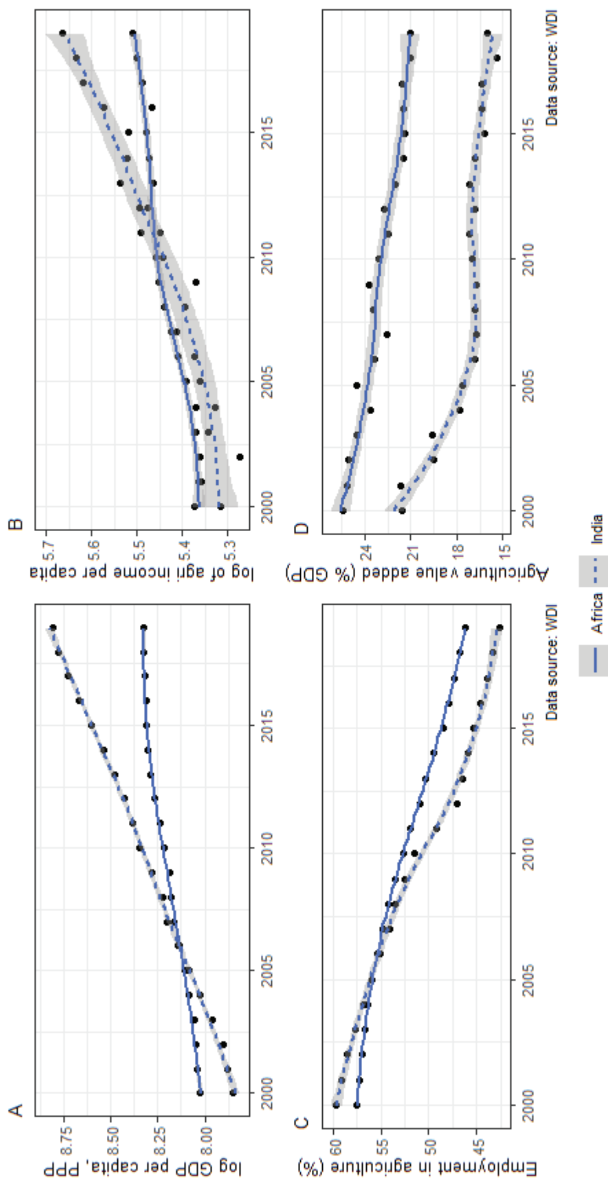


Table 4.1

Descriptive statistics for variables used in statistical analysis

	Obs.	*Mean*	*Stdev*	*Min*	*Max*
Indian states (N = 27)					
Stunting (% of children under-5)	108	42.47	9.97	20	64
Underweight (% of children under-5)	108	36.73	12.56	12	65
Wasting (% of children under-5)	108	17.52	5.41	6	35
Employment share in agriculture (%)	486	52.11	13.79	9	79
Agriculture value added (% GDP)	479	22.00	7.44	5	44
GDP per capita (constant 2011-12 INR) in 1000's	486	70.19	44.13	13	358
Agricultural income per capita (constant 2011-12 INR) in 1000's	468	13.56	6.47	3	37
Improved sanitation (% of population)	108	41.32	21.46	10	98
Rural population share (%)	486	70.57	12.54	30	90
Rainfall deviation	484	-0.00	1.00	-2	4
African countries (N = 41)					
Stunting (% of children under-5)	205	35.43	10.16	10	64
Underweight (% of children under-5)	193	19.28	7.63	7	43
Wasting (% of children under-5)	192	8.10	3.87	3	24
Employment share in agriculture (%)	779	52.89	20.40	5	92
Agriculture value added (% GDP)	768	23.07	13.46	2	79
GDP per capita (constant 2011-12 INR) in 1000's	778	96.63	106.28	11	658
Agricultural income per capita (constant 2011-12 INR) in 1000's	768	14.00	7.52	2	36
Improved sanitation (% of population)	737	31.60	21.25	3	94
Rural population share (%)	779	61.54	16.57	11	92
Rainfall deviation	779	-0.26	0.58	-1	1
INR = Indian rupees					

The relationship between undernutrition and agriculture value-added and share of employment is shown in Figure 4.3. The shaded regions indicate approximately 95 per cent pointwise confidence intervals. As the Figure suggests there is a marked difference in terms of undernutrition prevalence between African countries and Indian states, with many Indian states clustering at the high undernutrition range across the three anthropometric indicators. It is also evident that this relationship is non-linear and complex. In the lower panel of Figure 4.3, undernutrition improves as the share of agriculture in total GDP declines. Improvement in undernutrition is relatively fast for lower values of share of agriculture value-added. Furthermore, this pattern does not change if we look at the relationship between undernutrition and the share of agricultural employment (upper panel of Figure 4.3). For example, when the share of agriculture is lower than 50 per cent, the slope of the curve is steeper, implying undernutrition prevalence dropping quickly. A similar pattern is also observed when agriculture's employment share is below 20 per cent.

The other important determinant of undernutrition is income per capita, which is generally negatively associated with the undernutrition prevalence rate (Figure 4.4). However, as shown in the lower panel of Figure 4.4, wasting is less responsive to agricultural income per capita growth. The relationship is generally linear except for stunting and agricultural income per capita. In all the Figures, it appears that the undernutrition prevalence rate is higher in India than in Africa across the indicators. The associations in Figures 4.3 and 4.4 may not be interpreted causally, however. It is possible that other exogenous variables that promote structural transformation in agriculture also co-determine nutritional outcomes.

The effect of overall income per capita on stunting is significantly larger than agricultural income per capita. For example, unconditional on other potential determinants of stunting, the regression estimate suggests that a 10 per cent increase in GDP per capita is associated with a 2.4 per cent reduction in stunting, while an equivalent increase in agricultural income per capita leads to a 1.9 per cent reduction in stunting (see Table 4.2). The estimated growth elasticity is comparable to earlier literature.

Table 4.2 suggests that undernutrition is responsive to change in per capita income and other indicators of structural change in agriculture. The effect of structural change in agriculture on childhood

Figure 4.3

Undernutrition as a function of agriculture value-added and employment share

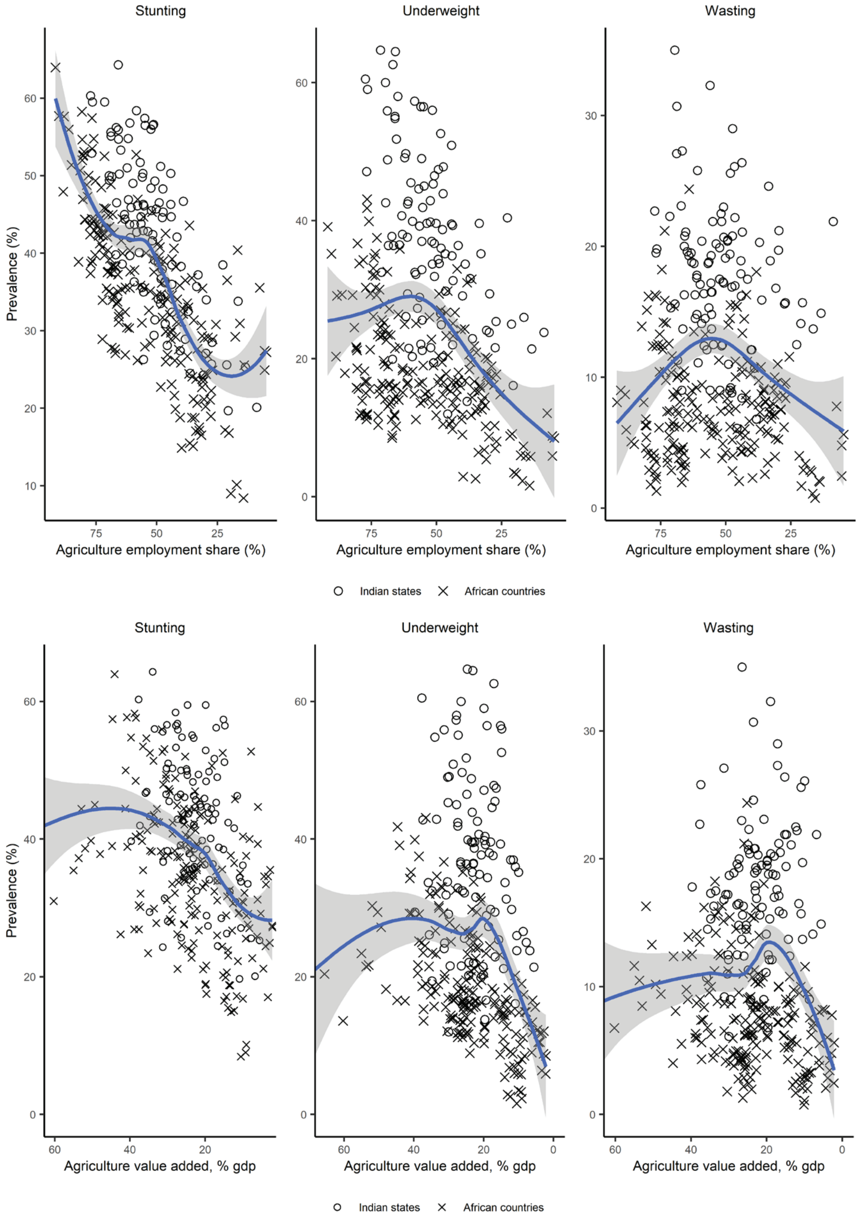
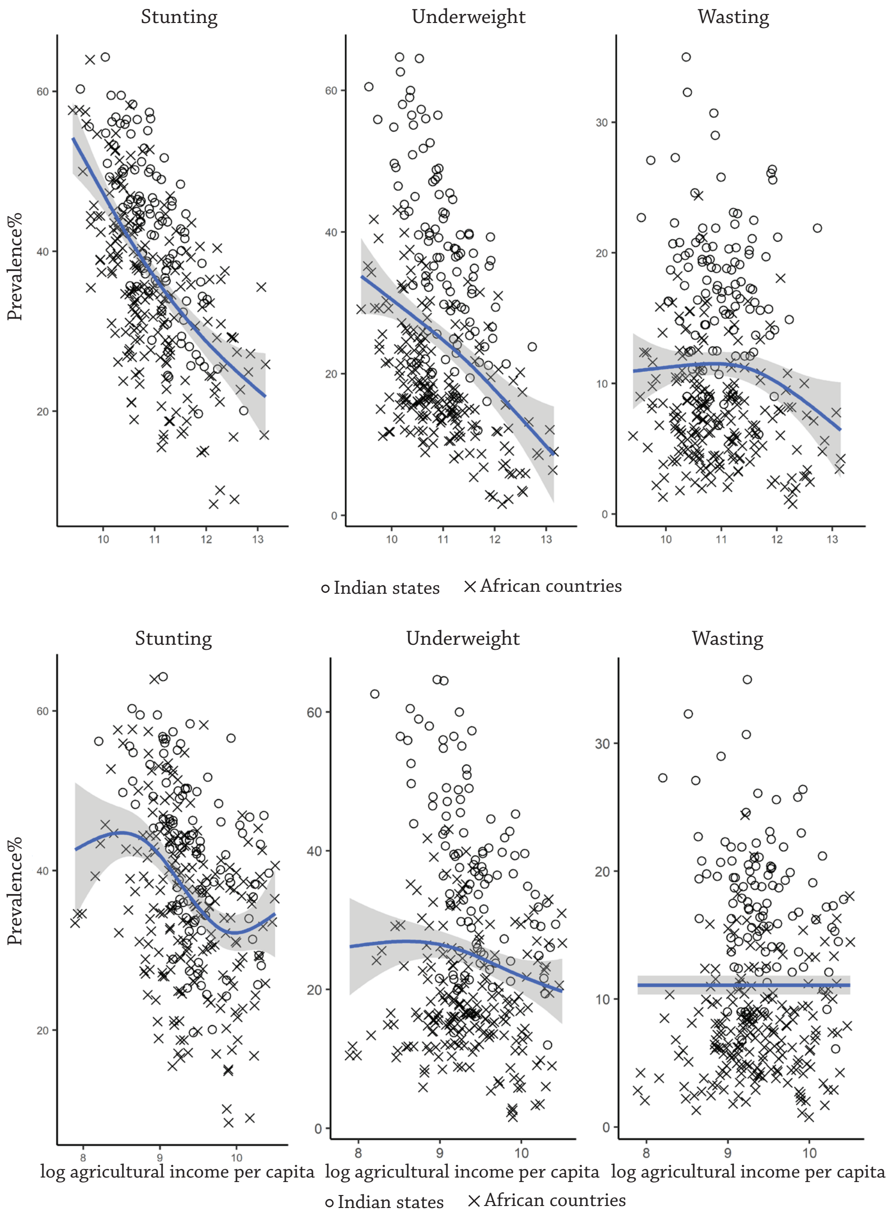


Figure 4.4

Undernutrition as a function of GDP and agricultural income per capita



undernutrition prevalence is significantly greater in India than in Africa, irrespective of the nutritional indicators. Moreover, a decrease in agriculture's share of employment is associated with a higher reduction in child stunting prevalence in both regions.

We further examine whether the agricultural transformation has a differential impact based on urban and rural populations. The hypothesis is that majority of the rural poor earn their livelihood from

Table 4.2

Unconditional elasticities of nutrition improvements with respect to structural changes

Indicators	*Full sample (N=312)*		*Africa (N=204)*		*India (N=108)*	
	Stunting	*under-weight*	*Stunting*	*under-weight*	*Stunting*	*under-weight*
GDP per capita	-0.24*	-0.21*	-0.23*	-0.24*	-0.33*	-0.34*
Agricultural income per capita	-0.19*	-0.02	-0.17**	0.05	-0.27*	-0.40*
Agriculture value added (% GDP)	0.22*	0.30*	0.20*	0.34*	0.29*	0.16
Agriculture employment share	0.41*	0.34*	0.38*	0.36*	0.50*	0.45*

Note: The estimated elasticities are unconditional on other potential determinants of undernutrition Statistical significance denoted at * $p<0.01$, ** $p<0.05$

agriculture, and any growth of the sector may benefit rural households more than urban households. Additionally, although undernutrition has been declining slowly over time, the gap between urban and rural space in terms of undernutrition prevalence persists, in some cases, it widens over time (see Figures C5 – C8). For example, in India, wasting prevalence is increasing with increasing per capita income in urban areas.

4.4.2 Regression results

In this section, we present and discuss the empirical results based on the model estimation outlined in section 4. We employ a semiparametric model to estimate the effects of structural change in agriculture on the prevalence of undernutrition. Alternatively, we reported fixed effect estimation in the Appendix as a robustness analysis. In the fixed-effect regressions, we correct for heteroscedasticity using weighted least squares - with observations weighted by the number of total observations in the sample.

All the semiparametric, as well as the fixed effect models, are adjusted for the following controls: GDP per capita, percentage of rural populations, the share of the population with access to an improved sanitation facility, rainfall deviations from the sample mean, region and year fixed effects. To examine the effect of agricultural income on undernutrition, however, the models were not adjusted for GDP per capita as the two variables are highly correlated.

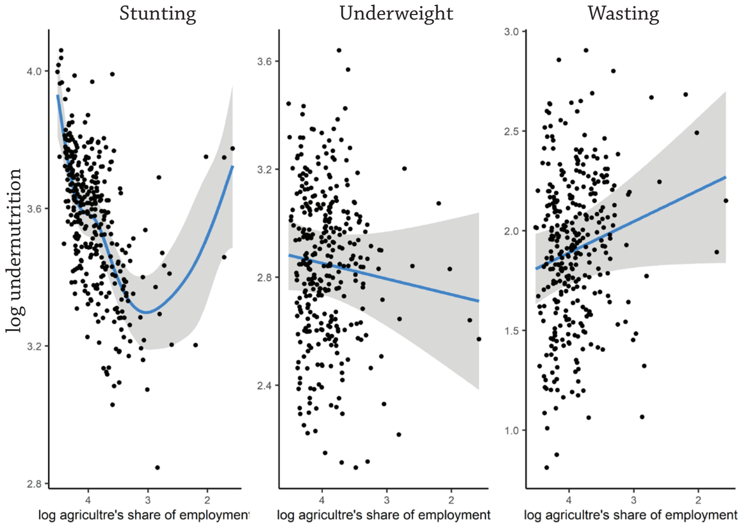
The semiparametric regression results reported in Figure 4.5, which control for overall income per capita and other covariates, indicate that stunting responds positively to declining in agriculture's share of employment while wasting is negatively correlated with agriculture's share of employment. On the other hand, the results suggest that the effect of agriculture share of employment is not statistically significant. At the tails of the distribution, the 95 per cent confidence interval is wide due to few observations. One of the limitations of the nonparametric estimator is that the estimates may be sensitive to outliers and the models might poorly fit in areas where there are not sufficient observations.

The relationship between the share of agricultural value-added and undernutrition is shown in Figure 4.6. At a higher value of agriculture's share of GDP, both undernutrition indicators are positively correlated with agriculture's share of GDP. However, countries with a low level of agriculture's share of GDP (or reduction in the share of agricultural value-added) are negatively associated with child stunting and underweight prevalence.

Below we present the estimated results of the effects of agricultural income per capita on undernutrition (Figure 4.7). After adjusting for other covariates, the relationship between undernutrition and agricultural income growth is linear, and the results suggest that

Figure 4.5

Undernutrition as a function of agriculture's share of employment.



Note: Generalised additive model partial dependence plots for the log of undernutri tion. Each plot shows a covariate and their partial dependence on undernutri tion prevalence in the context of the model.

as agricultural income per capita increases child stunting declines. However, agricultural income growth is negatively correlated with underweight and wasting prevalence.

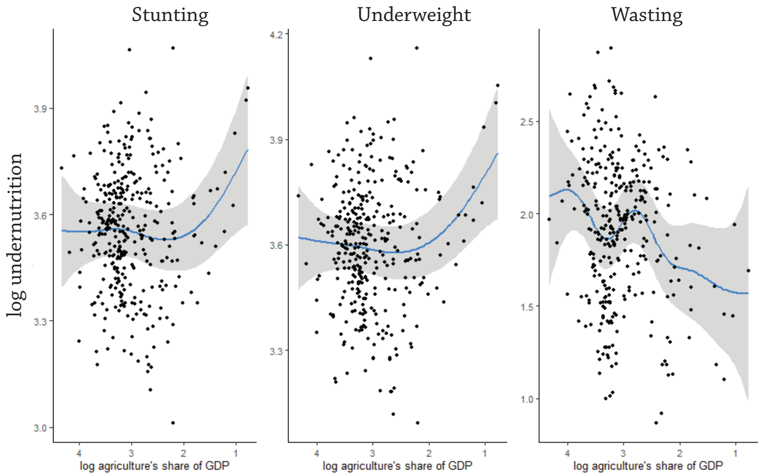
Undernutrition generally correlates with agricultural transformation indicators. However, the results suggest that undernutrition is neither predictable nor sufficiently explained by the agricultural transformation variables as several local factors play a role as co-determinants of nutrition outcomes. Finally, the parametric estimation results (based on fixed effect estimator) were reported in the Appendix with some contrasting results (see Tables C3-C5).

4.5 Discussion and conclusion

We examine the relationship between structural transformation in agriculture and undernutrition in Africa and India. Overall, our

Figure 4.6

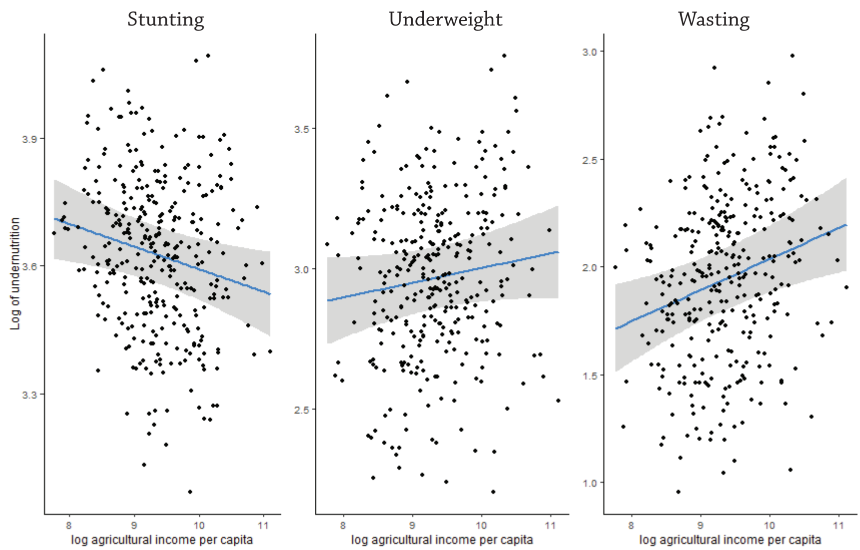
Undernutrition as a function of agriculture's share of GDP.



Note: Generalised additive model partial dependence plots for the log of undernutri tion. Each plot shows a covariate and their partial dependence on undernutri tion prevalence in the context of the model.

Figure 4.7

Undernutrition as a function of agricultural income per capita.



Note: Generalised additive model partial dependence plots for the log of undernutrition. Each plot shows a covariate and their partial dependence on undernutrition prevalence in the context of the model.

results suggest that agriculture's share of employment is strongly and positively associated with child stunting. Agricultural income per capita is also a good predictor of child stunting – higher per capita income is correlated with lower stunting rates. While the share of agriculture in total GDP is strongly correlated with child wasting in the selected countries/states between 2000 to 2018.

Although poverty is the root cause of undernutrition, it has multiple and interrelated factors that drive undernutrition prevalence. In addition to agricultural diversification and productivity growth, women's education, gender equality, and access to household resources (e.g., safe drinking water and sanitation facilities) are key drivers of the reduction in undernutrition (e.g., Gulati et al., 2012; Gulati and Roy, 2021; Jose et al., 2020; Pandey, 2021; Smith and Haddad, 2015).

The steady decline of both agriculture's share of employment and GDP is strongly associated with income growth, urbanisation, demographic transition, and poverty reduction in many low-income countries (Barrett et al., 2017). Urbanisation drives food system changes and preferences (de Bruin et al., 2021), with huge implications on nutrition and health outcomes. As income grows, people's consumption bundle shifts towards high-value food such as animal products, fruits, and vegetables (Worku et al., 2017).

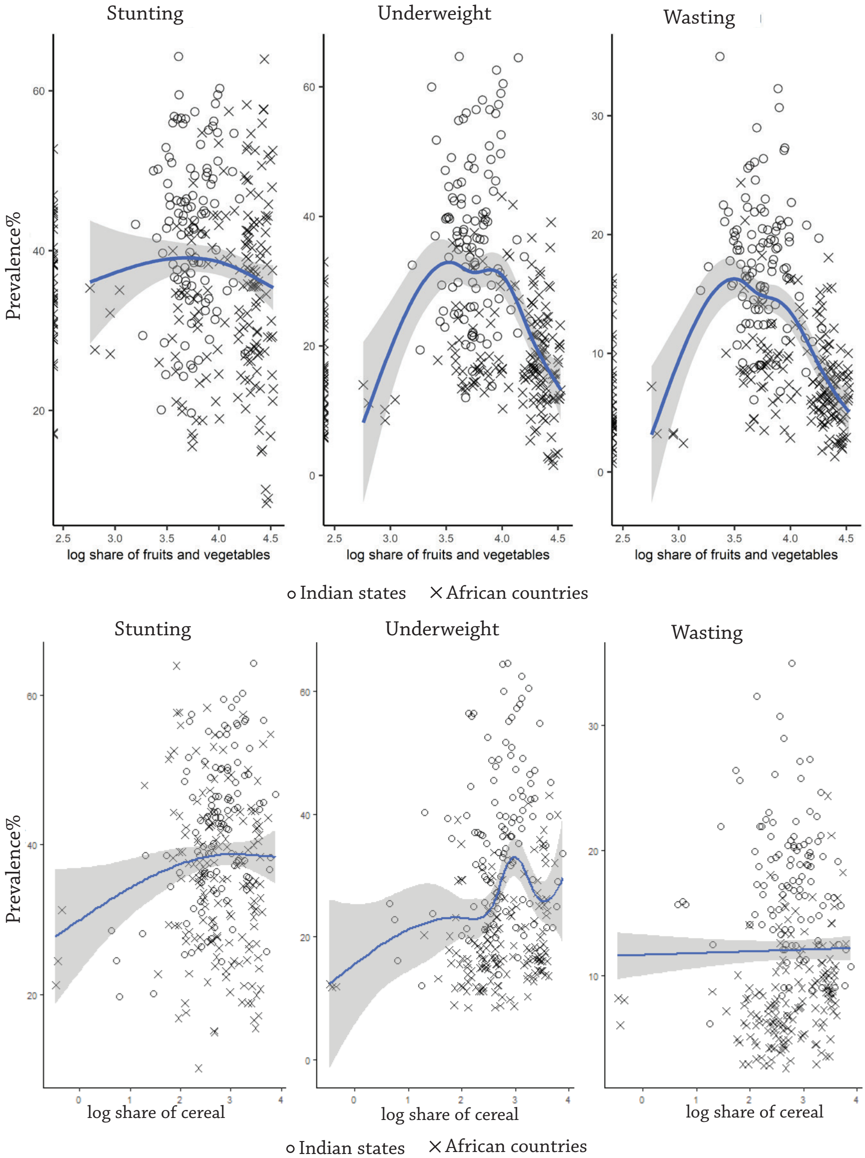
Agriculture's primary role is improving nutrition by increasing access to nutritious and healthy diets. Increasing agricultural productivity can improve diets through consumption from own production and through improved income from selling agricultural outputs. Many studies showed that agricultural growth is more effective in increasing the income of the poor. Increasing income of the poor improves their access to foods that have the potential to improve nutritional outcomes. Earlier evidence shows that national-level stunting rates have improved over time at all income levels (Masters et al., 2018). Although the importance of agriculture for poverty reduction is well-documented, less research has focused on how agriculture's contribution to the income of poor households influences nutrition outcomes (Kadiyala et al., 2014).

Another mechanism through which agricultural transformation can improve nutrition is dietary diversity, with improvements in production and marketing that increase households' access to various legumes, vegetables, fruits, and animal sourced-products. In the process of structural change in agriculture, there will be a shift in agricultural production from common staples towards high-values of fruits and vegetables and protein-rich foods (e.g., meat, milk, and milk by-products). Increasing the number of food groups in household consumption can be beneficial to reduce undernutrition. As can be seen in Figure 4.8, undernutrition is generally negatively associated with the share of high-value agricultural produces (fruits and vegetables) - this relationship is even steeper for underweight and wasting. Production diversity may also improve consumption diversity, especially in settings with limited market access (Sibhatu et al., 2015). Policies that facilitate exchange (through better infrastructure) can improve nutritional outcomes by giving households greater access to more diverse and nutritious food. However, this is not the case for countries that increase the production of staples (e.g., cereal crops) as shown in the lower panel of Figure 4.8. This finding is in line with Bennett's Law stating that an increase in income improves people's dietary diversity as people consume fewer calorie-dense starchy food and more nutrient-dense food such as meats, fruits, and vegetables (Bennett, 1941).

Empirical studies also show that agriculture productivity growth can affect the relative price of food. One example is the Green Revolution that started in the early 1960s in South Asia that dramatically reduced the price of main staple cereals, which in turn increased real household income as well as the demand for micronutrient-rich foods. On the other hand, lower staple food price increases the relative prices of micronutrition-rich foods, which may also affect their consumption. Although the economic theory is ambiguous on the net effect of change in relative food prices on the consumption of micronutrient-rich foods, some studies suggest that the real income effect dominates relative price effects (Gaiha et al., 2013). Furthermore, increasing food prices may benefit rural households through the increase in wages. During the 2004-2009 high food prices in Indian states, for example,

Figure 4.8

Undernutrition as a function of the share of fruits and vegetables, and cereal production



many rural Indian households benefited from the high food price through the increase in wage growth (Jacoby, 2013).

A radical transformation of the agricultural sector can reduce poverty by releasing the abundant labour supply to non-agricultural activities as well as by pulling surplus labour from less productive home production into agriculture (Emran and Shilpi, 2018), which can also increase income sources from the non-farm business. This is partly determined by the ability of the non-farm sector to absorb the excess labour supply from the agricultural sector. Previous studies suggest that the labour supply equilibrium may take some time to adjust moving labour from less productive to more productive sectors (Barrett et al., 2017). Altogether, increasing income either from the productivity growth of agriculture or from non-farm sectors can help a rural household to access nutritious and healthy foods. Several studies in low-income countries show that non-farm income among rural households is associated with improved dietary diversity as the extra income improve household's purchasing power and access to foods (e.g., Babatunde and Qaim, 2010; Do, 2019; Usman and Callo-Concha, 2021).

The potential benefits of the agriculture and allied sector are crucial in the fight against poverty and undernutrition. However, other socio-cultural norms may undercut the positive impacts of the agricultural sector (Kadiyala et al., 2014), because nutrition outcomes are driven by many interconnected factors. For instance, the first 1000 days of a child's life - from conception to the child's second birthday - are crucial to avoid growth faltering. Ensuring access to nutritious foods and proper child feeding practice alone does not prevent child growth faltering; it requires improving access to safe drinking water, good hygiene practices, improved sanitation facilities, improving maternal nutrition, and promoting the health care systems to prevent and control childhood illnesses (e.g., Dewey, 2016; Gerber et al., 2019; Usman and Gerber, 2020). This implies that the effect of agricultural growth on undernutrition reduction depends on the relative strength of the intersectoral linkages or the strength of the other sectors. Moreover, the trade-off between promoting agricultural production and nutrition needs to be confronted and the focus should be on increasing diversification of production towards a nutritious diet including fruits and vegetables. Bio-fortification is an innovative and feasible solution to improve the diet of households and the nutritional status of children. There are numerous instances of this technique having been implemented successfully in different countries (Gulati et al., 2012; Ruel et al., 1999). For instance, in Mozambique, the introduction of orange-fleshed sweet potato improved serum retinol in children under five years of age (Hotz et al., 2012).

Finally, on the one hand, the share of female school enrollment – another indicator of structural transformation, has been rapidly growing in both Africa and India. On the other hand, the share of the rural population has been quickly declining since 2000, although it remains high in Africa with over 65 per cent of the population living in rural areas (Figure C4).

5

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Public Spending and Development, Agricultural Growth and Nutrition

Comparing Indian States and African Countries

5.1 Introduction

The agricultural sector is vital for development, especially in low-income countries where it plays a significant role in generating income and employment. Growth in the agricultural sector reduces poverty more effectively than growth in other sectors, particularly in the early stages of structural transformation (Ivanic and Martin, 2018). Agriculture also plays a key role in combating malnutrition by ensuring the availability of food, which is crucial for addressing issues like stunting and undernutrition (Smith and Haddad, 2015). Public spending is a powerful tool for promoting agricultural growth, alleviating poverty, and improving food security (Takeshima et al., 2021). However, many lower-income countries fail to invest adequately in agriculture, particularly in high-impact areas such as agricultural research and development (R&D) (Goyal and Nash, 2017).

Fiscal constraints exacerbated by the COVID-19 pandemic and the war in Ukraine have challenged governments to re-focus public spending for sustainable development (Comelli et al., 2023). Increased public spending and reduced tax revenues have led to higher fiscal deficits and public debt, reaching the highest levels in decades (IMF, 2022a). Many developing countries, already at risk of debt distress before the pandemic, now face even greater challenges with rising debt levels and increased debt service costs (Kose et al., 2021; Miningou, 2023).

Governments often implement expenditure-based fiscal consolidation programs to restore macroeconomic stability. These adjustments affect public investments more than government consumption, especially when debt levels are high and during economic downturns (Bamba et al., 2020). Fiscal consolidations aimed at short-term stabilisation can harm long-term economic growth by reducing public investments essential for growth and stability (Ilzetzki et al., 2013; Izquierdo et al., 2019). Studies reveal significant reductions in social spending, including education and health, during fiscal consolidations (Ahmad and Khan, 2022; Lahiani et al., 2022; Miningou, 2023). These findings highlight the need for careful policy design to mitigate long-term adverse impacts on economic and social development. Additionally, studies on debt service reveal that increased external debt burdens negatively impact capital expenditure and shift spending away from social sectors such as education and health, while leaving economic sector spending unaffected (Mahdavi, 2004; Fosu, 2007, 2008, 2009).

This study aims to draw valuable insights by comparing public spending patterns on agriculture between Indian states and African countries. Both regions face challenges in transforming their agricultural sectors to ensure food security and poverty reduction. In India, public investments in research, development, irrigation, roads, and education have significantly boosted productivity and reduced poverty (Bathla et al., 2017; Gulati and Terway, 2018). However, regional disparities persist, with resource-rich northern and southern regions benefiting more than poorer, rainfed eastern and central areas (Bathla et al., 2020). Addressing these disparities is crucial for enhancing overall economic welfare in India (Panagariya et al., 2014). In contrast, Sub-Saharan Africa faces persistent rural poverty due to a lack of sustainable agricultural productivity growth. Improving agricultural productivity would raise farm household incomes, reduce food costs, and promote agro-industry development, but African countries underinvest in high-return areas such as infrastructure and agricultural R&D (Goyal and Nash, 2017).

This study investigates how fiscal constraints, particularly debt service ratios, affect public spending, with a specific focus on the agricultural sector. Despite its significance, there is limited evidence on how debt influences the composition of functional-sector expenditures, especially on the agricultural sector. To address this gap, this study employs the system-GMM estimator by Blundell and Bond (1998) on data from 15 African countries and 20 Indian states covering the period from 2005 to 2019. It examines how spending patterns impact agricultural growth and child malnutrition, using fixed-effect regression models to draw lessons from regions with significant agricultural advancements.

By examining the differential impacts of public spending strategies in Indian states and African countries, this study identifies effective strategies and highlight areas for mutual learning. Understanding how fiscal constraints and debt service obligations influence public spending can provide crucial insights into optimising budget allocations to achieve sustainable development goals. This comparative analysis contributes to the literature on agricultural public spending and offers practical policy recommendations for enhancing agricultural growth and reducing malnutrition in both regions.

5.2 Public expenditure on agriculture and its implication for development

5.2.1 Understanding government expenditure rationales with a focus on agriculture

Public expenditure on agriculture is vital for fostering agricultural growth. Goyal and Nash (2017) emphasize that government investments address market failures and inequality, filling gaps left by the private sector, which often cannot efficiently provide non-excludable and non-competitive goods and services. These investments mitigate economic inefficiencies and equity issues, benefiting the rural poor by reducing poverty and enhancing productivity. They identify four pathways through which public investment enhances agricultural productivity and reduces poverty: generating technology, disseminating knowledge, reducing transaction costs, and attracting private capital. Investments in agricultural R&D generate non-excludable, non-rivalrous knowledge, boosting productivity globally (Goyal and Nash, 2017). Knowledge dissemination through extension services and training transfers skills, improving productivity (Khan et al., 2012; Donkor et al., 2016; Danso-Abbeam et al., 2018). Infrastructure investments, such as rural roads and market information systems, reduce transaction costs and enhance market access (Dorosh et al., 2009; Foster et al., 2023). Lastly, public investments in large-scale infrastructure, like irrigation, attract private capital, encouraging technology adoption and productivity improvements (Jayne et al., 2015).

However, public investments in agriculture must be part of a broader strategy that includes health, education, social protection, and rural infrastructure, supported by effective policies. Investments in health and education complement agricultural spending by enhancing the well-being and productivity of rural populations, enabling them to participate more effectively in the economy (Fan and Zhang, 2008). Therefore, a strategic allocation of public funds across sectors is essential for inclusive growth, requiring a balanced approach to agricultural spending and efficient budgeting (Goyal and Nash, 2017).

Agricultural growth is vital for reducing poverty and enhancing food security, which are crucial for addressing child malnutrition. Increased agricultural productivity improves nutritional outcomes by raising household incomes and enhancing food availability and diversity (Gillespie and van den Bold, 2017; Gillespie et al., 2019; Sharma et al., 2021). Studies have shown that increased agricultural productivity and income lead to better dietary diversity and improved nutritional outcomes for children (Headey et al., 2012). However, combating malnutrition requires a comprehensive, multi-sectoral approach, including healthcare, education, water and sanitation, and social protection (World Health Organization, 2018; FAO et al., 2021; King et al., 2020; Duncan et al., 2022). Each sector operates as a complex system, uniquely contributing to addressing the underlying causes of malnutrition. Nutrition-sensitive social protection programs, such as school feeding and cash transfers, significantly combat malnutrition by addressing its underlying causes (Ruel et al., 2013; Scott et al., 2020; Zembe-Mkabile, 2023).

Different patterns of spending within the agricultural sector can also have varied impacts on child malnutrition rates. Investments in agricultural R&D and extension services can lead to the development and dissemination of nutrient-rich crop varieties and improved farming practices, enhancing food quality and availability (Fan and Zhang, 2008). Infrastructure investments, such as rural roads, improve market access and reduce post-harvest losses, thus increasing food security and stability of food supplies (Rosegrant et al., 2015; Rosegrant et al., 2017). Moreover, subsidies aimed at reducing the cost of agricultural inputs like fertilisers and seeds can increase crop yields and farmer incomes, enabling better access to food and other necessities. These subsidies need to be carefully targeted to avoid inefficiencies and ensure that the benefits reach the most vulnerable populations (Fan, 2008; Jayne et al., 2015). Programs that provide direct support to poor farmers, such as cash transfers or food aid, can also significantly improve child nutrition by ensuring households have the resources to purchase sufficient and nutritious food (Fan and Zhang, 2008; Mogues, 2011).

Integrated approaches that combine agricultural and non-agricultural investments, such as the Comprehensive Africa Agriculture Development Programme (CAADP), are essential for effectively tackling malnutrition (IFPRI, 2013). By prioritising agricultural growth and strategically allocating public expenditure to both agricultural and social sectors, governments can create synergistic effects that drive sustainable development and significantly reduce child malnutrition. However, the effectiveness of public expenditure depends on the efficiency and targeting of the spending. Poorly designed subsidies and ineffective spending can fail to reach intended beneficiaries and may exacerbate inequalities (Fan et al., 2008). Strategic allocation of resources towards high-impact areas like R&D, extension services, and rural infrastructure, while also supporting social services, can promote overall economic development and improve child nutrition outcomes (Goyal and Nash, 2017).

5.2.2 Fiscal policy, debt servicing, and public expenditure on agriculture: a theoretical perspective

The theoretical background for examining the relationship between fiscal constraints, particularly public debt service, and public expenditure on agriculture is rooted in several economic theories. These theories explain how economic policies influence external debt and economic growth, providing a foundation for understanding the intricate dynamics between debt management and sectoral budget allocations.

Keynesian-inspired theories, particularly those from the traditional Keynesian economic development framework, assert that increasing public debt can promote growth, especially during periods of economic recessions (Demikha et al, 2021; Oberholzer, 2021). Keynesian theory suggests that increased government spending, funded through debt, can stimulate full employment and induce a multiplier effect, leading to a proportional increase in investment and output. This perspective posits that public debt's impact on economic activity depends on the economy's state, with debt-financed spending being beneficial during recessions to boost aggregate demand (Aloulou et al., 2023).

Public choice theory offers a different perspective by analysing the role of public institutions in economic life. According to this theory, government officials aiming to maximise their chances of remaining in office will make decisions that align with the preferences of the median voter (Buchanan, 1989; Tullock, 1971). Thus, public debt often results from the electoral motivations of public leaders and the bureaucratic interests of civil servants (Tullock, 1978). This view highlights the political economy aspect of public spending, where expansionist fiscal policies are used to garner electoral support, leading to increased public debt. However, the median-voter model is likely unsuitable for developing countries, where democratic processes are often incomplete. Instead, a social welfare function that reflects a weighted average of the preferences of various political coalitions would be more appropriate (Fosu, 2007; 2008; 2010).

Within the public choice theory framework, Fosu (2010) explores how liquidity constraints due to debt servicing might influence the composition of public spending across different functional sectors. In this context, the government is assumed to choose levels of sector-specific expenditures to maximise a social welfare function. Effective debt-servicing requirements could shift budgets away from social sectors or public investments, affecting economic activities and social welfare. This issue is particularly relevant in developing economies, especially in Africa, where fiscal constraints due to debt servicing have been significant. Public spending is assumed to provide consumable services to the citizenry, contributing to societal utility. Given the government's budget constraint—where total revenue is derived from domestic sources and external aid but reduced by debt servicing obligations—an increase in debt service can negatively impact resource allocation to various sectors. This diversion of resources from potentially productive investments can adversely affect long-term economic growth and social welfare. This relationship underscores the need for effective debt management to sustain investments in agriculture and other critical sectors.

Classical and neoclassical theories emphasize the negative implications of public deficits, arguing that public debt is detrimental to economic growth due to the crowding-out effect or the risk of Ricardian equivalence (Aloulou et al., 2023). Monetarists suggest that increased government borrowing raises interest rates, reducing private investment and consumption. This phenomenon, known as the interest rate crowding-out effect, can slow economic growth by making credit more expensive for the private sector (Ijirshar et al., 2016). Additionally, Friedman's (1957) inflation crowding-out theory argues that deficit financing can lead to inflationary pressures if economic agents anticipate future tax increases, ultimately neutralising the intended stimulus effect (Mensah et al, 2019).

The Ricardo–Barro equivalence theorem, developed by Barro (1974), critiques deficit financing by suggesting that rational economic agents anticipate future tax burdens resulting from current borrowing. As a result, rather than increasing consumption, agents save the additional income, thereby neutralising the fiscal stimulus. This theory underscores the limitations of using public debt as a tool for economic stimulus, as it merely shifts the tax burden to future generations without enhancing current consumption (Aloulou et al., 2023).

In the context of public expenditure on agriculture, these theoretical perspectives provide insight into how debt dynamics can influence budget allocations. High debt-service ratios, often a result of substantial public debt, can constrain fiscal space, limiting the government's ability to invest in productive sectors such as agriculture. The debt overhang theory, articulated by Krugman (1988), Sachs (1989), and Cohen (1992), posits that excessive debt can deter investment by creating uncertainty about future debt repayment. This theory uses the Laffer curve to illustrate that beyond a certain threshold, increasing debt reduces the expected value of repayment, thereby discouraging further investment and economic growth (Aloulou et al., 2023).

Applying these theoretical insights to the agricultural sector, it becomes evident that high debt levels can significantly impact public spending on agriculture. When governments prioritise debt servicing over sectoral investments, critical areas such as agricultural R&D, infrastructure, and extension services may receive inadequate funding. This underinvestment can hinder agricultural productivity, adversely affecting food security and economic growth, particularly in developing countries where agriculture is crucial for livelihoods and economic stability. Moreover, the interplay between debt management and public spending decisions is further complicated by political economy considerations. Expansionary fiscal policies driven by electoral motivations can lead to unsustainable debt levels, necessitating austerity measures that can disproportionately affect sectoral allocations like agriculture. Thus, the theoretical framework underscores the need for balanced fiscal policies that consider the long-term impacts of debt on sectoral investments and overall economic growth.

5.3 Data and measures

The study utilises panel data from 15 African countries and 21 Indian states between 2005 and 2019. The African countries include Benin, Burkina Faso, Ethiopia, Ghana, Kenya, Malawi, Mali, Rwanda, Senegal, Tanzania, Uganda, Nigeria, South Africa, Egypt, and Morocco. The Indian states include Bihar, Assam, Chhattisgarh, Jammu & Kashmir, Jharkhand, Madhya Pradesh, Uttar Pradesh, Himachal Pradesh, Odisha, Punjab, Rajasthan, Uttarakhand, West Bengal, Andhra Pradesh, Gujarat, Haryana, Karnataka, Kerala, Maharashtra, and Tamil Nadu. These regions were chosen to capture a range of contexts, including variations in economic development, agriculture, natural resources, climate, and nutrition, to understand how public expenditure impacts development and welfare.

Public expenditure data for African countries primarily comes from the SPEED database (IFPRI, 2019) and is supplemented by IMF's GFS (IMF, 2022b), ReSAKSS (ReSAKSS, 2022), and FAO's MAFAP database. For South Africa, data were sourced from the National Treasury (National Treasury, 2022) and OECD's PSE database (OECD, 2022). In India, public expenditure data is sourced from the Reports of the Comptroller and Auditor General (CAG) of India and expenditure budget reports of the Ministry of Finance, Government of India from 2005 to 2020 (CAG, Various years a), (CAG, Various years b), (Ministry of Finance, Various years).

Malnutrition data for African countries were sourced from the Joint Child Malnutrition Estimates (UNICEF et al., 2020), and for Indian states, from the National Family Health Survey (NFHS) 3, 4 and 5 (Ministry of Health and Family Welfare, n.d.). Additional economic, demographic, and agricultural performance indicators and rainfall data were sourced from the World Bank's Development Indicators (WDI) for African countries (World Bank, 2022) and from various Indian government agencies for Indian states. Rainfall data for India was obtained from the India Meteorological Department for Indian states (IMD, n.d.). Detailed list of indicators and their definitions are provided in Appendix Table D1.

5.4 Trends, size, and cmposition of public expenditure: An overview

This section analyses trends and composition of public expenditures across five sectors: agriculture, education, health, social protection, and infrastructure from 2005 to 2019. Additionally, it examines the composition of expenditures on food and agriculture at the country or state level using the MAFAP methodology for the same period.

5.4.1 Trends in total public expenditure and its composition

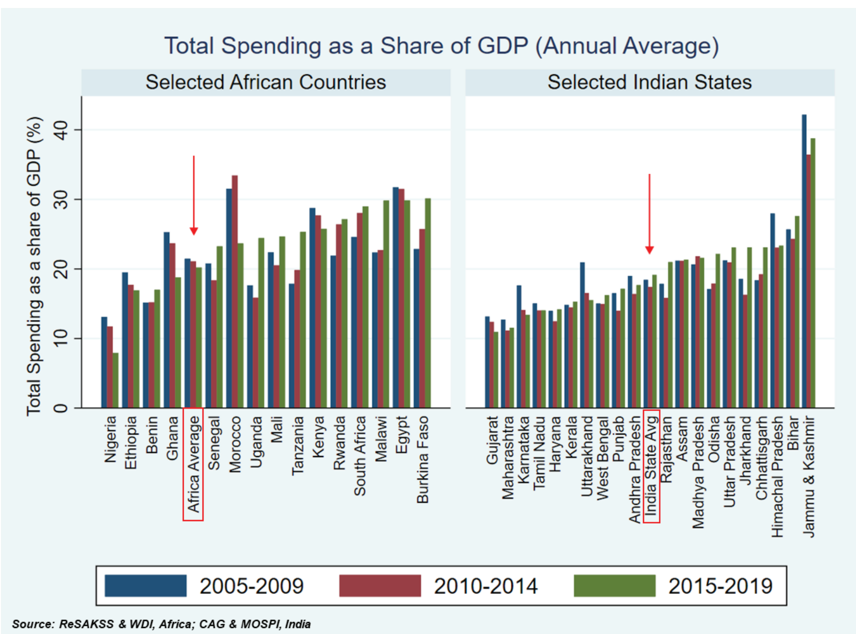
Over the 15-year period, per capita total public expenditure in the African countries and Indian states experienced overall growth. In Africa, the average per capita public expenditure from 2005 to 2009 was $1,120.3, growing at an annual rate of 2.6 per cent (Table D2). During the subsequent period from 2010 to 2014, the average per capita spending rose to $ 1251.7, with an annual growth rate of 4.1 per cent, before slightly declining to $1,232.7 between 2015 and 2019, at an annual rate of -0.4 per cent. Similarly, in Indian states, the average per capita total public expenditure was $533.5 during the 2005–2009 period, growing at an annual rate of 5.1 per cent. Between 2010 and 2014, it increased to $677.6, reflecting an annual growth rate of 5.8 per cent and from 2015 to 2019, the average per capita expenditure further rose to $975.0, with an annual growth rate of 6.6 per cent during the period. Although both African countries and Indian states experienced growth, the growth rate in Indian states was significantly higher.

Measuring total public expenditure as a percentage of GDP/GSDP shows the spending relative to the economy's size. In African countries, total public expenditure was about 21 per cent of GDP over the 15-year period, two percentage points higher than in Indian states. From 2015 to 2019, Malawi, Egypt, and Burkina Faso spent up to 30 per cent of their GDP, while Nigeria spent about 8 per cent period (Table D2). In Indian states, total public expenditure remained around 19 per cent of GSDP from 2005 to 2019. From 2015 to 2019, Himachal Pradesh, Bihar, and Jammu and Kashmir spent the most, with allocations ranging from 25 to 40 per cent of their GSDP, while Gujarat and Maharashtra spent about 11 to 12 per cent of their GSDP (Figure 5.1).

To compare government spending priorities, we analysed the composition of total spending by functional classification (Figure 5.2). In African countries, social protection and education were top priorities, averaging around $197-$219 and $142 per capita from 2005 to 2014 (Table D3), constituting about 9 per cent and 11 per cent of total expenditures. Indian states, however, prioritised agriculture and education, dedicating around 19 per cent and 16 percent of their budgets to these sectors. Per capita spending on agriculture averaged $118, $132, and $164, while per capita spending on education averaged $79, $115, and $153 during the 2005-2009, 2010-2014 and 2015-2019

Figure 5.1

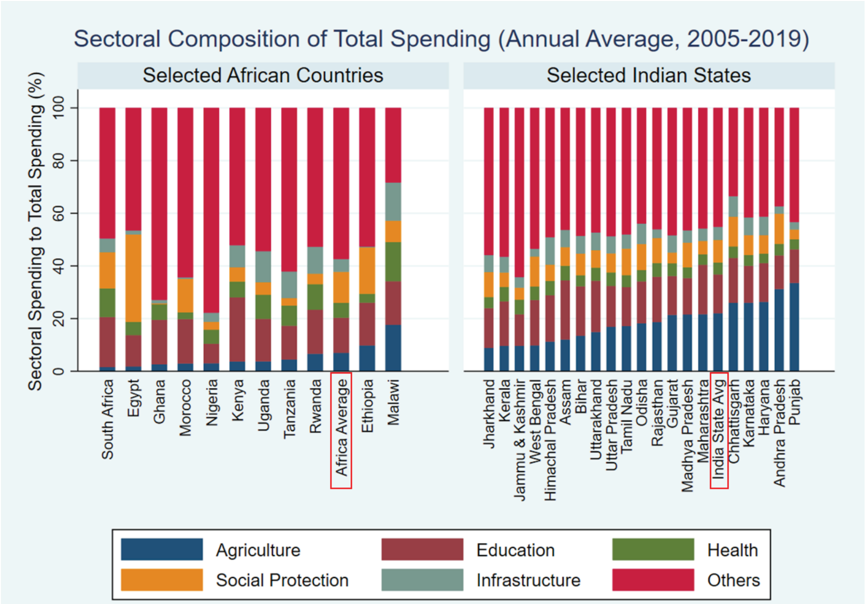
Total spending share in GDP, (Annual average 2005-2019)



Note: African countries' and Indian states' averages are population-weighted averages.

Figure 5.2

Sectoral composition of total spending (Annual average, 2005-2019)



Source: RESAKSS:, Africa; CAG, India.

Notes:

i. African countries' and Indian states' averages are population-weighted averages.

ii. This figure is based on public expenditure data from 2005 to 2019, with varying data availability for African countries within this period.

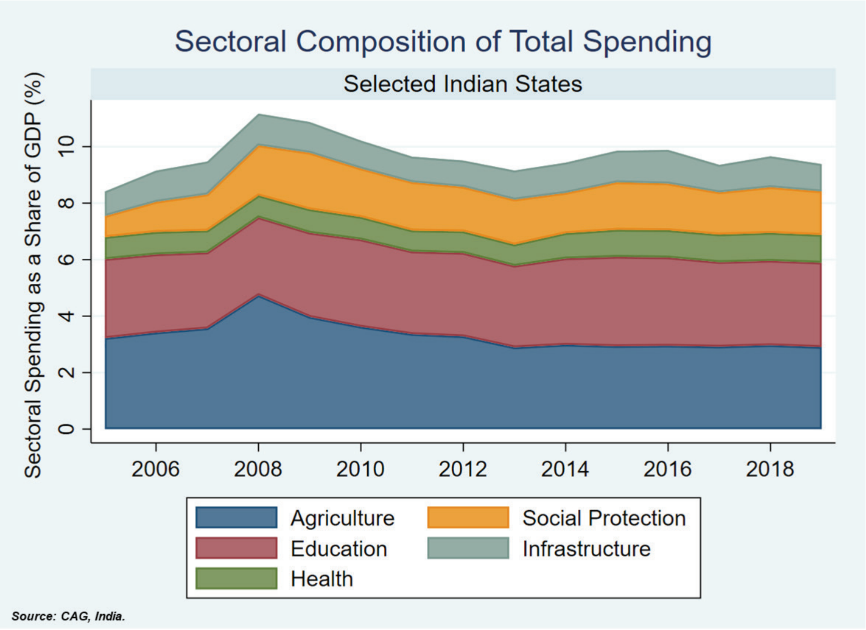
iii. Out of the all-India share of sectoral PE, Union Government accounts for agriculture 62 per cent, education 7 per cent, health 20 per cent, social protection 36 per cent, infrastructure 68 per cent.

periods, respectively. Infrastructure spending was the smallest share in both regions. Overall, Indian states showed a greater commitment to agriculture than African countries.

From 2005 to 2019, sectoral spending in Indian states remained stable, with agriculture consistently receiving a significant budget share (Figure 5.3). During the 2008 food crisis, agricultural spending in GDP increased substantially to maintain stable food prices, with 19 per cent of fiscal revenue and 70 per cent of the increased fiscal costs in 2008 attributed to food and fertiliser subsidy programs (Yu, 2015).

Figure 5.3

Trends in sectoral composition of total spending for the Indian states, 2005-2019



Note:African countries' and Indian states' averages are population-weighted averages.

This reflects the government's strong commitment to food security and price stability during economic stress.

5.4.2 Trends in public expenditure on agriculture

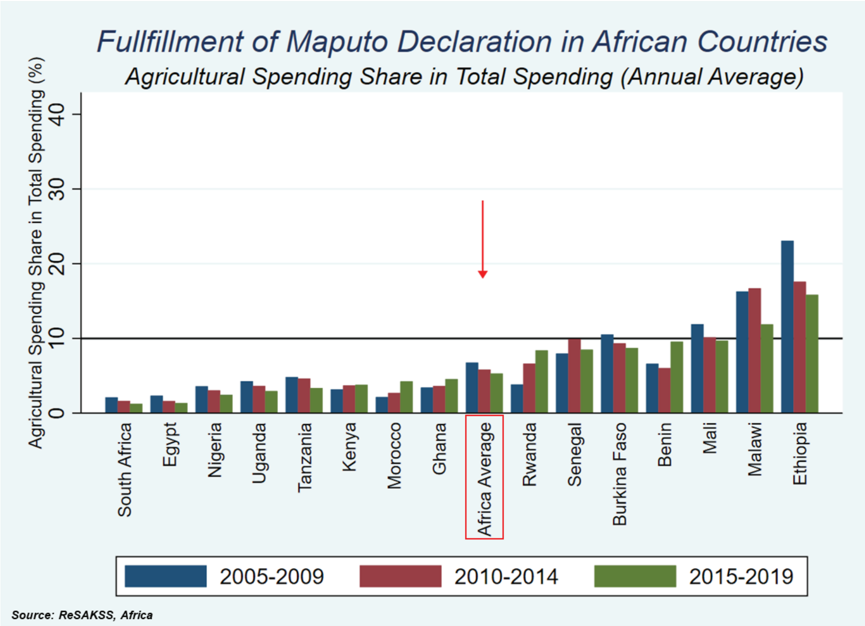
In African countries, agricultural expenditure ranged from $35 to $37 per capita, making up 5 to 8 per cent of total spending from 2005 to 2019 (Table D3). Per capita spending decreased by 2.8 per cent annually from 2015 to 2019, remaining less than 22 per cent of what Indian states spent per capita. Indian states allocated $118 to $164 per capita to agriculture, representing 16 to 20 per cent of total spending over the same period (Table D3). Despite overall increases in per capita expenditure, the share of agricultural spending in total budgets declined from 21 per cent to 16 per cent.

Despite commitments like the 2003 Maputo Declaration and the 2014 Malabo Declaration, which aimed to allocate 10 per cent of national spending to agriculture, most African countries have not met this target. Ethiopia consistently met the target, while Burkina Faso, Malawi, and Mali met it only until recent years (Figure 5.4). This underfunding highlights the challenges in prioritising agriculture in public budgets across Africa.

Public agricultural expenditure in African countries lags behind that of Indian states across multiple indicators. Agricultural spending

Figure 5.4

Fulfilment of Maputo Declaration in African countries, 2005-2019

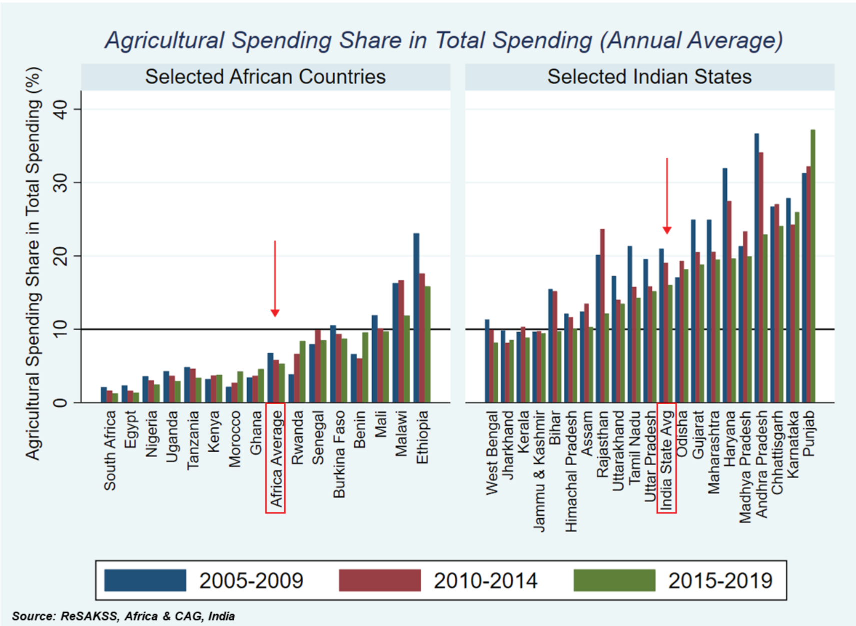


Note:African countries' and Indian states' averages are population-weighted averages.

as a share of overall public expenditure is significantly lower in African countries than in Indian states (Figure 5.5). Indian states demonstrate a strong commitment to agriculture, with most states allocating over 10 per cent of their total spending to the agricultural sector. Over the

Figure 5.5

Share of agricultural spending in total spending among African countries and Indian states



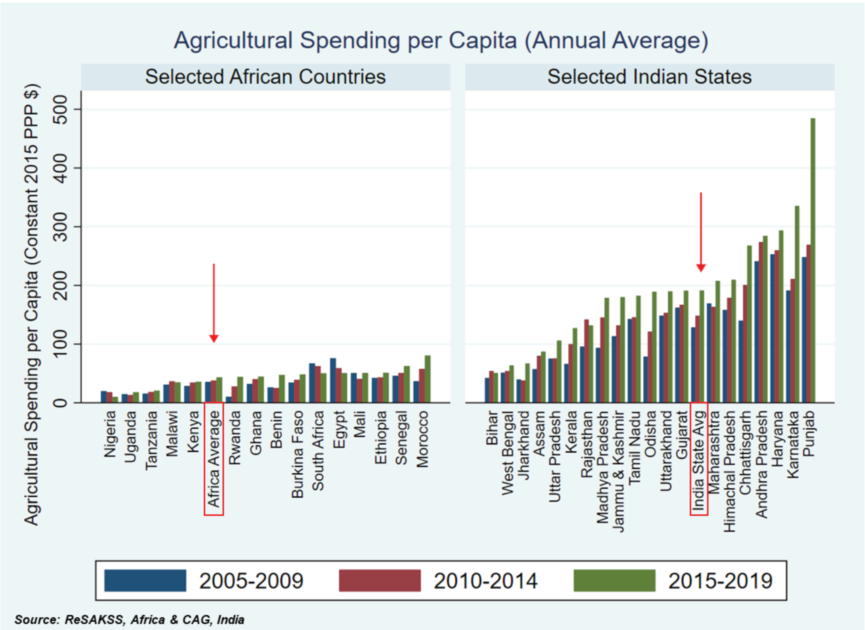
Note: African countries' and Indian states' averages are population-weighted averages.

three periods examined, Indian states allocated roughly three times the agricultural spending share compared to African states. However, it is important to note a general downward trend in the share of agricultural spending within the total budget among Indian states over time, as is to be expected in the economic development process.

By another indicator—spending per capita— the selected African countries also registered substantially lower expenditures compared to Indian states (Figure 5.6; Table D3). On average, the African countries spent $35 to $37 per capita on agriculture, while Indian states spent significantly more, ranging from $118 to $163 per capita over the period between 2005 and 2019. Additionally, spending patterns in Africa are varied, whereas Indian states have shown consistent stability in their agricultural spending over the years. This stark difference

Figure 5.6

Agricultural spending per capita (Annual Average, 2005-2019)



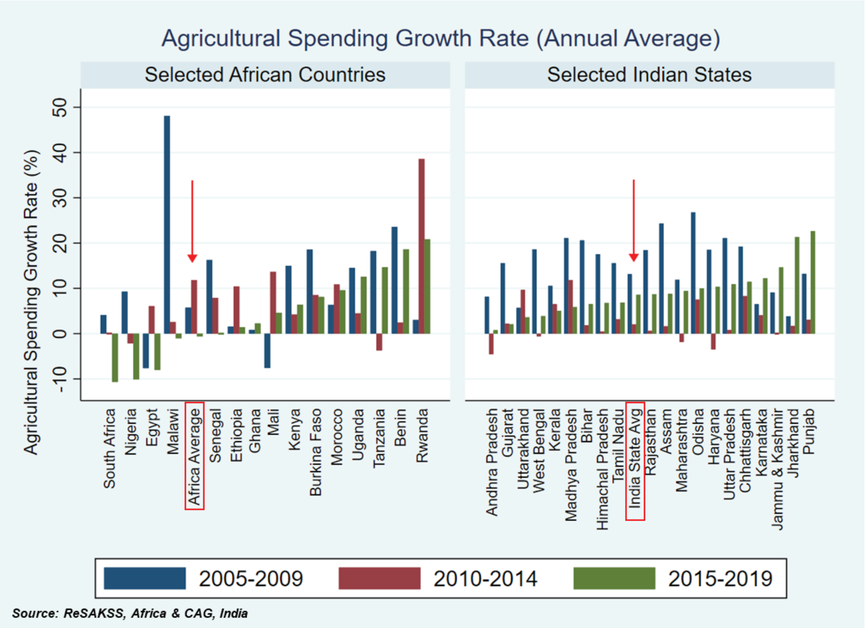
Note: African countries' and Indian states' averages are population-weighted averages.

underscores the disparity in public agricultural investment between the two regions, reflecting varying priorities and fiscal capacities.

Agricultural spending growth is another key indicator that highlights significant differences between African countries and Indian states (Figure 5.7). In African countries, agricultural spending was erratic, with negative growth in the last period: 3.7 per cent (2005-2009), 1.7 per cent (2010-2014), and -2.8 per cent (2015-2019) (Table D3). Variations were wide, with some countries like Nigeria and South Africa seeing declines, while others like Tanzania and Rwanda had increases. Indian states had more consistent growth: 11.6 per cent (2005-09), 1.1 per cent (2010-14), and 7.3 per cent (2015-19). This highlights the instability of agricultural investment in African countries compared to the stable growth in Indian states.

Figure 5.7

Agricultural spending growth rate (Annual average, 2005-2019)



Notes:

i. African countries' and Indian states' averages are population-weighted averages.

ii. Ghana removed as an outlier observation at 200 per cent for the period 2010-2014.

An alternative indicator is the Agriculture Orientation Index (AOI), which compares agriculture's share of public spending to its share in the economy. An AOI of 1 indicates balanced spending relative to economic contribution. None of the African countries reach an AOI of 1, showing a gap between agricultural spending and its economic importance (Figure 5.8). Conversely, over half of the Indian states have AOI values close to or above 1, indicating better alignment between spending and agriculture's economic role.

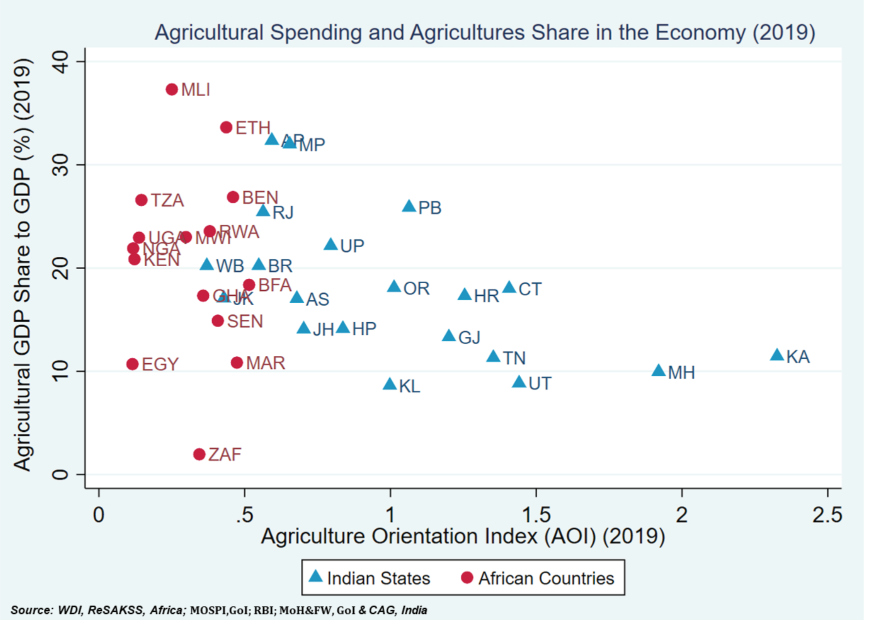
Significant deviations observed in the African countries between sectoral spending and economic contributions necessitate closer scrutiny. This raises an important question: why is agricultural spending in Africa experiencing such a negative trend? One key reason is the limited fiscal space available for sustaining increased expenditure. Many African countries experience very low annual tax revenue growth. Agricultural expenditures are restricted by limited revenue growth unless there is a significant reallocation of the budget or an increase in debt. Additionally, countries in Sub-Saharan Africa allocate a significant share of their public budgets to debt interest payments. Furthermore, government expenditures for all critical sectors, including infrastructure, health, and education compete with allocations to agriculture (Pernechele et al., 2021).

5.4.3 Composition of public expenditure on food security and agriculture

Monitoring national government expenditures on agriculture is crucial, as empirical studies show that investments in public goods like research, extension services, and off-farm irrigation yield the

Figure 5.8

Agricultural orientation index, (2019)



Source: WDI, ReSAKSS, Africa; MOSPI,GoI; RBI; MoH&FW, GoI & CAG, India highest returns (Goyal and Nash, 2017; Pernechele et al., 2021). Therefore, assessing both the amount and allocation of spending is essential to identify areas for effective resource reallocation to enhance agricultural performance. This section examines food and agriculture expenditure allocations from 2004 to 2018, following the MAFAP methodology, focusing on spending trends in private goods for producers and consumers (input subsidies) and key public goods (research, extension services, and irrigation infrastructure).

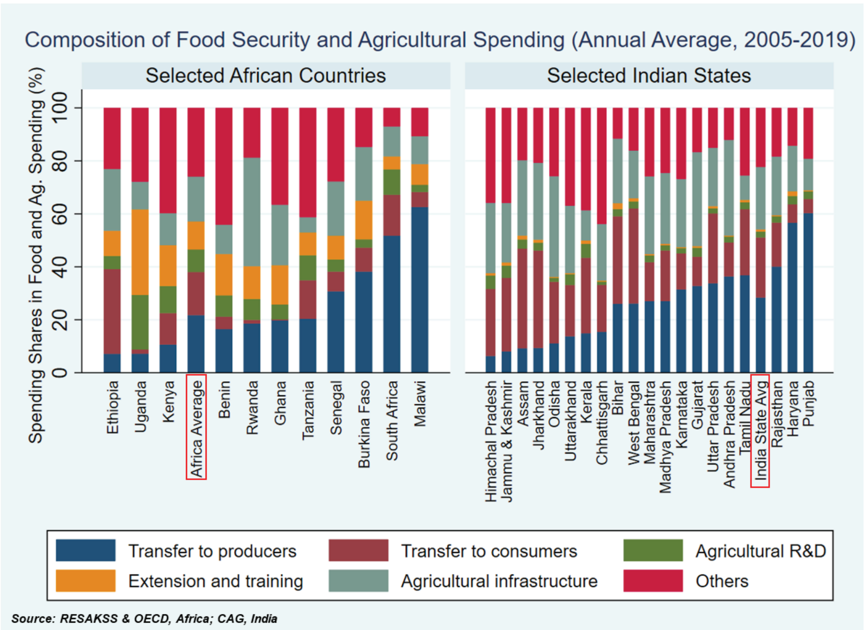
Expenditures on private goods, including producer and consumer transfers like input subsidies and food aid, constituted over 30 to 52 per cent of total food and agriculture spending in the African countries and Indian states analysed (Table D4 and Figure 5.9). Transfers to producers dominate food and agricultural expenditures in both African countries and Indian states, averaging 19 per cent and 29 per cent, respectively, from 2005 to 2019. In Africa, input subsidies constituted nearly 13 per cent of the food and agriculture budget, with insufficient funding for R&D and extension services despite rising investments in irrigation infrastructure. Indian states similarly allocated about 29 per cent to input subsidies, a trend bolstered by the 2007/08 food crisis (Figure 5.9). Consumer transfers, such as cash transfers and school feeding programs, averaged 11 per cent in African countries and 23 per cent in Indian states, further limiting long-term development spending.

Research and knowledge dissemination accounted for about 15 per cent of total food and agriculture expenditures in African countries but only 3.4 per cent in Indian states, highlighting differing priorities (Figure 5.10 and Table D4). Agricultural infrastructure spending, including feeder roads and off-farm irrigation, averaged 13 per cent in African countries and 24 per cent in Indian states, with infrastructure spending being the second-largest category in Indian states after producer transfers.

Agricultural R&D spending has been consistently underfunded in both Indian states and African countries, despite its proven high returns globally and in Sub-Saharan Africa (Figure 5.11). Both regions fall short of the African Union's target of allocating 1 per cent of agricultural GDP to R&D. However, Indian states show a positive trend in

Figure 5.9

Composition of food security and agricultural spending (Annual average, 2005-2019)



Notes:

i. African countries' and Indian states' averages are population-weighted averages.

ii. This figure is based on public expenditure data from 2005 to 2019, with varying data availability for African countries within this period.

iii. Transfer to consumers in South Africa does not include cash transfers, while agricultural infrastructure includes all rural roads for Indian states as opposed to only feeder roads.

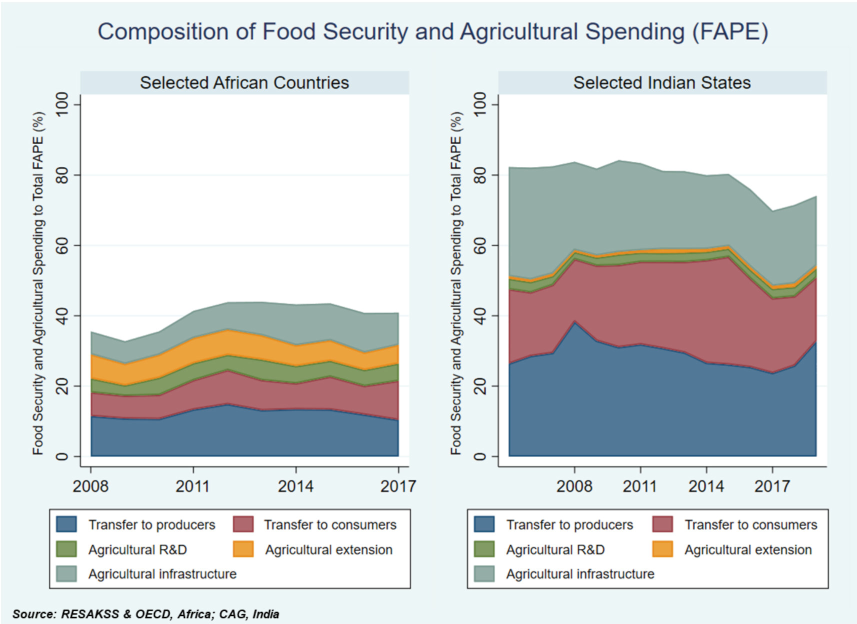
R&D investment, unlike the decline seen in most African countries. This disparity highlights a difference in commitment, with underinvestment in R&D hindering sustainable agricultural growth and long-term sector challenges in both regions.

5.5 Empirical analysis

The primary aim of this study is to explore the implications of government spending patterns on economic development in India and Africa, focusing on their effects on agricultural production and

Figure 5.10

Trend in composition of food security and agricultural spending (2005-2019)



Notes:

i. African countries' and Indian states' averages are population-weighted averages.

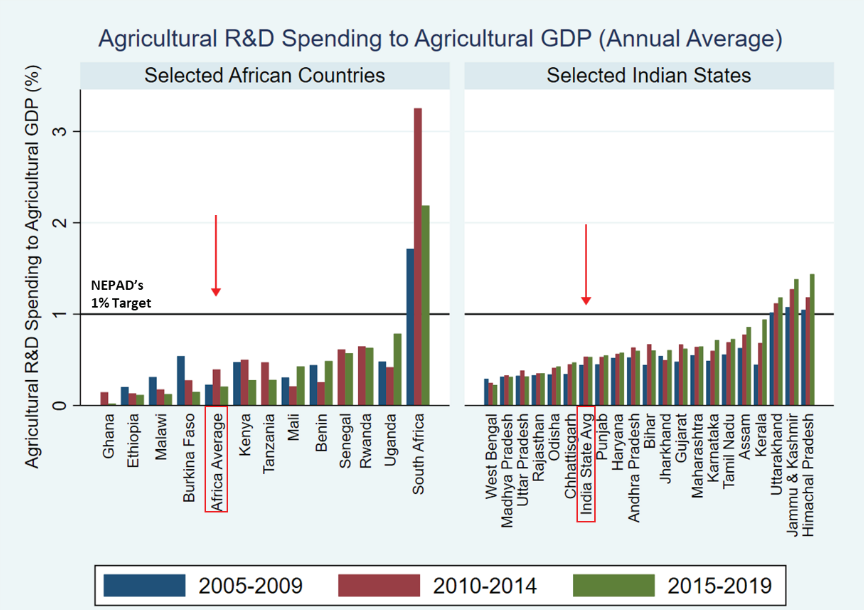
ii. Selected African countries include Benin, Burkina Faso, Ethiopia, Ghana (2013), Kenya, Ma - lawi, Mali, Rwanda (2012), Senegal (2010), South Africa, Tanzania (2011), Uganda.

iii. Transfer to consumers in South Africa does not include cash transfers, while agricultural infra -structure includes all rural roads for Indian states as opposed to only feeder roads.

child malnutrition from 2005 to 2019. To achieve these objectives, the study employs a two-stage empirical strategy. The first stage examines the impact of worsening fiscal constraints, particularly debt service ratios, on public expenditure on agriculture. The second stage assesses how changes in government spending patterns affect development outcomes, focusing on agricultural growth and child malnutrition.

Figure 5.11

Share of agricultural R&D spending to agricultural GDP (Annual average, 2005-2019)



Source: ReSAKSS, Africa & CAG, India

Notes:

i. African countries' and Indian states' averages are population-weighted averages.

ii. This figure is based on public expenditure data from 2005 to 2019, with varying data availability for African countries within this period.

5.5.1 *First stage: impact of fiscal constraints on public expenditure on agriculture and social protection*

The first part of the analysis aims to understand public spending patterns, focusing on allocations towards the agriculture sector. As outlined in the theoretical framework, government spending capacity is determined by its revenue and debt servicing obligations, with international aid also playing a significant role in many developing countries. The importance of these factors can change over time, particularly when fiscal conditions deteriorate, prompting shifts in spending patterns (Fan, 2008).

Societal preferences, indicated by level of economic development, can reflect the welfare function and influence the demand for sectors expenditures (Fosu, 2009). The level of economic development, often measured by GDP per capita, influences government capacity to generate revenue and allocate funds for public expenditures.

Factors like external aid and debt significantly impact agricultural spending. Limited tax revenue in developing countries restricts public spending, necessitating reliance on external borrowing and aid (Fan, 2008). However, tax revenue is endogenous to government expenditure (Fosu, 2009) and is thus excluded from the reduced-form model. While external aid is considered exogenous (Fosu, 2009), it is excluded from the model as it is not relevant for Indian states. The model includes actual debt service to test the impact of fiscal constraints on agricultural spending.

Political dynamics significantly influence government spending, with politicians often increasing public expenditure in pre-election periods to bolster re-election chances, leading to political budget cycles. Studies show that during these periods, spending rises in visible sectors like education and infrastructure, while health and social services receive less attention (Baleiras and Costa, 2004; Tellier, 2006; Stastna, 2015). Therefore, election cycle effects are controlled for in the reduced-form model. Demographic factors also impact public spending levels and composition, with urbanisation influencing variations in per capita expenditures on social security and welfare in developing countries (Fan, 2008).

To model changes in government spending on agriculture, we use a reduced-form specification, incorporating debt servicing and other control variables to examine its impact on agricultural expenditure.[18]

18. An appropriate specification of the theoretical model can be derived from the institutional framework for government decision-making, leading to a structural model. However, structural models in the context of developing countries often face significant challenges due to the complex and poorly understood budgetary processes of pseudo-democratic governments (Fosu, 2008). Consequently, many studies have adopted reduced-form models for robustness Fosu, (2007; 2008; 2010).

$$APE_{it} = \alpha + \beta_1 APE_{it-1} + \beta_2 LGDPP_{it-1} + \beta_3 DEBTSERV_{it} + \beta_4 URBANP_{it} + \beta_5 ELECTION_{it-1} + \nu_i + \lambda_t + \varepsilon_{it} \quad (12)$$

ν_i represents unobserved country-specific effects, λ_t captures the unobservable individual-invariant time effect, and ε_{it} is the standard error term. The dependent variable APE_{it} represents the share of agricultural allocation in the government budget. This variable captures how the budget shifts in response to changes in specific revenue components, such as debt service, which is the primary focus of this research. This specification helps mitigate any potential omitted-variable issues arising from the budgeting process. The model includes debt service as a percentage of GDP ($DEBTSERV_{it}$), GDP per capita ($LGDPP_{it-1}$), and urbanisation ($URBANP_{it}$) variables. GDP per capita is measured in natural logs and lagged by one period to remove any simultaneity bias. The model also includes a dummy variable for election years ($ELECTION_{it-1}$), set to 1 if there was a legislative election in the previous year and 0 otherwise. Given potential autocorrelation in the dependent variable, the model includes the lag of agricultural spending share in total spending. These explanatory variables capture economic, fiscal, structural, and political factors influencing public expenditure patterns.

Under fiscal constraints from high debt service, governments must allocate scarce resources between critical sectors like agriculture and social protection. While social protection programs provide immediate relief and reduce poverty, they may limit investments in agriculture, which are crucial for long-term food security and economic growth. Investment in agriculture, including R&D and infrastructure, enhances productivity and reduces malnutrition. To evaluate this trade-off, two additional models are estimated: one assessing social protection allocation ($SPPE_{it}$) and another using the ratio of agricultural to social protection spending ($APE/SPPE_{it}$) as the dependent variable. This analysis provides insights into government priorities under fiscal constraints and their impact on agricultural productivity and social welfare.

The Blundell and Bond (1998) system-GMM estimator is preferred for estimating the models above for several reasons. OLS estimates are biased due to unobserved country-specific heterogeneity, and the fixed-effects estimator is inconsistent with short panels (Nickell, 1981). Fixed-effects also underestimates covariate influence and worsens measurement error bias (Hauk and Wacziarg, 2009). The difference-GMM estimator, while addressing endogeneity and heterogeneity, suffers from weak instrument problems in time-persistent panels (Alonso-Borrego and Arellano, 1999). In contrast, system-GMM provides more reliable and efficient estimators in dynamic panels with persistent variables and less bias even when the stationary condition is doubtful (Blundell and Bond, 1998; Blundell et al., 2001).

5.5.2 Second stage: effect of public expenditure on development outcomes

The second stage of the analysis examines the impact of public spending on agricultural growth and child malnutrition in selected African countries and Indian states using descriptive and empirical methods. A comparative analysis of high and low agricultural growth performers (top and bottom quartiles based on agricultural GDP per capita growth from 2005 to 2019) is conducted. This analysis focuses on total government expenditure and its functional components, such as spending on agriculture, education, health, social protection, and infrastructure. Additionally, the study assesses agricultural spending composition, including R&D, extension services, infrastructure, and transfers to producers and consumers. Statistical tests compare means, medians, and distributions between high and low performers, providing insights into effective public spending patterns without establishing causality.

To investigate the impact of public expenditure on child malnutrition, this study employs methodologies from Smith and Haddad (2015) and Takeshima et al. (2021), using a panel-data model that accounts for unobserved country-specific fixed effects to control for time-invariant characteristics like dietary patterns, cultural norms, climate, and geography. Leveraging within-country variations over time, a country fixed-effects model is estimated to examine the impact of public spending patterns on child malnutrition rates, as detailed below.

$$y_{it} = \alpha + \sum_{s=1}^{m} \gamma_s PE_{ist} + \sum_{j=1}^{k} \beta_j X_{ijt} + \gamma_i + \varepsilon_{it},$$

$$\varepsilon_{it} \sim N(0, \sigma^2) \qquad (13)$$

Where α is a scalar, β_js are regression coefficients for control variables X_j, γ_i are unobservable country-specific, time-invariant effects, and ε_{it} is a stochastic error term. The dependent variable y_{it} represents the child malnutrition indicators, including the prevalence of stunting, wasting, underweight, and overweight among children under 5. The variable PE_{ist} represents a set of relevant public expenditure variables, which include either five sectors—agriculture, health, education, social protection, and infrastructure—or five types of public expenditure on food and agriculture: agricultural R&D, extension services, infrastructure, transfers to producers, and transfers to consumers.

For each outcome, we estimate the model using two versions of the PE_{ist} variable. In the first version, PE_{ist} includes the share of government expenditure in sector *s*, expressed as a percentage of total government expenditure, or the share of public expenditure on food and agriculture in type *s*, expressed as a percentage of total public expenditure on food and agriculture. In the second version, PE_{ist} represents the government expenditure per capita in sector *s* or the government expenditure per capita on food and agriculture in type *s*. The first version aims to capture the effect of government spending patterns, while the second version focuses on the level of spending within each sector. The model includes control variables reflecting broader determinants of nutritional status at state or national levels, including GDP per capita, urbanisation, population structure, and rainfall variability. By transforming each variable into deviations from country-specific averages, we eliminate γ_i since they are time-invariant, allowing for unbiased and consistent estimates of β_j using Ordinary Least Squares (OLS), provided the error term is uncorrelated with independent variables.[19] However, the model results should be viewed as associations rather than causal evidence. This is because two-way causality may still be present, even when past public expenditures (PEs) are used instead of current PEs for the X_{ijt} variables.

5.6 Empirical results

5.6.1 Impact of fiscal constraints on public expenditure on agriculture and social protection

To test the hypothesis on the impact of high debt service on agricultural spending in African countries, a dynamic regression model was estimated, controlling for various variables. Additionally, to compare agricultural and social protection spending under fiscal constraints, another regression analysis was conducted. The system-GMM estimations for these models are presented in Table 5.1. GDP per capita and debt service as a percentage of GDP were treated as endogenous variables. The system-GMM estimator addressed instrument proliferation by collapsing the instrument matrix (Roodman, 2009). The table includes two-step results with robust standard errors, t-statistics, significance levels, and p-values of the Hansen, Sargan, and autocorrelation tests, along with the number of observations, countries, and instruments.

The empirical results reported in column 1 indicate that high debt service ratios do not significantly predict public expenditure on agriculture, challenging the notion that higher debt service obligations limit agricultural spending. However, higher debt service ratios are associated with a lower share of agricultural spending relative to social protection, suggesting that governments prioritise social protection when faced with high debt service obligations (column 3). There is significant persistence in public expenditure on agriculture

19. Given the unbalanced panel, it is not appropriate to include a time trend or period dummy variables in this equation (for example, one for each decade). This is because any particular year or group of years is not available for all countries in the study.

over time, likely linked to the implementation of enduring, multi-year agricultural projects. Public expenditure on agriculture increased significantly during the 2008 food crisis, indicating that governments responded to the crisis by reallocating more resources to the agricultural sector. Additionally, real GDP per capita, urbanisation, legislative elections, and regional dummy variables were not significant predictors of public expenditure on agriculture, suggesting that these factors do not substantially influence agricultural spending decisions.

The analysis of public expenditure on social protection reveals several key findings. Firstly, there is significant persistence in public expenditure on social protection over time, suggesting that once established, these spending patterns tend to be maintained. However, public expenditure on social protection decreased significantly in 2007, highlighting a notable reduction during the global financial crisis. This indicates that economic stressors such as the financial crisis can have a substantial impact on social protection spending. Additionally, variables such as real GDP per capita, debt service to GDP ratio, urbanisation, legislative elections, and regional dummy variables were not significantly associated with public expenditure on social protection.

The analysis reveals several important findings regarding the allocation of spending on agriculture relative to social protection. There is significant persistence in the share of spending on agriculture compared to social protection over time, indicating stable expenditure patterns. However, higher debt service ratios are linked to a lower share of spending on agriculture relative to social protection, suggesting that governments tend to prioritise social protection when confronted with higher debt service obligations. Notably, the share of public expenditure on agriculture relative to social protection increased significantly in 2007, coinciding with the global financial crisis. Additionally, factors such as real GDP per capita, urbanisation, legislative elections, and regional dummy variables did not show significant associations with the share of public expenditure on agriculture compared to social protection, indicating that these variables do not substantially influence the relative allocation of spending between these sectors.

Table 5.1

Impact of fiscal constraints on public expenditure on agriculture and social protection

Variables	*(1)* *Share of agricultural PE in total PE (log) (System GMM)*	*(2)* *Share of social protection PE in total PE (log) (System GMM)*	*(3)* *Share of agricultural PE to social protection PE (log) (System GMM)*
Share of agricultural PE to total PE (log) (t-1)	0.646* (0.321)		
Share of combined social protection PE to total PE (log) (t-1)		0.774** (0.328)	
Share of agricultural PE to social protection PE (log) (t-1)			0.921*** (0.156)
GDP per capita (constant 2015 PPP) (log) (t-1)	0.197 (0.335)	0.0653 (0.509)	0.339 (0.466)
Share of governmental debt service to GDP (%)	0.0165 (0.0415)	0.0933 (0.116)	-0.208** (0.100)
Share of urban population in total population (%)	-0.00733 (0.0111)	-0.00254 (0.0147)	-0.0127 (0.0163)
Presence of at least one legislative election (t-1)	-0.0255 (0.0357)	0.0720 (0.0667)	-0.0884 (0.0541)
India	0.343 (0.553)	0.00327 (0.151)	0.262 (0.280)
2007	0.0502 (0.0490)	-0.232* (0.130)	0.304** (0.133)
2008	0.173** (0.0802)	0.0444 (0.141)	0.157 (0.146)
2009	-0.00392 (0.105)	0.196 (0.167)	-0.237 (0.165)
2010	-0.0133 (0.0889)	-0.00884 (0.190)	-0.0111 (0.219)

2011	-0.0164 (0.0834)	-0.0336 (0.191)	0.00342 (0.205)
2012	-0.0314 (0.0892)	0.0388 (0.192)	-0.136 (0.221)
2013	-0.120 (0.0948)	-0.0652 (0.202)	-0.152 (0.248)
2014	-0.127 (0.101)	-0.0173 (0.238)	-0.113 (0.290)
2015	-0.0906 (0.103)	0.256 (0.407)	-0.674 (0.433)
2016	-0.109 (0.116)	-0.0896 (0.207)	-0.124 (0.272)
2017	-0.138 (0.122)	-0.117 (0.265)	-0.0235 (0.317)
2018	-0.0671 (0.185)	0.00357 (0.264)	-0.224 (0.332)
2019	-0.137 (0.177)	-0.0627 (0.291)	-0.203 (0.367)
Constant	-0.781 (2.482)	-0.195 (2.958)	-2.134 (3.090)
Observations	440	318	312
R-squared			
Number of countries	33	28	28
AR(1)	0.0607	0.0165	0.000737
AR(2)	0.107	0.826	0.332
Hansen	0.119	0.114	0.169
Sargan	0.0571	0.365	0.265
Number of Instruments	24	21	23

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

5.6.2 Effect of public expenditure and its composition on agricultural growth

Analysing public spending's role in agricultural growth and food security in India and Africa involves comparing high and low agricultural growth regions. This study examines total government expenditure and its breakdown by function (agriculture, education, health, social protection, infrastructure) and within agriculture (R&D, extension services, infrastructure, subsidies, and consumer transfers). T-tests were used to compare spending patterns between high and low performers, though the findings are descriptive and do not establish causality.

Table 5.2 lists the high and low performers in agricultural growth (2005-2019), identified by top quartile growth in agricultural GDP per capita. The high growth group includes seven Indian states and Ghana, while the low growth group includes both African countries and Indian states. High growth regions achieved substantial agricultural GDP growth, with increases in per capita agricultural GDP ranging from 39 to 293 per cent, with notable increases in Madhya Pradesh and Andhra Pradesh, averaging a 70 per cent increase in per capita agricultural GDP, significantly outpacing the low growth group.

Table 5.4 compares government expenditure between high and low agricultural growth regions from 2005 to 2019. High growth regions allocate 3.3 per cent of GDP to agriculture, significantly more than the 1.8 per cent in low growth regions. High growth regions spend 20.8 per cent of total public expenditure on agriculture, compared to 9.7 per cent in low growth areas, highlighting their investment focus. Conversely, high growth regions spend less on health (2.3 per cent of GDP vs. 3.7 per cent) and education (0.7 per cent vs. 1.5 per cent). Social protection and infrastructure spending are also slightly lower in high growth regions, emphasizing their prioritisation of agricultural investment.

Table 5.5 compares government expenditures in the food and agricultural sector between high and low agricultural growth regions from 2005 to 2019. High growth regions allocated 36.52 per cent of their agricultural budget to producer transfers, compared to 34.74 per

Table 5.2

High and low growth countries in agricultural GDP (2005 – 2019)

High Growth				
Top 25% of African countries and Indian states that recorded highest growth in agricultural GDP 2005 - 2019				
Country	Ag. GDP 2005 (Per capita constant 2015 PPP $)	Ag. GDP 2019 (Per capita constant 2015 PPP $)	Ag. GDP Change (Per capita constant 2015 PPP $)	Ag. GDP Change (%)
Karnataka	865	1239	373	43.2
Gujarat	1003	1396	392	39.1
Ghana	587	1007	421	71.7
Tamil Nadu	681	1148	468	68.7
Rajasthan	831	1447	617	74.2
Haryana	1383	2026	644	46.6
Madhya Pradesh	796	1607	811	101.7
Andhra Pradesh	672	2636	1963	292.8
Low Growth				
Bottom 25% of African countries and Indian states that recorded lowest growth in agricultural GDP 2005 - 2019				
Country	Ag. GDP 2005 (Per capita constant 2015 PPP $)	Ag. GDP 2019 (Per capita constant 2015 PPP $)	Ag. GDP Change (Per capita constant 2015 PPP $)	Ag. GDP Change (%)
Kerala	1245	893	-352.2	-28.3
Nigeria	1105	1094	-10.8	-0.98
Burkina Faso	352	345	-6.8	-1.93
South Africa	249	265	16.7	6.71
Malawi	305	346	41.1	13.5
Uttarakhand	770	829	59.3	7.7
Senegal	423	512	88.1	20.8
Bihar	317	434	117	36.9

Table 5.3

High and low growth countries/ states: levels and changes in agricultural GDP (2005 – 2019)

	Ag. GDP (Per Capita Constant US$)		*Change in Ag. GDP (2005 - 2019)*	
	2005	2019	(Per Capita Constant US$)	(%)
High Growth	814	1422	542	70.2
Low Growth	387	473	28.9	7.2

Note: High and low growth average figures are based on simple averages.

cent in low growth regions, spending $85.63 per capita versus $20.30. High growth regions spent less on consumer transfers (14.32 percent vs. 18.05 per cent), with per capita spending of $32.10 versus $20.68. Agricultural R&D and extension expenditures were also lower in high growth regions, at 2.74 per cent and 1.28 per cent respectively, compared to 4.75 per cent and 5.58 per cent in low growth regions. Conversely, high growth regions invested significantly more in agricultural infrastructure, allocating 24.61 per cent of their budget compared to 18.02 per cent in low growth regions, spending $55 per capita versus $17.84. This strategic focus on producer support and infrastructure correlates with higher agricultural growth.

Table 5.4

Differences between high and low growth countries and states - public expenditure over 2005-2019

	High growth	*Low growth*	*Difference*
Total Public expenditure			
% of GDP, mean 2005-2019	16.46	19.47	-3.00***
Per Capita Constant 2015 PPP $, mean 2005-2019	870	991	-121
Agricultural expenditure			

% of GDP, mean 2005-2019	3.32	1.82	1.49***
% of Total PE, mean 2005-2019	20.79	9.74	11.05***
Per Capita Constant 2015 PPP $, mean 2005-2019	175	61	113***
Health expenditure			
% of GDP, mean 2005-2019	2.34	3.65	-1.30***
% of Total PE, mean 2005-2019	14.67	17.16	-2.50***
Per Capita Constant 2015 PPP $, mean 2005-2019	125	246	-120***
Education expenditure			
% of GDP, mean 2005-2019	0.71	1.53	-0.82***
% of Total PE, mean 2005-2019	4.45	7.05	-2.61***
Per Capita Constant 2015 PPP $, mean 2005-2019	39	115	-76***
Social protection expenditure			
% of GDP, mean 2005-2019	1.48	1.78	-0.29**
% of Total PE, mean 2005-2019	8.17	7.82	0.35
Per Capita Constant 2015 PPP $, mean 2005-2019	72	142	-70***
Infrastructure expenditure			
% of GDP, mean 2005-2019	0. 82	1.39	-0.57***
% of Total PE, mean 2005-2019	5.13	6.67	-1.54***
Per Capita Constant 2015 PPP $, mean 2005-2019	45	76	-32***
Results based on student's t-test. ***p<0.01, **p<0.05, *p<0. 1.			

Notes:

i. High and low growth average figures are based on simple averages.

ii. This table is based on public expenditure data from 2005 to 2019, with varying data availability for African countries within this period.

Table 5.5

Differences between high and low growth countries and states – agriculture and food security related public expenditure over 2005-2019

	High growth	*Low growth*	*Difference*
Transfer to Producers			
% of Agri & food Secur PE, mean 2005-2019	36.52	34.74	1.79
Per Capita Constant 2015 PPP $, mean 2005-2019	85.63	20.30	65.33***
Transfer to Consumers			
% of Agri & food Secur PE, mean 2005-2019	14.32	18.05	-3.73***
Per Capita Constant 2015 PPP $, mean 2005-2019	32.10	20.68	11.42***
Agricultural R&D			
% of Agri & food Secur PE, mean 2005-2019	2.74	4.75	-2.01***
Per Capita Constant 2015 PPP $, mean 2005-2019	5.87	3.88	1.99***
Agricultural Extension			
% of Agri & food Secur PE, mean 2005-2019	1.28	5.58	-4.29***
Per Capita Constant 2015 PPP $, mean 2005-2019	1.51	2.44	-0.92***
Agricultural Infrastructure			
% of Agri & food Secur PE, mean 2005-2019	24.61	18.02	6.5***
Per Capita Constant 2015 PPP $, mean 2005-2019	55	17.84	37.15***
Results based on student's t-test. ***p<0.01, **p<0.05, *p<0. 1.			

Notes:

i. High and low growth average figures are based on simple averages.

ii. This table is based on public expenditure data from 2005 to 2019, with varying data availability for African countries within this period.

5.6.3 *Effect of public expenditure and its composition on child malnutrition*

Effect of public expenditure and its composition on child stunting rates

Table 5.6 shows fixed-effects panel-data models examining how public spending patterns affect child stunting rates. Model (1) reveals that the share of agricultural expenditure within the total government budget significantly reduces stunting rates, while spending on education, health, social protection, and infrastructure does not show significant effects. Model (2) finds that higher per capita agricultural spending significantly reduces stunting, with no significant effects from per capita expenditures in other sectors. Model (3) shows no significant association between different types of agricultural expenditure and stunting rates. However, Model (4) indicates that higher per capita investment in agricultural infrastructure significantly reduces stunting. Control variables show GDP per capita negatively correlates with stunting, while urban population share, and the elderly population share positively correlate with stunting. Rainfall variability has no significant effect. These findings emphasize the importance of agricultural expenditure, particularly in infrastructure, in reducing child stunting, suggesting policymakers should prioritise these investments.

Effect of public expenditure and its composition on child wasting rates

Table 5.7 presents the findings from fixed-effects panel-data models on how public spending impacts child under-5 wasting. Model (1) indicates that the share of agricultural public expenditure relative to total public expenditure negatively correlates with wasting rates, but not significantly. Similarly, education, health, social protection, and infrastructure expenditures show no significant effects. Model (2) reveals that higher per capita agricultural and educational spending significantly reduce wasting rates, highlighting the importance of these investments in enhancing child nutrition. Models (3) and (4)

Table 5.6

Fixed-Effects panel-data model estimations of the impact of public spending patterns on child stunting rates

Variables	*Stunting* (Fixed effects)			
	(1)	(2)	(3)	(4)
Share of agricultural PE to total PE (log)	-0.259*			
Share of educational PE to total PE (log)	0.200			
Share of health PE to total PE (log)	-0.295			
Share of social protection PE to total PE (log)	0.0164			
Share of infrastructural PE to total PE (log)	0.0636			
Agricultural PE per capita (constant 2015 PPP) (log)		-4.333*		
Educational PE per capita (constant 2015 PPP) (log)		-8.545		
Health PE per capita (constant 2015 PPP) (log)		-0.323		
Social protection PE per capita (constant 2015 PPP) (log)		-0.347		
Infrastructural PE per capita (constant 2015 PPP) (log)		1.014		
Share of transfer to producers to agricultural PE (log)			0.00706	
Share of transfer to consumers to agricultural PE (log)			0.00693	
Share of agricultural R&D to agricultural PE (log)			0.349	
Share of agricultural infrastructure to agricultural PE (log)			-0.0422	
Transfer to producers per capita (constant 2015 PPP) (log)				-0.904
Transfer to consumers per capita (constant 2015 PPP) (log)				-0.127

Agricultural R&D per capita (constant 2015 PPP) (log)				1.582
Agricultural Infrastructure per capita (constant 2015 PPP) (log)				-2.339***
GDP per capita (constant 2015 PPP) (log)	-14.69***	-4.601	-15.42***	-13.69***
Share of Urban population in total population (%)	0.298**	0.262**	-0.000856	0.00873
Population share 15 to 64 (%)	-0.250	-0.0101	-0.164	-0.174
Population share 65 and above (%)	1.114	2.578*	4.404**	4.167**
Rainfall (z-score) deviation	1.079	1.937	1.347	1.097
Constant	161.7***	114.5***	149.1***	144.4***
Observations	75	75	117	110
R-squared	0.772	0.808	0.682	0.688
Number of countries/ states	27	27	29	29
Significance level: *** p<0.01, ** p<0.05, * p<0.1				

Table 5.7

Fixed-Effects panel-data model estimations of the impact of public spending patterns on child wasting rates

Variables	*Wasting* (Fixed effects)			
	(1)	(2)	(3)	(4)
Share of agricultural PE to total PE (log)	-0.244			
Share of educational PE to total PE (log)	-0.154			
Share of health PE to total PE (log)	0.475			
Share of social protection PE to total PE (log)	0.193			
Share of infrastructural PE to total PE (log)	0.205			
Agricultural PE per capita (constant 2015 PPP) (log)		-4.171**		
Educational PE per capita (constant 2015 PPP) (log)		-12.80**		

Health PE per capita (constant 2015 PPP) (log)		7.243		
Social protection PE per capita (constant 2015 PPP) (log)		1.272		
Infrastructural PE per capita (constant 2015 PPP) (log)		1.679		
Share of transfer to producers to agricultural PE (log)			0.0260	
Share of transfer to consumers to agricultural PE (log)			0.0534	
Share of agricultural R&D to agricultural PE (log)			0.129	
Share of agricultural infrastructure to agricultural PE (log)			0.00449	
Transfer to producers per capita (constant 2015 PPP) (log)				-0.284
Transfer to consumers per capita (constant 2015 PPP) (log)				0.162
Agricultural R&D per capita (constant 2015 PPP) (log)				0.494
Agricultural Infrastructure per capita (constant 2015 PPP) (log)				-1.130
GDP per capita (constant 2015 PPP) (log)	-8.777***	-3.490	-6.376***	-5.710***
Share of Urban population in total population (%)	0.0610	-0.00809	-0.0142	-0.0231
Population share 15 to 64 (%)	0.408*	0.457**	0.470**	0.546**
Population share 65 and above (%)	2.262	3.294*	1.730	1.526
Rainfall (z-score) deviation	-3.183*	-2.193	-3.186*	-3.741**
Constant	48.75**	40.86*	25.87	22.23*
Observations	75	75	117	110
R-squared	0.289	0.366	0.217	0.263
Number of countries/ states	27	27	29	29
Significance level: *** p<0.01, ** p<0.05, * p<0.1				

explore specific agricultural expenditures, finding with model (4) that agricultural infrastructure per capita significantly reduces wasting rates. GDP per capita consistently shows a significant negative relationship with wasting, indicating that higher economic development improves child nutrition outcomes. The share of the urban population and working-age population present mixed results, while rainfall deviation shows a significant negative effect, linking adverse weather to higher wasting rates. In summary, higher per capita investments in agriculture and education are crucial for reducing child wasting rates, suggesting policymakers should prioritise these areas.

Effect of public expenditure and its composition on underweight prevalence in children

Table 5.8 shows the results from fixed-effects panel-data models on how public spending affects child under-5 underweight. Model (1) indicates a significant negative association between agricultural public expenditure share and underweight rates, implying higher agricultural spending reduces underweight prevalence. Conversely, shares of education, health, social protection, and infrastructure spending show no significant effects. Model (2) reveals significant negative associations between per capita agricultural and educational spending and underweight rates, emphasizing the importance of these investments in improving child nutrition. Models (3) and (4) analyse specific agricultural expenditures. Interestingly, agricultural R&D expenditure shows a positive association with underweight rates, suggesting potential inefficiencies or lagged benefits in this sector. GDP per capita consistently shows a significant negative relationship with underweight rates, indicating higher economic development improves child nutrition. Urban population share and population aged 65+ show positive associations with underweight rates, reflecting challenges in urban areas and resource allocation for the elderly. Rainfall deviation has a significant negative effect. Overall, increasing the share and per capita investments in agriculture and education is crucial for reducing child underweight rates.

Table 5.8

Fixed-Effects panel-data model estimations of the impact of public spending patterns on underweight prevalence in children

Variables	*Underweight (Fixed effects)*			
	(1)	(2)	(3)	(4)
Share of agricultural PE to total PE (log)	-0.315*			
Share of educational PE to total PE (log)	-0.333			
Share of health PE to total PE (log)	0.467			
Share of social protection PE to total PE (log)	-0.00350			
Share of infrastructural PE to total PE (log)	0.108			
Agricultural PE per capita (constant 2015 PPP) (log)		-4.652***		
Educational PE per capita (constant 2015 PPP) (log)		-15.24**		
Health PE per capita (constant 2015 PPP) (log)		7.676*		
Social protection PE per capita (constant 2015 PPP) (log)		-0.242		
Infrastructural PE per capita (constant 2015 PPP) (log)		1.858*		
Share of transfer to producers to agricultural PE (log)			0.0224	
Share of transfer to consumers to agricultural PE (log)			0.0863	
Share of agricultural R&D to agricultural PE (log)			0.304*	
Share of agricultural infrastructure to agricultural PE (log)			0.0312	

Transfer to producers per capita (constant 2015 PPP) (log)				-0.863
Transfer to consumers per capita (constant 2015 PPP) (log)				-0.0787
Agricultural R&D per capita (constant 2015 PPP) (log)				2.198***
Agricultural Infrastructure per capita (constant 2015 PPP) (log)				-1.149
GDP per capita (constant 2015 PPP) (log)	-16.94***	-8.793	-15.12***	-15.17***
Share of Urban population in total population (%)	0.162*	0.134*	0.0540	0.0835
Population share 15 to 64 (%)	0.0525	0.166	0.125	0.118
Population share 65 and above (%)	2.887	4.040**	2.185	2.228*
Rainfall (z-score) deviation	-1.050	-0.0245	-1.283	-1.955
Constant	151.4***	125.1***	122.8***	129.9***
Observations	75	75	117	110
R-squared	0.745	0.783	0.653	0.655
Number of countries/ states	27	27	29	29
Significance level: *** p<0.01, ** p<0.05, * p<0.1				

Impact of public expenditure and its composition on child overweight rates

Table 5.9 presents fixed-effect regression results on the impact of public spending patterns on child overweight rates. Model (1) shows a significant negative association between health public expenditure share and overweight rates, suggesting higher health spending reduces child overweight. Other expenditure shares (agricultural, educational, social protection, and infrastructural) do not show significant effects. Model (2) also finds no significant associations between per capita public expenditure (agricultural, educational, health, social protection, infrastructural) and overweight rates. Model (3) indicates a significant negative association between consumer transfers in agricultural expenditure and overweight rates. Other expenditure shares (transfers to producers, agricultural R&D, and infrastructure) are not significant. Model (4) shows a significant negative association between agricultural R&D per capita and overweight rates, suggesting higher investment in agricultural R&D reduces child overweight. Other per capita expenditures (transfers to producers, consumer transfers, agricultural infrastructure) are not significant.

Across all models, GDP per capita is significantly positively associated with overweight rates, indicating higher economic development correlates with higher child overweight. Urban population share shows a positive association with overweight rates in Model (1), suggesting urbanisation might increase child overweight due to lifestyle changes. The elderly population share is positively associated with overweight rates in Model (2). Rainfall deviation is not significant. Overall, targeted spending in health and specific agricultural components (consumer transfers and agricultural R&D) is crucial for reducing child overweight rates, highlighting the importance of strategic public fund allocation for improving child health outcomes.

Table 5.9

Fixed-Effects panel-data model estimations of the impact of public spending patterns on child overweight rate

Variables	*Overweight (Fixed effects)*			
	(1)	(2)	(3)	(4)
Share of agricultural PE to total PE (log)	0.0551			
Share of educational PE to total PE (log)	0.186			
Share of health PE to total PE (log)	-0.465**			
Share of social protection PE to total PE (log)	-0.0446			

Share of infrastructural PE to total PE (log)	0.0982			
Agricultural PE per capita (constant 2015 PPP) (log)		1.004		
Educational PE per capita (constant 2015 PPP) (log)		-0.929		
Health PE per capita (constant 2015 PPP) (log)		-2.048		
Social protection PE per capita (constant 2015 PPP) (log)		-0.344		
Infrastructural PE per capita (constant 2015 PPP) (log)		-0.0212		
Share of transfer to producers to agricultural PE (log)			0.0103	
Share of transfer to consumers to agricultural PE (log)			-0.0587**	
Share of agricultural R&D to agricultural PE (log)			-0.0354	
Share of agricultural infrastructure to agricultural PE (log)			0.0116	
Transfer to producers per capita (constant 2015 PPP) (log)				0.186
Transfer to consumers per capita (constant 2015 PPP) (log)				0.0908
Agricultural R&D per capita (constant 2015 PPP) (log)				-0.972*
Agricultural Infrastructure per capita (constant 2015 PPP) (log)				-0.0593
GDP per capita (constant 2015 PPP) (log)	1.580	3.463**	0.0752	0.864
Share of Urban population in total population (%)	0.0738*	0.0522	-0.0173	-0.0325

Population share 15 to 64 (%)	0.0465	0.112	0.0622	0.0339
Population share 65 and above (%)	-0.182	0.342	2.279*	1.801
Rainfall (z-score) deviation	0.166	0.320	0.373	0.801
Constant	-14.59**	-25.89**	-9.190	-11.42***
Observations	72	72	114	107
R-squared	0.352	0.304	0.316	0.274
Number of countries/ states	27	27	29	29
Significance level: *** p<0.01, ** p<0.05, * p<0.1				

5.7 Conclusion and policy implication

This study explored the implications of government spending patterns on economic development in India and Africa, with a focus on their effects on agricultural production and child malnutrition from 2005 to 2019. Using a two-stage empirical strategy, we examined how worsening fiscal constraints posed by debt servicing affect the fiscal allocation focusing on the agriculture and social protection sectors. In the second stage, we assessed how changes in government spending patterns affected agricultural output and development outcomes such as child malnutrition.

Our findings reveal several key insights. Firstly, higher debt service ratios do not significantly predict public expenditure on agriculture. However, they are associated with a lower share of agricultural spending relative to social protection, indicating that governments tend to prioritise social protection when faced with high debt service obligations. This underscores the need for a balanced approach to public spending, ensuring essential sectors like agriculture are not neglected even under fiscal constraints.

Public agricultural spending in African countries is consistently lower than in Indian states, showing a negative trend over the period studied. This is evident in both the share of agricultural spending relative to agricultural GDP and total public spending. African countries need to boost agricultural public spending to enhance productivity and reduce child malnutrition.

The study highlights the importance of enhancing public spending on agricultural R&D and extension services for technology adoption. Despite high returns, agricultural R&D remains significantly underfunded in both African countries and Indian states. In India, agricultural extension services receive the least allocation of resources, averaging less than 1 per cent of total agricultural spending. Effective extension services, especially in areas where information constraints impede the uptake of modern inputs, can be a cost-effective strategy. Policymakers should balance investments between R&D and extension services to maximise technological adoption and agricultural productivity.

Overemphasis on unproductive input subsidies, such as those for seeds and fertilisers, often leads to inefficiencies. It is essential to reform these subsidies and broaden the policy mix to include investments in extension, rural credit markets, and infrastructure for input distribution. Shifting government spending from private to public goods, particularly focusing on agricultural R&D and infrastructure, can yield larger growth effects. Evidence points to the significant benefits of investing in agricultural infrastructure, R&D, and extension services over subsidies, emphasizing the need for strategic allocation and reallocation of public resources to maximise their impact on agricultural growth and child nutrition.

The analysis of high and low growth performers in agricultural GDP per capita shows that high growth performers allocate a substantially larger share of their GDP to agricultural expenditure compared to low growth performers. Conversely, high growth performers spend less on health and education, highlighting a strategic focus on agricultural investments over other sectors. This prioritisation correlates with significant agricultural GDP growth, with high growth performers achieving an average increase of 70 per cent per capita agricultural GDP, approximately ten times higher than the low growth group. High growth performers also invested more in agricultural infrastructure and direct support to producers, while spending less on agricultural

R&D and extension services, suggesting that direct support to producers and infrastructure investment are critical for achieving high agricultural growth.

Regarding child malnutrition, the study shows that the share of agricultural public expenditure relative to total public expenditure is significantly associated with reductions in stunting, wasting, and underweight rates among children. Higher per capita investment in agriculture, particularly in agricultural infrastructure, is strongly linked to improved child nutrition outcomes. These support previous research's strong agriculture-nutrition linkage assumptions, which state that household level agricultural production and domestic agricultural output continues to be a major source of food and macro- and micronutrients for children. Public expenditure on other sectors, such as health, education, social protection, and infrastructure, has had somewhat inconsistent results on these outcomes.

These results highlight the need for strategic allocation and reallocation of public resources to maximise their impact on agricultural growth and child nutrition. Policymakers should focus on increasing agricultural public spending, especially in underfunded areas like agricultural R&D and extension services, while reforming unproductive input subsidies to enhance overall productivity and technological adoption. Shifting government spending from private to public goods, such as agricultural R&D and infrastructure, can yield larger growth and malnutrition reduction effects. Ensuring efficient and targeted public spending, even under fiscal constraints, is essential for fostering sustainable economic development and improving child nutrition outcomes in India and Africa.

6

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Conclusions and Recommendations

Agriculture will remain at the heart of the growth-employment nexus in India and Africa for the decades to come. Both regions have a high share of poor and undernourished people in the world who largely depend on agriculture. Fostering higher agricultural growth and promoting agricultural transformation is essential for overall inclusive development. Through our finding from the cluster analysis, we identify opportunities and best practices for mutual South-South learning to not only put the two regions on a high agricultural growth trajectory but also to make the agricultural sectors resilient and sustainable while providing nutrition for all.

Five clusters of Indian states and African countries can be identified that share similar agricultural, economic, and social characteristics, thus allowing for state-country comparisons. Our comparative analysis shows that almost all Indian states and African countries have experienced substantial agricultural growth since 2000, but also saw the typical patterns of sectoral transformation, i.e. declining of shares of agricultural GDP and employment in the overall economy. Agricultural productivity has increased for all and roughly doubled in many Indian states and African countries. The drivers of agricultural growth differed between the two regions. While agricultural intensification was the main driver of India's agricultural output growth, many African countries made use of agricultural area expansion to increase agricultural output.

Gains in productivity and progress in structural transformation, rather than pure intensification, proved essential to achieve sustained impacts on food and nutrition security. Agricultural diversification played a significant role in agricultural growth and nutrition improvements in India and Africa. A high share of livestock in agricultural output has provided a profitable avenue to empower small and marginal dairy farmers and created jobs along the dairy value chain. Positive nutrition outcomes could also be achieved through agricultural policies that seek to reduce micronutrient deficiencies and create synergies between related sectors, including water and sanitation as well as women's education.

Increasing agricultural spending is crucial for boosting productivity and reducing child malnutrition. Our analysis shows that high agricultural growth performers among Indian states and African countries allocate more GDP to agricultural spending, prioritise infrastructure and direct support to producers, and achieve significantly higher agricultural GDP growth, which is linked to reductions in child malnutrition and improved child nutrition outcomes. However, overall, public spending on agriculture in African countries and some Indian states remains low, both as a share of total public spending and relative to agriculture's role in the economy. Similarly, agricultural R&D is underfunded in both regions despite its high returns while extension services receive minimal funding in India. Moreover, excessive focus on input subsidies leads to inefficiencies.

Based on our analysis, the following recommendations are put forward:

1. **Investments in the development and scaling of locally relevant innovations will be key to sustainable intensification and value-addition in the agricultural sectors.** Priority areas include investments in irrigation and water management, digitalisation, climate-smart agriculture, post-harvest management, agroprocessing and value chain efficiency.
2. **Supporting agricultural diversification into livestock and high-value crops will empower smallholder farmers, improve nutrition and expand value chains.** Shifting to high-value commodities requires investment in market infrastructure and a well-connected road network, including through private investment and public-private partnerships.

3. **African and Indian policymakers should increase public spending on agriculture, particularly in underfunded areas such as R&D and extension services, to boost productivity and drive technological adoption.** Strengthening extension services is especially important in regions with significant information gaps that hinder the uptake of modern agricultural inputs.
4. **In African countries and Indian states, reforming inefficient input subsidy programs and reallocating resources toward public goods like agricultural infrastructure, R&D and extension services is essential for long-term growth and productivity.** Shifting funds from private goods, such as subsidies and food aid, to public investments will enhance productivity and resilience in these regions.
5. **In both regions, nutrition-sensitive agricultural policies should be integrated with social sectors such as water, sanitation and women's education.** Governments should foster innovation and cross-sectoral linkages, replicating proven interventions such as biofortification and targeted social programs, while prioritising investments in agricultural infrastructure to reduce child malnutrition.
6. **A balanced approach to public spending is needed in both African countries and Indian states, even under fiscal constraints, to avoid compromising critical agricultural investments for short-term social protection programs.** Agricultural investments are essential for long-term growth, poverty reduction, and improved food security and nutrition outcomes, and must be protected in times of fiscal pressure.
7. **Development partners need to take the diversity in growth trajectories, sectoral characteristics and fiscal environments in African countries and Indian states into account when deciding on their level and type of engagement.** Such a targeted approach is essential to ensure that their development investments are aligned with local priorities and capabilities.

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Annexure

A. *Overview of India-Africa Comparison of Agricultural and Food Transformation*

Table A1

Principal components derived by PCA with factor loading, 2000

Variable	*PC 1*	*PC 2*	*PC 3*	*PC 4*	*Unexplained*
GDP	-0.07	-0.09	0.60	0.03	0.13
Agriculture GDP	0.09	0.16	0.55	-0.23	0.19
GDP per capita	-0.02	-0.41	0.19	0.15	0.11
Per capita Agricultural GDP	0.37	-0.27	-0.16	-0.24	0.29
Employment in agriculture	-0.01	0.39	-0.27	0.01	0.13
Population density	0.17	0.32	0.27	-0.12	0.38
Irrigation ratio	0.43	0.16	0.05	0.09	0.07
GVOA per hectare	0.40	0.05	0.04	-0.01	0.24
Share of Agriculture in GDP	0.10	0.25	-0.29	-0.27	0.30
Share of Livestock In GVOA	0.03	0.03	-0.05	0.83	0.15
Fertiliser Utilisation	0.41	0.10	0.11	0.08	0.12
Tractor intensity	0.46	-0.12	-0.12	0.07	0.17
Underweight	-0.02	0.54	0.12	0.24	0.17
Poverty	-0.28	0.26	-0.03	-0.14	0.33
Eigen Value	5.0	3.7	1.3	1.2	
Variance (%)	31	24	16	9	
Cumulative explained Variance (%)	31	54	71	80	

Source: Author's calculation

Table A2

Principal components derived by PCA with factor loading, 2016

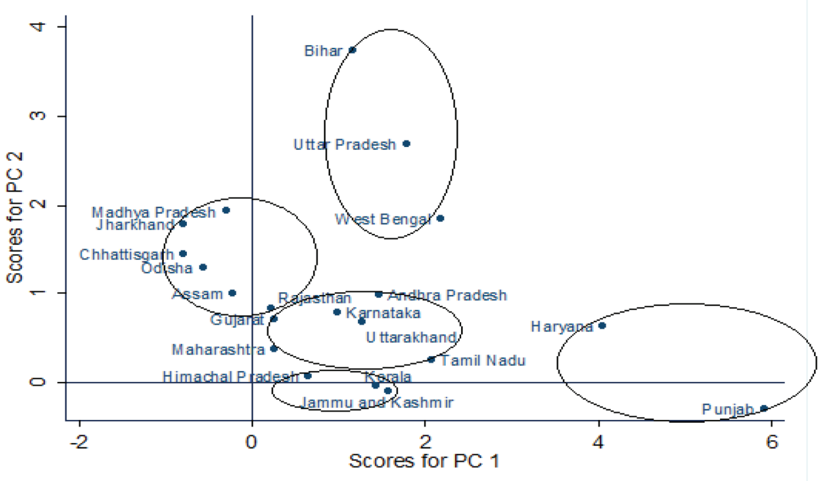
Variable	*PC 1*	*PC 2*	*Unexplained*
Per capita Agricultural GDP	0.35	-0.01	0.60
Employment in agriculture	-0.39	0.36	0.25
Population	0.13	0.41	0.61
Irrigation ratio	0.42	0.34	0.20
GVOA per hectare	0.39	0.26	0.37
Share of Agriculture in GDP	-0.27	0.34	0.54
Share of Livestock In GVOA	0.30	-0.02	0.70
Underweight	0.04	0.61	0.24
Poverty	-0.47	0.18	0.22
Eigen Value	3.3	2.0	
Variance (%)	36.3	22.5	
Cumulative explained Variance (%)	36	59	

Source: Author's calculation

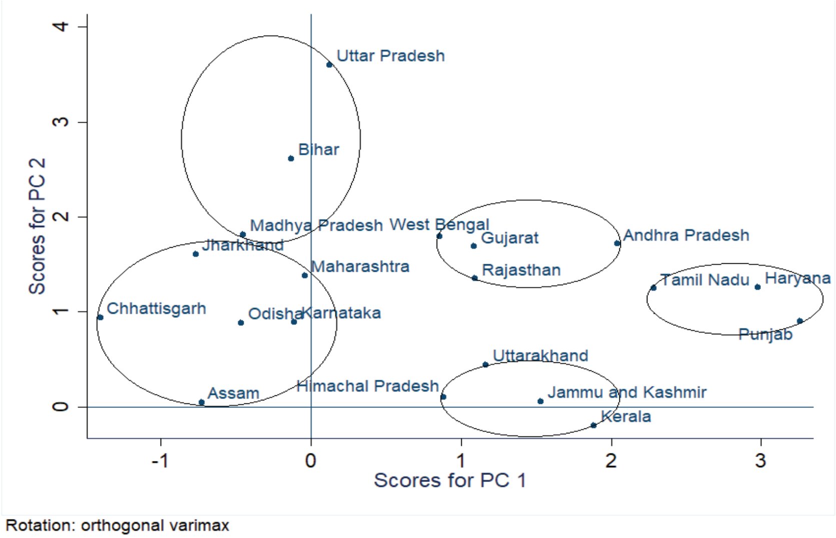
Figure A3

Score plot of five clusters delineated by principal component axis, 2000 and 2016

Clustering for 2000



Clustering for 2016



Source: Created by authors

Table A4

One-to-one nearest neighbour matching, 2000 and 2016

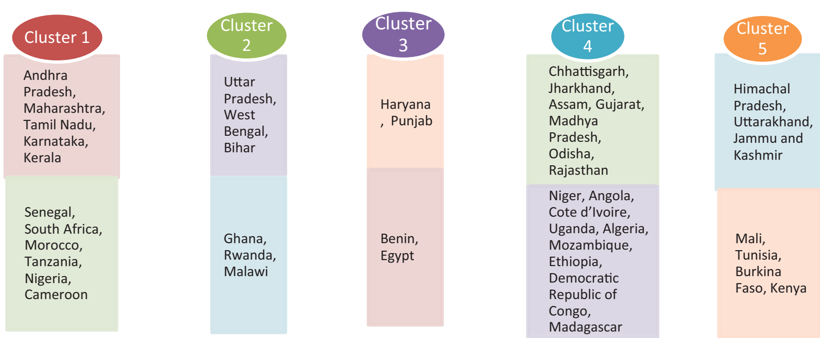
2000		*2016*	
African countries	Indian states	African countries	Indian states
Algeria	Gujarat	Algeria	Tamil Nadu
Angola	Jharkhand	Angola	Maharashtra
Benin	Haryana	Benin	Andhra Pradesh
Burkina Faso	Uttarakhand	Burkina Faso	Karnataka
Cameroon	Kerala	Cameroon	Gujarat
Congo, Dem. Rep.	Odisha	Congo, Dem. Rep.	Uttar Pradesh
Cote d'Ivoire	Assam	Cote d'Ivoire	Jammu and Kashmir
Egypt	Punjab	Egypt	Haryana
Ethiopia	Madhya Pradesh	Ethiopia	Chhattisgarh
Ghana	Uttar Pradesh	Ghana	Himachal Pradesh
Kenya	Jammu and Kashmir	Kenya	Assam
Madagascar	Rajasthan	Madagascar	Bihar

Malawi	Bihar	Malawi	Assam
Mali	Himachal Pradesh	Mali	Odisha
Morocco	Tamil Nadu	Morocco	Kerala
Mozambique	Gujarat	Mozambique	Assam
Niger	Chhattisgarh	Niger	Madhya Pradesh
Nigeria	Maharashtra	Nigeria	Jharkhand
Rwanda	West Bengal	Rwanda	Assam
Senegal	Andhra Pradesh	Senegal	Uttarakhand
South Africa	Maharashtra	South Africa	Punjab
Tanzania	Karnataka	Tanzania	West Bengal
Tunisia	Himachal Pradesh	Tunisia	Kerala
Uganda	Assam	Uganda	Rajasthan

Source: Authors' calculation

Figure A5

Clusters Analysis for 2000



Source: Author's Compilation from 2000 data

B. *Drivers of Agriculture Growth in Africa and India: Lessons for South-South Learnings*

Table B1

Selected variables for empirical analysis

Categories	*Variables**	*Description*
Dependent Variable		
Agricultural GDP	$AGDP_{it}$	Gross State/Country Domestic Product in Agriculture at 2011-12 INR constant prices
Explanatory variables		
Inputs	$fertilizer_{it}$	Fertilizer utilisation (kg per hectare)
	$Tractor_{it}$	Tractor density per 1000 hectares
	$Irrigation_{it}$	Tractor of cropped area under irrigation
	$Input\ Index_{it}$	Input index which is constructed by taking the average of the normalized values of fertiliser use, tractors density and irrigation.
	$Agri\_Area_{it}$	Area under cultivation in hectares
Incentives	ToT_{it}	Terms (relative prices): measured as a ratio of agricultural deflator relative to manufacturing deflator
Structural transformation	$H2_{it}$	A proxy for diversification in agricultural sector. It is the Herfindahl-Hirschman Index measuring market concentration or specialisation in agricultural sector. The index is summation of square of the share of each sector in agriculture i.e. cereal, fruits & vegetables and livestock in GVOA. Higher the value of H2 lower is the diversification in agricultural sector.
	$AgriGDP_{it}$	Share of agricultural gross domestic product in Agriculture and allied activities (GSDPA) in the gross domestic product (GDP)
Infrastructure	$Transport\ Index_{it}$	The composite index is calculated as a weighted average of indicators for each component where weights are based on the standard deviation of each normalized component. The index is constructed using two indicators: (i) total paved roads (km per 10000 inhabitants) and (ii) total road network in km (per sq km of exploitable land area)
	$Electricity\ Index_{it}$	Total electricity generated in a country/state measured in millions of kilowatt-hours produced per hour and per inhabitant

	ICT $Index_{it}$	It is a composite index measuring total phone subscription in a country including both fixed-line telephone and mobile-cellular phones subscription per 100 inhabitants in a given year
Weather	Rainfall $Index_{it}$	Index of average rainfall in the state/country by assuming long term mean as 100.

Source: Author's compilation

C. *Impact of Structural Transformation in Agriculture on Nutrition Outcomes in Africa and India*

Table C1

Description of variables and measurement

Variables	*Description or measurement*
Stunting	Prevalence of stunting among under-5-year-old children
Underweight	Prevalence of underweight among under-5-year-old children
Wasting	Prevalence of wasting among under-5-year-old children
Normalized child malnutrition index	Average of the normalized values of the indicators underweight, stunting and wasting.
GDP per capita	Natural log of per capita income at 2011-12 INR constant prices
Livestock share	Share of the value of output of livestock sector in total value of the output of agriculture and allied sectors.
Share of agricultural value-added	% of agriculture in total GDP
Share of agricultural employment	% of agricultural employment in the total workforce
Agricultural income per capita	Natural log of gross state/country domestic product of agriculture at 2011-12 INR constant prices divided by the total population
Improved sanitation	% of the population having access to improved sanitation facilities
Rainfall variability	Standardized rainfall yearly amount

Table C2

Country/year observations included in undernutrition regression

Africa		*India*	
Country	Year	State	Year
Angola	2007, 2015	Andhra Pradesh	2000, 2005, 2010, 2016
Benin	2001, 2014, 2018	Arunachal Pradesh	
Burkina Faso	2003, 2006, 2009-2014, 2016/17	Assam	
Burundi	2000, 2005, 2010, 2016	Bihar	
Cameroon	2004, 2006, 2011, 2014, 2018	Chattisgarh	
Central African Republic	2000, 2006, 2010, 2012, 2018	Goa	
Chad	2000, 2004, 2010, 2015	Gujarat	
Comoros	2000, 2012	Hatyana	
Congo, Dem. Rep.	2001, 2007, 2010, 2013	Himachal Pradesh	
Congo, Rep.	2005, 2011, 2014	Jammu & Kashmir	
Cote d'Ivoire	2006/07, 2012, 2016	Jharkhand	

Egypt, Arab Rep.	2000, 2003, 2005, 2008, 2014	Karnataka	
Eswatini	2000, 2006, 2008, 2010, 2014	Kerala	
Ethiopia	2000, 2005, 2011, 2014, 2016	Madhya Pradesh	
Gabon	2000, 2012	Manipur	
Gambia	2006, 2010, 2012/13, 2018	Meghalaya	
Ghana	2003, 2006, 2008, 2011, 2014, 2017	Mizoram	
Guinea	2005, 2007, 2012, 2016, 2018	Nagaland	
Kenya	2000, 2003, 2005, 2008, 2008, 2014	Orissa	
Lesotho	2000, 2004, 2014, 2009, 2018,	Punjab	
Liberia	2000, 2007, 2010, 2013, 2016	Rajasthan	
Madagascar	2004, 2009, 2012, 2018	Tamil Nadu	
Malawi	2000, 2002, 2004, 2006, 2009, 2010, 2014, 2015, 2018	Uttar Pradesh	
Mali	2001, 2006, 2010, 2015, 2018	Uttarakhand	
Morocco	2003, 2011, 2017	West Bengal	
Mozambique	2001, 2003, 2008, 2011, 2015		
Namibia	2000, 2007, 2013		
Niger	2000, 2006, 2012, 2014, 2016, 2018		
Nigeria	2003, 2008, 2011, 2013-2016, 2018		
Rwanda	2000, 2005, 2009, 2010, 2012, 2015		
Sao Tome and Principe	2000, 2006, 2008, 2014		
Senegal	2000, 2005, 2011/12, 2013/14, 2015-2017		
Sierra Leone	2000, 2005, 2008, 2010, 2013		
South Africa	2004, 2008, 2012, 2016		
Sudan	2006, 2010, 2014		

Tanzania	2004, 2009, 2010/11, 2013/14, 2015, 2018		
Togo	2006, 2008, 2010, 2012, 2014, 2017		
Tunisia	2000, 2012		
Uganda	2000, 2006, 2009, 2011/12, 2014, 2016		
Zambia	2002, 2007, 2013, 2018		
Zimbabwe	2005, 2009/10, 2014/15		

Table C3

Undernutrition as a function of the agricultural share of GDP – Fixed effect

	(1) Stunting	(2) Underweight	(3) Wasting	(4) Normalized
log agr. GDP share	0.866***	0.881**	-1.188**	-0.028
	[0.256]	[0.432]	[0.554]	[0.190]
log agr. GDP share squared	-0.137***	-0.117*	0.210**	0.014
	[0.041]	[0.067]	[0.084]	[0.029]
log GDP per capita	-0.042	0.064	0.163	-0.015
	[0.039]	[0.060]	[0.123]	[0.039]
Controls	YES	YES	YES	YES
Observations	293	281	282	273
# Countries/ states	68	68	68	68
Year fixed effect	YES	YES	YES	YES

Robust SEs are given in square bracket. Standard errors are clustered at the country/state level. Controls include the percentage of rural populations, the share of the population with access to an improved sanitation facility, rainfall deviations from the sample mean, region and year fixed effects

Statistical significance denoted at * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Figure C1

Margins for Stunting

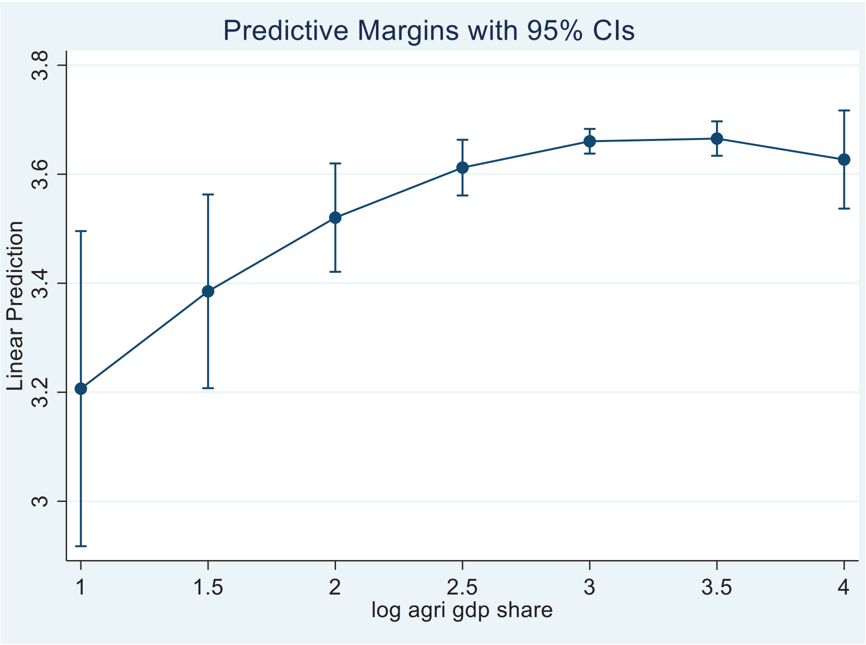


Table C4

Undernutrition as a function of the agricultural share of employment – Fixed effect

	(1) Stunting	(2) Underweight	(3) Wasting	(4) Normalized
log agri. employment share	0.243***	0.525***	0.647*	0.321***
	[0.075]	[0.138]	[0.374]	[0.106]
log GDP per capita	-0.068**	0.028	0.151	-0.029
	[0.030]	[0.055]	[0.095]	[0.027]
Controls	YES	YES	YES	YES
Observations	275	275	274	277
# Countries/ states	68	68	68	68
Year fixed effect	YES	YES	YES	YES

Robust SEs are given in square bracket. Standard errors are clustered at the country/state level.

Statistical significance * p<0.1, ** p<0.05, *** p<0.01. Controls include the percentage of rural populations, the share of the population with access to an improved sanitation facility, rainfall deviations from the sample mean, region, and year fixed effects.

Table C5

Undernutrition as a function of agricultural income per capita – Fixed effect

	(1)	(2)	(3)	(4)
	Stunting	Underweight	Wasting	Normalized
log agri income per capita	-0.034	-0.010	0.154**	-0.009
	[0.034]	[0.046]	[0.069]	[0.021]
Controls	YES	YES	YES	YES
Observations	292	280	281	272
# Countries/ states	68	68	68	68
Year fixed effect	YES	YES	YES	YES

Robust SEs are given in square bracket. Standard errors are clustered at the country/state level.

Statistical significance * p<0.1, ** p<0.05, *** p<0.01. Controls include the percentage of rural populations, the share of the population with access to an improved sanitation facility, rainfall deviations from the sample mean, region, and year fixed effects

Figure C2

GDP and agricultural income per capita income growth between 2000 and 2019

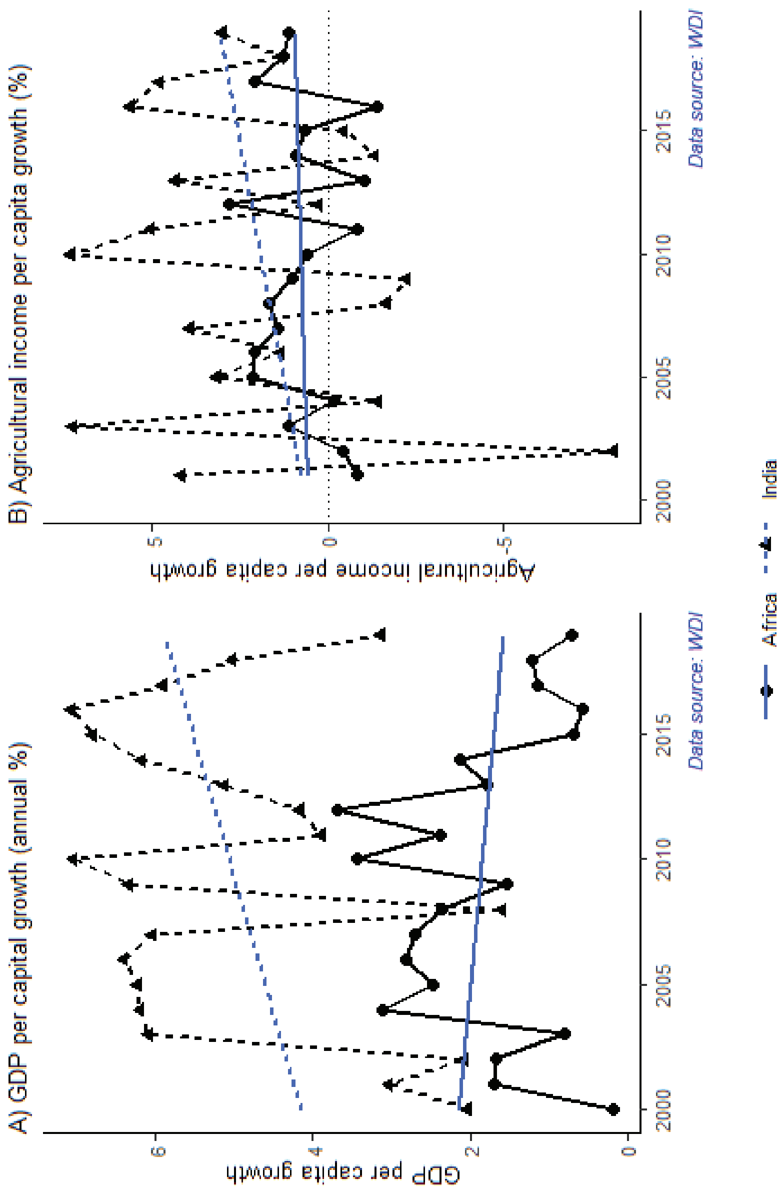


Figure C3

Undernutrition as a function of non-agricultural income per capita.

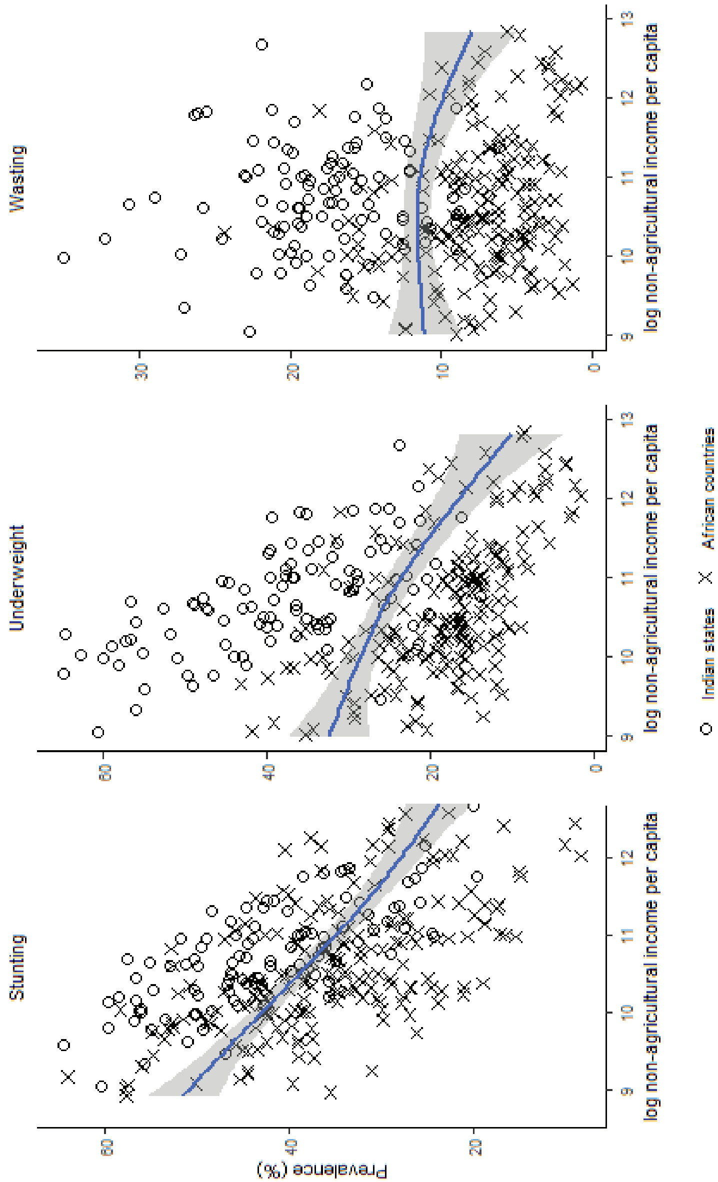


Figure C4

Female school enrollment and share of rural population from 2000 to 2019.

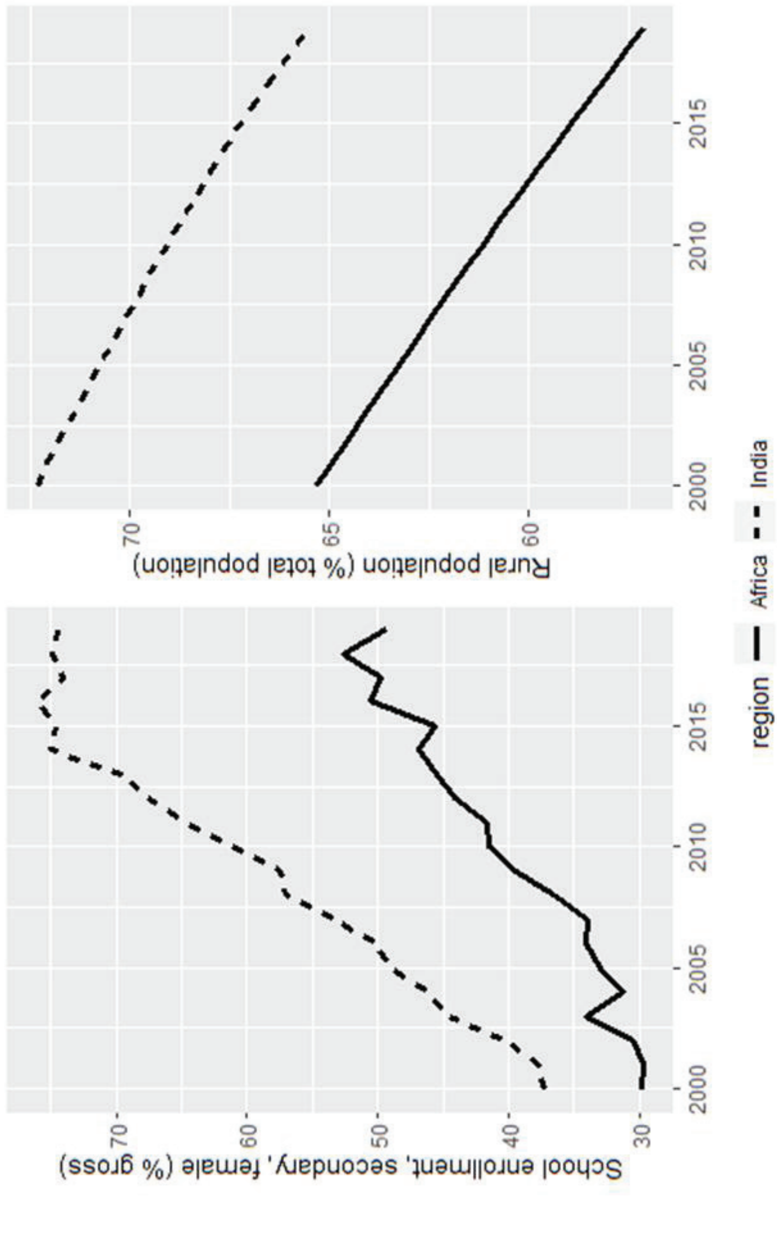


Figure C5

Undernutrition as a function of income per capita by rural-urban.

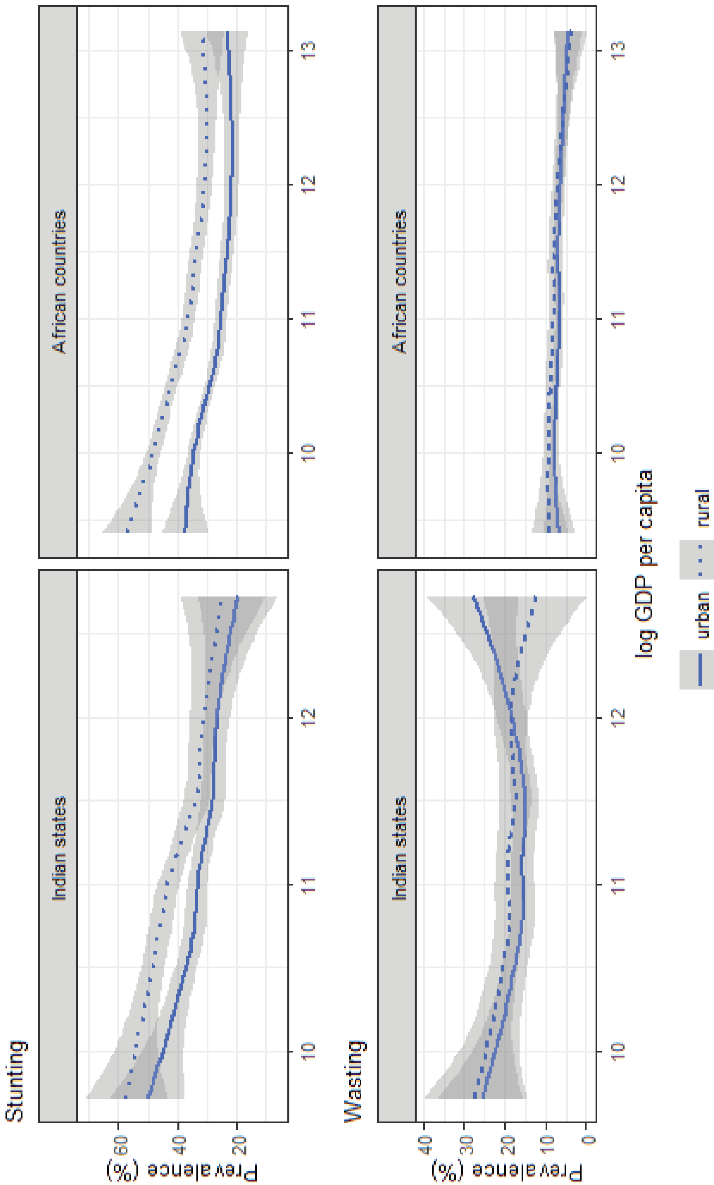


Figure C6

Undernutrition as a function of agricultural income per capita by rural-urban.

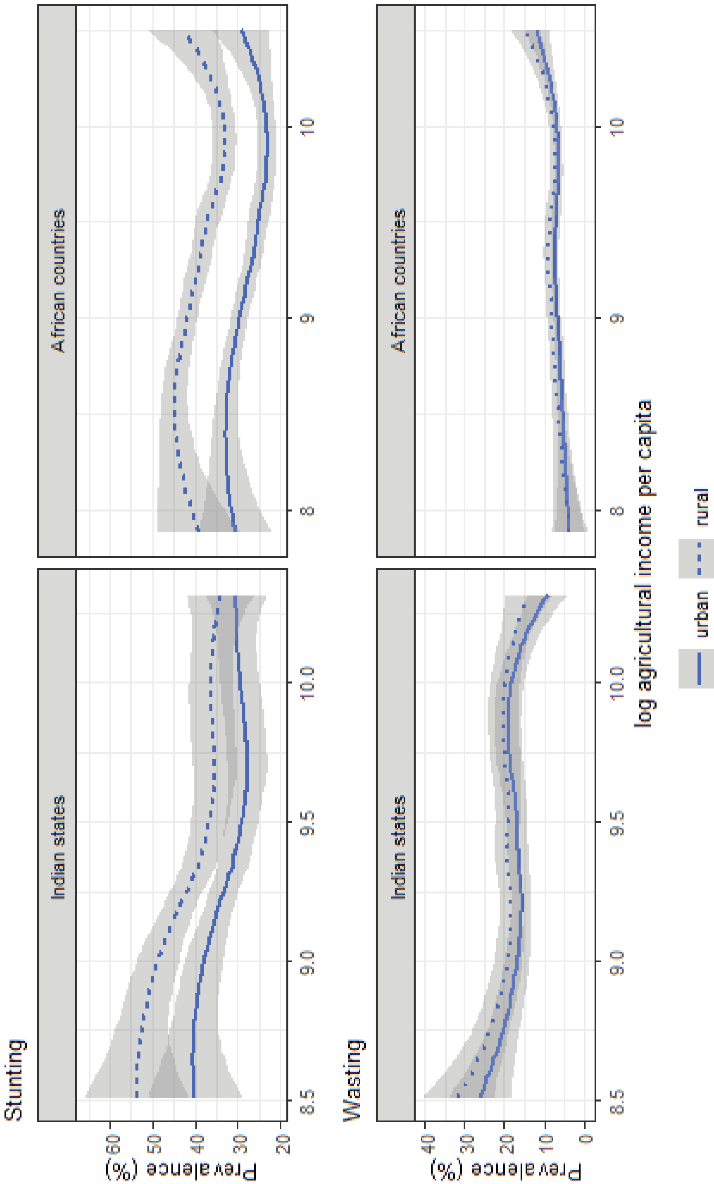


Figure C7

Undernutrition as a function of agricultural value-added by rural-urban.

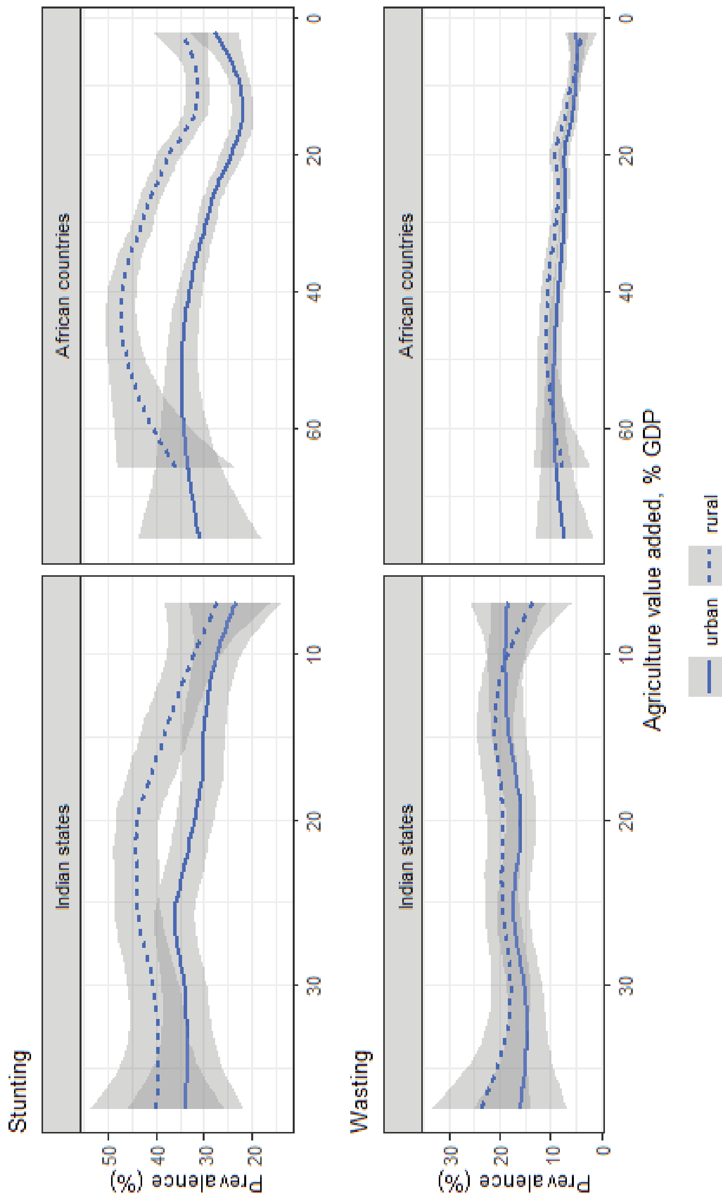
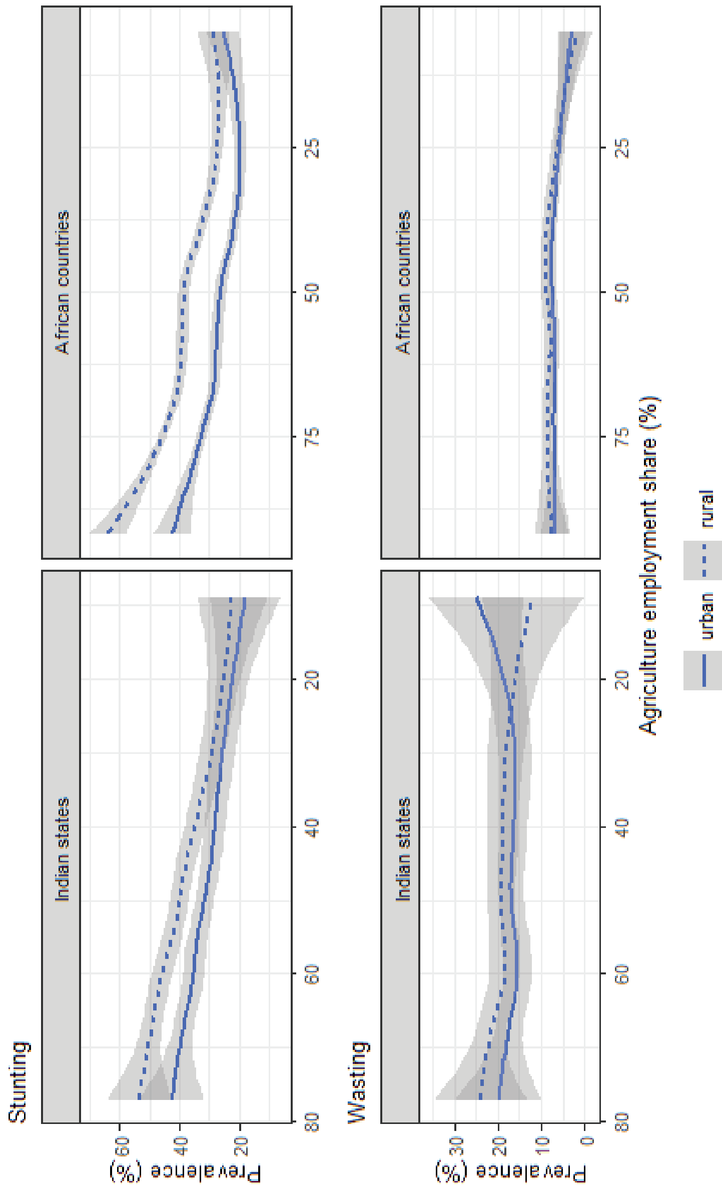


Figure C8

Undernutrition as a function of share of agricultural employment by rural-urban.



D. *Public Spending and Development, Agricultural Growth and Nutrition: Comparing Indian States and African Countries*

Table D1

Indicators, and definitions

Indicators	*Definition of variables for African countries*	*Definition of variables for Indian states*
Public expenditures		
Total public expenditure (PE) (Constant 2015 PPP $ and percentage share of GDP (%))	Total public expenditure	Total public expenditure
PE on health (Constant 2015 PPP $, as percentage share of GDP (%), as percentage share of PE (%))	Medical and public health	Public health and family welfare; Medical and public health & family welfare
PE on education (Constant 2015 PPP $, as percentage share of GDP (%), as percentage share of PE (%))	General and technical education	General and technical education
PE on social protection (Constant 2015 PPP $, as percentage share of GDP (%), as percentage share of PE (%))	Sickness and disability, Old age, family and children, unemployment, social exclusion, R&D social protection, etc	Social welfare and nutrition; Social security and welfare; Nutrition; Rural employment guarantee scheme
PE on infrastructure (Constant 2015 PPP $, as percentage share of GDP (%), as percentage share of PE (%))	Road, Water, Railway, and Air Transportation and communication	Road, Water, Railway, and Air Transportation
PE agriculture (Constant 2015 PPP $, as percentage share of GDP (%), as percentage share of PE (%))	Agriculture, forestry, fishing and hunting, irrigation and flood control	Crop husbandry, Soil and water conservation, animal husbandry, dairy development, Fisheries, Forestry, Plantation, food, storage and warehousing, Agriculture R&E, Agriculture financial institutions, Co-operation
Public expenditure agriculture (APE) (MAFAP data)		
Agricultural R&D (Constant 2015 PPP $, as percentage share of GDP (%), as percentage share of APE (%))	Public expenditures financing research activities improving agricultural production	Public expenditures financing research activities improving agricultural production

Agricultural Extension (Constant 2015 PPP $, as percentage share of GDP (%), as percentage share of APE (%))	Public expenditures financing provision of extension services; Public expenditures technical assistance for agricultural sector agents collectively; Public expenditures agricultural training	Public expenditures financing provision of extension services; Public expenditures technical assistance for agricultural sector agents collectively; Public expenditures agricultural training
Agricultural Infrastructure (Constant 2015 PPP $, as percentage share of GDP (%), as percentage share of APE (%))	Public expenditures financing off-farm collective infrastructure, including spending on feeder roads, and off-farm irrigation	Public expenditures financing off-farm collective infrastructure, including spending rural roads and Irrigation and flood control
Transfer to producers (Constant 2015 PPP $, as percentage share of GDP (%), as percentage share of APE (%))	Monetary transfers to individual agricultural producers (farmers), including spending on production subsidies based on outputs, input subsidies, & income support	Monetary transfers to individual agricultural producers (farmers), including spending input subsidies and income support schemeS. The major subsidies are for fertilisers, credit, and power. Other subsidy components are less significant and inconsistent across Indian states. Therefore, only input subsidies and income support are considered in the payments to producers.
Transfer to consumers (food aid, cash transfers and school feeding programs)	Monetary transfers to final consumers of agricultural commodities individually in the form of food aid, cash transfers, and school feeding programs	Food subsidy considered as the transfer to consumers and not disaggregated into the different items of food aid, cash transfers, and school feeding program.
Food and nutrition Security		
Stunting	Proportion of children under age 5 who are stunted (%)	Proportion of children under age 5 who are stunted (%)
Wasting	Proportion of children under age 5 who are wasted (%)	Proportion of children under age 5 who are wasted (%)

Underweight	Proportion of children under age 5 who are underweight (%) World Bank (2021)	Proportion of children under age 5 who are underweight (%)World Bank (2021)
Overweight	Proportion of children under age 5 who are overweight (%)	Proportion of children under age 5 who are overweight (%)
Agriculture sector performance		
Agriculture GDP (Billion constant 2015 PPP $, in per capita US$)		
GDP (Billion constant 2015 PPP $, in per capita US$)		
General gross government debt (In US$, percentage of GDP)		
General gross government debt service		
Demographic indicators		
Urbanization	Urban population share in total population (%)	Urban population share in total population (%)
Population structure	Population share 0 to 14 (%) Population share 15 to 64 (%) Population share 65 and above (%)	Population share 0 to 14 (%) Population share 15 to 64 (%) Population share 65 and above (%)
Politico-institutional indicators		
Election cycle	Dummy variable taking on the value 1 if there is a legislative election in a country in a year	Dummy variable taking on the value 1 if there is a legislative election in a country in a year
Agricultural finance indicators		
Agriculture orientation index	Ratio of credit to agriculture to total credit normalized by share of agriculture in GDP	Ratio of credit to agriculture to total credit normalized by share of agriculture in GDP
Rainfall	Yearly annual precipitation (mm), Z score index, coefficient of variation	Yearly annual precipitation (mm), Z score index, coefficient of variation

Table D2

Trend in total public spending 2005-2019

	Per capita total expenditure (2015 PPP)			*Per capita total expenditure growth rate (%)*			*Ratio of total expenditure to GDP (%)*		
	2005-2009	2010-2014	2015-2019	2005-2009	2010-2014	2015-2019	2005-2009	2010-2014	2015-2019
Africa Average	*1120.3*	*1251.7*	*1232.7*	*2.6*	*4.1*	*-0.4*	*21.5*	*21.1*	*20.2*
Benin	389.5	404.7	493.0	19.7	-5.1	9.8	15.2	15.2	17.0
Burkina Faso	313.0	404.6	532.3	6.0	4.7	6.9	22.9	25.7	30.1
Egypt, Arab Rep.	3161.1	3473.9	3535.8	7.9	0.0	-1.5	31.7	31.5	29.9
Ethiopia	181.2	240.6	316.7	-6.2	15.8	3.5	19.5	17.7	16.9
Ghana	903.4	1107.0	991.2	-1.6	3.1	1.2	25.3	23.7	18.8
Kenya	917.6	976.5	1020.4	-3.7	9.3	4.9	28.7	27.7	25.8
Malawi	185.9	220.3	306.5	2.2	0.7	17.3	22.4	22.7	29.8
Mali	411.3	386.7	502.7	-1.3	7.5	0.2	22.4	20.5	24.7
Morocco	1695.4	2136.0	1893.4	3.6	1.6	-0.7	31.5	33.4	23.7
Nigeria	548.8	585.0	404.1	6.2	-3.9	-9.2	13.1	11.7	7.9
Rwanda	266.1	408.1	514.6	9.1	9.5	3.9	21.9	26.4	27.2
Senegal	581.7	521.2	754.1	3.8	-2.2	10.6	20.8	18.4	23.2
South Africa	3144.6	3790.6	3946.1	9.9	1.6	-2.0	24.6	28.0	29.0
Tanzania	311.0	406.5	599.9	6.9	8.2	2.7	17.9	19.8	25.3
Uganda	343.3	375.0	622.8	-6.3	19.1	4.5	17.6	15.9	24.4

India State Average	*533.5*	*677.6*	*975.0*	*5.1*	*5.8*	*6.6*	*18.4*	*17.4*	*19.1*
Andhra Pradesh	657.8	804.7	1240.0	7.1	4.8	8.6	19.0	16.4	17.7
Assam	453.2	595.8	847.1	9.8	3.9	8.9	21.2	21.2	21.3
Bihar	269.5	362.0	522.7	6.3	7.2	4.1	25.7	24.3	27.6
Chhattisgarh	516.9	739.9	1104.8	11.3	7.4	7.2	18.4	19.2	23.1
Gujarat	646.3	816.6	1019.8	4.4	4.9	3.9	13.2	12.4	11.0
Haryana	782.6	950.8	1490.5	10.6	2.2	10.1	14.0	12.5	14.2
Himachal Pradesh	1291.7	1534.6	2073.9	6.1	3.2	6.1	28.0	23.1	23.3
Jammu & Kashmir	1172.6	1352.0	1921.7	3.6	0.9	9.2	42.2	36.4	38.8
Jharkhand	407.7	472.8	781.7	-1.5	6.7	7.5	18.6	16.3	23.1
Karnataka	685.4	871.2	1289.1	5.6	6.3	7.3	17.6	14.1	13.4
Kerala	683.0	977.6	1436.3	6.1	9.1	4.6	14.8	14.5	15.3
Madhya Pradesh	435.8	623.9	897.5	4.2	8.2	6.6	20.7	21.8	21.6
Maharashtra	675.0	799.3	1065.0	4.5	2.9	6.9	12.7	11.1	11.5
Odisha	448.5	628.1	1044.0	8.5	7.8	10.1	17.1	17.9	22.2
Punjab	790.2	836.0	1271.8	1.3	2.6	14.2	16.5	14.0	17.2
Rajasthan	470.3	628.0	1083.5	4.6	9.6	8.1	17.9	15.8	21.0
Tamil Nadu	664.3	921.1	1275.8	7.4	7.6	6.1	15.0	14.0	14.0
Uttar Pradesh	379.1	478.7	699.1	9.1	4.9	5.6	21.2	20.9	23.1
Uttarakhand	859.7	1178.7	1416.3	3.4	12.0	4.2	21.0	16.5	15.5
West Bengal	445.4	547.9	780.5	6.8	4.2	5.6	15.0	14.9	16.2

Table D3

Composition of government expenditure 2005–2019

	Per capita sectoral expenditure (2015 PPP dollar)			*Share of sectoral expenditure in total expenditure (%)*			*Per capita sectoral expenditure growth rate (%)*		
	2005-2009	2010-2014	2015-2019	2005-2009	2010-2014	2015-2019	2005-2009	2010-2014	2015-2019
Agriculture									
Africa Average	36.8	35.2	35.7	7.5	6.0	5.3	3.7	1.7	-2.8
Benin	25.5	24.5	45.8	6.6	6.4	9.6	20.0	-0.5	15.2
Burkina Faso	33.2	38.0	46.7	11.6	10.5	10.8	15.1	5.3	5.1
Egypt, Arab Rep.	72.1	56.0	47.7	2.3	1.6	1.4	-9.4	3.7	-9.9
Ethiopia	41.5	42.4	50.2	21.7	13.1	12.5	-1.3	7.4	-1.3
Ghana	31.2	33.9	42.9	5.2	3.4	4.6	-1.7	9.0	5.5
Kenya	29.1	35.1	36.9	5.3	5.1	4.1	11.6	1.6	4.2
Malawi	30.8	36.0	34.4	16.6	18.5	12.5	43.9	-0.3	-3.7
Mali	49.0	39.4	48.7	12.6	11.2	11.9	-10.6	10.2	1.3
Morocco	36.5	57.5	80.6	2.1	2.6	4.3	5.0	9.4	8.3
Nigeria	19.6	17.8	9.9	6.0	6.0	3.4	6.4	-4.8	-12.3
Rwanda	10.1	27.1	43.3	3.7	6.6	8.6	0.3	35.1	17.9
Senegal	46.5	51.4	63.7	8.0	8.0	8.4	13.2	5.0	-2.7
South Africa	66.0	62.1	50.1	2.0	1.6	1.2	3.0	-1.3	-11.7
Tanzania	15.1	18.2	20.2	4.3	4.3	3.4	15.1	-6.5	11.0

Uganda	14.6	13.3	18.3	7.5	4.4	4.0	11.2	1.5	8.9
India State Average	*118.0*	*132.4*	*163.6*	*21.0*	*19.1*	*16.0*	*11.6*	*1.1*	*7.3*
Andhra Pradesh	240.9	273.9	284.2	36.7	34.1	22.9	7.0	4.7	0.2
Assam	57.2	80.1	87.2	12.4	13.5	10.3	22.4	0.3	7.6
Bihar	42.2	54.1	50.7	15.5	15.2	9.7	17.9	-0.2	4.8
Chhattisgarh	139.8	200.6	267.6	26.7	27.1	24.1	16.8	6.4	9.9
Gujarat	162.0	167.0	190.9	24.9	20.5	18.8	13.5	0.6	0.7
Haryana	253.1	259.9	293.5	32.0	27.5	19.7	16.4	-5.1	8.7
Himachal Pradesh	158.1	178.9	209.5	12.1	11.6	10.1	16.1	-0.5	6.0
Jammu & Kashmir	113.4	131.8	180.1	9.7	9.7	9.5	6.8	-1.5	13.6
Jharkhand	39.7	38.2	66.9	9.8	8.2	8.5	1.7	-0.1	19.5
Karnataka	191.1	210.9	335.3	27.9	24.3	26.0	5.0	2.8	11.2
Kerala	66.2	99.9	127.0	9.6	10.3	8.9	10.0	5.9	4.4
Madhya Pradesh	93.6	145.3	178.8	21.3	23.3	19.9	18.9	9.9	4.0
Maharashtra	169.2	163.5	207.7	24.9	20.6	19.5	10.2	-3.1	8.4
Odisha	78.6	121.2	189.2	17.1	19.3	18.2	25.1	6.6	9.5
Punjab	248.1	269.1	484.6	31.3	32.2	37.2	11.8	1.9	21.5
Rajasthan	95.7	141.9	131.7	20.2	23.7	12.2	16.2	-1.1	7.2
Tamil Nadu	142.8	145.6	182.4	21.4	15.8	14.3	13.9	2.2	6.3
Uttar Pradesh	75.4	75.6	105.9	19.6	15.8	15.2	18.9	-0.9	9.4
Uttarakhand	148.6	153.4	189.7	17.3	14.0	13.5	3.9	8.1	2.3
West Bengal	51.2	54.0	63.8	11.3	9.9	8.2	17.1	-1.6	3.2

Health									
Africa Average	61.3	72.7	35.4	5.2	4.3	0.8	3.9	7.0	0.1
Benin									
Burkina Faso									
Egypt, Arab Rep.	147.3	195.9	235.9	4.4	5.3	6.3	8.1	11.6	-7.2
Ethiopia	6.9	10.5	15.4	3.6	3.2	3.4	3.5	15.9	10.4
Ghana	37.9			6.4			25.1		
Kenya	32.3	40.0		6.0	6.0		2.2	11.1	
Malawi	27.3	33.5		14.6	15.1		22.9	-16.3	
Mali									
Morocco	42.5			2.6			1.2		
Nigeria	17.3	17.4		5.2	5.4		6.5	5.8	
Rwanda	29.0	40.7		9.4	10.4		17.9	3.9	
Senegal									
South Africa	334.1	463.8	480.6	9.9	11.5	11.1	7.1	4.8	0.5
Tanzania	25.3	39.3		7.2	9.0		-2.3	16.6	
Uganda	18.5	23.1		9.5	8.7		-3.1	14.0	
India State Average	*22.0*	*31.1*	*49.6*	*4.2*	*4.5*	*5.1*	*6.4*	*8.8*	*8.3*
Andhra Pradesh	25.9	35.9	59.6	3.9	4.5	4.8	9.6	3.2	14.3
Assam	22.4	31.1	56.6	4.8	5.3	6.7	27.1	-3.3	18.7
Bihar	11.3	13.1	25.0	4.2	3.6	4.8	0.6	9.4	11.2
Chhattisgarh	18.5	30.6	61.3	3.6	4.1	5.5	13.0	14.8	10.4

Gujarat	22.0	40.9	61.5	3.4	5.0	6.0	10.8	13.0	5.3
Haryana	23.7	34.5	59.6	3.0	3.6	4.0	13.5	6.4	12.2
Himachal Pradesh	65.1	82.6	126.1	5.1	5.4	6.1	5.1	5.5	8.2
Jammu & Kashmir	58.7	74.4	120.0	5.0	5.5	6.2	8.1	3.4	12.7
Jharkhand	16.4	18.6	36.0	4.0	3.9	4.6	-0.6	9.7	9.8
Karnataka	25.0	37.2	56.7	3.6	4.2	4.4	8.4	11.6	5.5
Kerala	34.3	53.8	86.2	5.0	5.5	6.0	5.6	11.3	8.4
Madhya Pradesh	16.0	24.7	41.0	3.7	3.9	4.6	3.7	13.6	10.9
Maharashtra	23.1	32.5	47.1	3.4	4.1	4.4	5.5	8.7	6.0
Odisha	16.2	25.3	54.2	3.6	4.0	5.2	15.1	14.8	10.5
Punjab	25.6	36.5	47.7	3.2	4.4	3.9	0.0	9.9	4.3
Rajasthan	22.1	33.8	61.8	4.7	5.3	5.7	7.8	12.6	8.7
Tamil Nadu	26.9	43.0	64.9	4.1	4.7	5.1	11.2	8.0	6.9
Uttar Pradesh	20.2	23.9	35.8	5.4	5.0	5.1	8.7	5.7	5.9
Uttarakhand	40.1	54.7	75.2	4.7	4.8	5.4	0.6	14.2	2.9
West Bengal	20.2	28.0	44.4	4.5	5.1	5.7	10.4	6.3	7.2
Education									
Africa Average	*142.7*	*142.7*	*63.2*	*11.9*	*9.2*	*0.8*	*2.9*	*5.9*	*0.6*
Benin									
Burkina Faso									
Egypt, Arab Rep.	406.3	410.1	452.5	12.2	11.2	12.0	-1.0	1.0	3.8
Ethiopia	32.1	53.7	74.9	16.5	15.9	16.4	2.0	16.7	15.9

Ghana	101.2			17.3			14.1		
Kenya	140.2	144.3		26.2	21.8		1.0	1.1	
Malawi	28.4	40.3		15.5	18.4		13.3	3.7	
Mali									
Morocco	279.7			17.0			2.2		
Nigeria	23.1	25.1		7.1	7.9		1.5	13.9	
Rwanda	51.7	64.9		17.0	16.5		10.4	3.6	
Senegal									
South Africa	612.0	788.9	821.1	18.2	19.8		4.1	4.2	0.2
Tanzania	35.4	80.7		9.4	18.5		32.1	11.8	
Uganda	35.2	36.4		18.1	13.7		-4.6	6.4	
India State Average	*79.3*	*115.2*	*152.8*	*15.2*	*17.2*	*15.9*	*6.5*	*6.8*	*6.1*
Andhra Pradesh	68.4	108.4	177.2	10.5	13.5	14.3	3.5	9.9	15.3
Assam	90.0	146.7	189.3	20.0	24.6	22.7	5.8	10.9	3.1
Bihar	52.2	67.9	95.8	19.4	18.7	18.3	4.4	7.0	5.6
Chhattisgarh	73.4	135.4	208.5	14.1	18.2	18.9	15.0	13.5	6.8
Gujarat	85.8	129.4	154.2	13.3	15.9	15.1	7.7	6.9	2.6
Haryana	111.9	157.9	200.1	14.1	16.6	13.4	16.8	3.1	4.4
Himachal Pradesh	215.1	286.5	359.9	16.6	18.7	17.4	7.3	4.8	4.5
Jammu & Kashmir	108.4	167.8	277.5	9.2	12.4	14.4	9.1	4.7	14.2
Jharkhand	65.2	75.0	105.2	16.1	15.9	13.5	7.4	4.2	7.0
Karnataka	98.2	131.8	161.6	14.3	15.2	12.6	5.6	7.2	4.5

Kerala	116.8	169.9	234.4	17.1	17.4	16.3	5.3	8.5	4.2
Madhya Pradesh	53.3	89.5	135.7	12.2	14.3	15.1	11.0	10.8	8.3
Maharashtra	116.6	166.9	192.7	17.2	20.9	18.2	10.0	3.4	5.3
Odisha	73.7	104.9	154.1	16.3	16.8	14.8	14.3	4.5	8.1
Punjab	89.6	122.2	150.5	11.3	14.6	12.2	4.0	6.1	3.3
Rajasthan	82.9	111.8	174.8	17.6	18.0	16.1	8.4	6.5	7.6
Tamil Nadu	91.9	143.6	190.6	13.8	15.6	15.0	10.2	8.7	5.5
Uttar Pradesh	54.5	80.3	106.6	14.5	16.8	15.3	6.4	6.6	5.9
Uttarakhand	163.4	220.7	275.7	18.9	19.9	19.6	13.5	1.7	5.0
West Bengal	73.4	105.9	123.8	16.4	19.4	15.8	12.1	3.0	4.9
Social protection									
Africa Average	*218.5*	*197.4*	*34.2*	*10.1*	*8.3*	*1.9*	*18.1*	*0.8*	*12.2*
Benin									
Burkina Faso									
Egypt, Arab Rep.	1191.8	1132.4	1093.6	34.8	31.1	29.0	25.1	-6.4	12.8
Ethiopia	30.5	49.4	178.7	15.7	15.2	39.0	13.3	6.4	423.0
Ghana									
Kenya	35.0	25.9		6.4	3.9		19.1	-13.3	
Malawi	14.2	18.7		7.7	8.6		41.4	-1.2	
Mali									
Morocco	210.1			12.8			8.8		
Nigeria	8.1	13.2		2.4	4.0		46.9	-0.1	

Rwanda	11.4	16.6		3.8	4.2		25.0	0.1	
Senegal									
South Africa	459.9	537.0		13.7	13.7		5.3	2.1	
Tanzania	10.3			2.9			45.4		
Uganda	8.7	13.1		4.5	5.0		-12.9	34.7	
India State Average	*37.0*	*57.3*	*78.6*	*7.1*	*8.7*	*8.1*	*30.8*	*4.7*	*10.9*
Andhra Pradesh	58.7	87.3	184.1	8.7	10.7	14.9	50.6	14.7	9.7
Assam	34.0	50.2	43.9	7.2	8.6	5.3	49.6	-0.7	49.1
Bihar	21.4	30.0	44.2	7.7	8.3	8.4	37.6	1.8	11.8
Chhattisgarh	69.8	92.7	89.3	12.9	12.7	8.1	54.9	-1.6	5.4
Gujarat	25.4	36.2	39.8	3.9	4.5	3.9	19.5	1.2	8.1
Haryana	48.2	68.1	115.2	6.1	7.2	7.7	18.4	4.0	10.3
Himachal Pradesh	72.6	99.2	132.1	5.5	6.5	6.3	23.4	-4.1	13.7
Jammu & Kashmir	45.1	65.1	94.0	3.9	4.8	4.9	5.0	4.6	13.2
Jharkhand	41.6	46.6	61.5	10.4	9.9	7.9	42.0	-2.4	8.7
Karnataka	43.4	66.1	113.4	6.2	7.7	8.7	57.2	-5.9	19.7
Kerala	22.7	56.6	105.2	3.3	5.7	7.3	22.0	18.5	5.4
Madhya Pradesh	46.2	57.9	71.6	10.5	9.4	8.1	54.9	-1.0	11.8
Maharashtra	25.6	48.2	58.7	3.8	6.0	5.5	0.9	20.2	11.2
Odisha	39.6	71.8	98.4	8.8	11.5	9.4	19.9	12.4	16.0
Punjab	22.2	35.2	51.1	2.8	4.2	4.1	51.6	1.8	14.3
Rajasthan	51.8	58.1	89.4	10.7	9.4	8.3	77.3	-2.2	10.7

Tamil Nadu	57.1	109.6	121.7	8.6	11.9	9.7	11.3	11.6	1.1
Uttar Pradesh	27.1	41.4	42.3	6.8	8.8	6.1	47.9	-3.5	3.9
Uttarakhand	37.3	68.2	122.9	4.3	6.4	9.0	31.8	83.5	0.6
West Bengal	30.2	65.8	121.9	6.5	12.0	15.5	47.5	2.4	17.8
Infrastructure (Transport and communication)									
Africa Average	*25.3*	*20.2*	*6.5*	*3.5*	*2.1*	*0.0*	*33.5*	*-1.6*	*44.6*
Benin									
Burkina Faso									
Egypt, Arab Rep.	46.4			1.5			4.2		
Ethiopia	0.6	0.4	4.5	0.3	0.1	1.0	44.9	0.2	1589.4
Ghana	7.9			1.3			20.1		
Kenya	39.2	66.4		7.1	10.0		25.4	9.8	
Malawi	24.9	30.0		14.7	13.4		6.2	35.6	
Mali									
Morocco	10.5			0.6			-21.0		
Nigeria	11.4	12.2		3.3	3.7		87.0	-21.6	
Rwanda	29.3	45.7		9.3	11.6		35.7	-0.1	
Senegal									
South Africa	165.2	204.0	211.1	5.0	4.8		4.3	1.3	3.2
Tanzania	36.5			10.6			155.4		
Uganda	19.8	37.2		10.1	14.0		13.4	16.8	
India State Average	*29.5*	*36.7*	*52.1*	*5.6*	*5.4*	*5.4*	*27.1*	*7.3*	*7.7*

Andhra Pradesh	21.0	26.3	26.0	3.1	3.2	2.1	259.5	7.8	-4.3
Assam	26.2	33.1	73.2	5.8	5.5	8.3	12.8	5.2	32.7
Bihar	20.8	26.7	26.7	7.5	7.5	5.1	67.5	-2.3	-4.9
Chhattisgarh	53.0	43.3	74.7	11.0	5.7	6.8	-14.6	16.7	4.3
Gujarat	41.9	60.5	58.6	6.4	7.4	5.8	12.0	2.8	-0.7
Haryana	65.5	73.6	78.1	8.4	7.7	5.2	10.4	0.4	-0.7
Himachal Pradesh	131.8	156.6	228.9	10.1	10.2	11.0	11.8	0.1	10.0
Jammu & Kashmir	62.1	45.9	66.4	5.2	3.4	3.5	23.7	-4.3	13.8
Jharkhand	18.7	35.1	59.1	4.6	7.3	7.5	18.8	14.2	1.5
Karnataka	45.0	60.5	86.1	6.5	6.9	6.7	15.1	8.0	5.0
Kerala	41.1	65.4	75.7	6.0	6.7	5.3	10.9	5.9	3.8
Madhya Pradesh	25.1	25.5	37.7	5.8	4.1	4.2	14.0	1.8	7.7
Maharashtra	28.8	38.8	54.4	4.2	4.9	5.1	29.9	-0.4	12.5
Odisha	26.8	48.2	101.4	5.8	7.5	9.9	28.5	20.1	4.0
Punjab	31.0	23.2	22.7	3.9	2.8	1.8	3.6	0.3	-6.0
Rajasthan	14.1	24.8	34.5	3.0	3.9	3.2	3.5	19.1	2.6
Tamil Nadu	40.1	44.0	68.7	6.0	4.8	5.4	5.0	4.0	13.2
Uttar Pradesh	25.4	28.6	48.6	6.8	5.9	6.9	0.9	16.0	17.8
Uttarakhand	76.0	72.4	69.7	8.8	6.5	5.1	3.0	5.2	-10.7
West Bengal	12.8	15.7	25.2	2.9	2.9	3.2	5.6	4.2	13.7

Table D4

Composition of food security and agricultural expenditure 2005–2019

	Share of components of food and agricultural expenditure in total food and agricultural expenditure (%)			
	2005-2009	2010-2014	2015-2019	2005-2019
Transfer to producers				
Africa Average	17.4	23.2	15.3	18.6
Benin	13.0	16.9	17.3	16.5
Burkina Faso	47.6	43.4	25.5	38.2
Ethiopia	13.0	6.0	3.1	7.2
Ghana		12.6	25.1	20.1
Kenya	8.8	11.8	10.6	10.6
Malawi	66.4	74.1	48.0	62.6
Mali	20.0	41.1	35.9	32.3
Rwanda		20.8	17.3	18.6
Senegal		35.4	26.2	30.8
South Africa	64.8	58.5	59.9	61.2
Tanzania		27.7	10.6	20.3
Uganda	6.3	4.6	12.8	7.2
India State Average	31.1	30.0	26.8	29.3
Andhra Pradesh	35.3	36.5	37.4	36.4
Assam	10.2	8.3	9.2	9.2
Bihar	37.1	19.5	21.5	26.0
Chhattisgarh	18.4	16.6	11.2	15.4
Gujarat	37.6	31.3	29.5	32.8
Haryana	59.6	57.5	52.7	56.6
Himachal Pradesh	5.3	5.0	8.7	6.3
Jammu & Kashmir	7.8	7.0	9.3	8.0
Jharkhand	11.3	8.9	7.9	9.4
Karnataka	33.4	27.9	33.0	31.4
Kerala	15.5	13.5	15.7	14.9
Madhya Pradesh	25.6	32.9	22.7	27.1
Maharashtra	22.5	29.8	28.7	27.0
Odisha	13.1	10.2	9.8	11.1

Punjab	69.7	66.1	45.1	60.3
Rajasthan	36.7	47.6	36.0	40.1
Tamil Nadu	39.1	37.0	34.4	36.8
Uttar Pradesh	34.3	35.6	31.5	33.8
Uttarakhand	17.3	12.2	11.8	13.8
West Bengal	31.5	26.1	20.8	26.1
Transfer to consumers				
Africa Average	7.9	14.4	10.8	11.0
Benin	3.0	3.0	7.1	4.7
Burkina Faso	10.6	8.1	8.8	9.1
Ethiopia	28.8	34.3	31.4	32.0
Ghana		0.0	0.0	0.0
Kenya	15.0	10.3	11.6	11.9
Malawi	6.1	0.9	10.1	5.7
Mali	0.5	3.2	2.7	2.1
Rwanda		1.4	1.3	1.4
Senegal		4.4	10.5	7.4
South Africa	12.2	21.7	22.9	18.3
Tanzania		9.4	21.5	14.6
Uganda	2.8	0.5	1.4	1.6
India State Average	19.5	25.3	23.0	22.6
Andhra Pradesh	12.7	12.3	13.3	12.8
Assam	38.9	38.2	35.7	37.6
Bihar	24.1	31.6	43.5	33.1
Chhattisgarh	16.7	19.5	17.1	17.7
Gujarat	6.4	13.6	13.0	11.0
Haryana	5.3	8.6	7.0	7.0
Himachal Pradesh	23.9	29.7	22.3	25.3
Jammu & Kashmir	31.8	28.9	22.5	27.8
Jharkhand	32.4	41.3	36.7	36.8
Karnataka	13.0	16.0	11.8	13.6
Kerala	29.8	31.2	24.5	28.5
Madhya Pradesh	19.5	21.6	16.3	19.1
Maharashtra	11.4	18.2	14.6	14.7

Odisha	25.7	27.5	16.7	23.3
Punjab	4.3	7.2	4.3	5.3
Rajasthan	13.0	20.1	16.8	16.6
Tamil Nadu	24.5	25.9	24.4	24.9
Uttar Pradesh	20.8	31.4	26.9	26.4
Uttarakhand	15.7	24.1	18.3	19.3
West Bengal	31.9	41.6	34.1	35.8
Agricultural R&D				
Africa Average	4.7	8.8	5.5	6.3
Benin	9.1	7.1	8.6	8.1
Burkina Faso	5.0	3.0	1.7	3.1
Ethiopia	2.6	6.4	5.0	5.0
Ghana		13.2	0.6	5.6
Kenya	13.9	9.9	7.9	10.2
Malawi	2.2	3.1	2.8	2.7
Mali	3.7	4.1	7.2	5.0
Rwanda		9.4	7.0	7.9
Senegal		4.9	4.3	4.6
South Africa	8.4	13.9	12.1	11.4
Tanzania		9.4	9.5	9.5
Uganda	18.7	20.9	23.2	20.6
India State Average	2.5	2.6	2.5	2.6
Andhra Pradesh	1.4	1.9	4.0	2.5
Assam	3.6	3.1	3.9	3.5
Bihar	3.0	2.7	2.5	2.7
Chhattisgarh	1.2	1.4	1.3	1.3
Gujarat	2.7	3.8	3.7	3.4
Haryana	3.1	3.2	3.3	3.2
Himachal Pradesh	4.7	4.9	5.7	5.1
Jammu & Kashmir	5.0	4.3	4.8	4.7
Jharkhand	3.1	3.2	2.6	2.9
Karnataka	1.9	2.5	2.0	2.1
Kerala	5.6	4.8	5.2	5.2
Madhya Pradesh	2.1	1.8	1.9	1.9

Maharashtra	2.3	2.7	2.4	2.5
Odisha	1.8	1.7	1.4	1.6
Punjab	3.2	3.4	2.4	3.0
Rajasthan	2.3	2.2	2.8	2.5
Tamil Nadu	2.1	2.8	3.0	2.6
Uttar Pradesh	2.0	2.3	1.5	1.9
Uttarakhand	4.6	4.1	3.6	4.1
West Bengal	3.5	2.4	2.3	2.7
Agriculture extension				
Africa Average	8.5	12.0	6.6	9.0
Benin	19.3	18.9	10.7	15.6
Burkina Faso	15.6	15.9	12.5	14.6
Ethiopia	13.4	7.3	9.2	9.5
Ghana		16.4	13.8	14.8
Kenya	22.3	20.4	4.0	15.4
Malawi	4.5	6.3	12.1	7.8
Mali	8.3	4.3	4.0	5.5
Rwanda		15.6	10.4	12.4
Senegal		7.4	10.4	8.9
South Africa	7.4	5.1	4.0	5.7
Tanzania		8.7	8.3	8.6
Uganda	30.5	41.0	20.8	32.3
India State Average	0.7	0.9	0.9	0.8
Andhra Pradesh	0.1	0.1	0.2	0.1
Assam	2.2	1.5	0.6	1.4
Bihar	1.2	2.7	2.7	2.2
Chhattisgarh	0.3	0.3	0.4	0.3
Gujarat	0.6	0.6	0.5	0.6
Haryana	1.4	2.1	1.7	1.7
Himachal Pradesh	0.7	0.7	1.0	0.8
Jammu & Kashmir	1.8	1.0	0.7	1.2
Jharkhand	1.3	1.2	0.9	1.2
Karnataka	0.2	0.3	0.2	0.2
Kerala	0.7	0.8	2.4	1.3

Madhya Pradesh	0.5	0.5	0.8	0.6
Maharashtra	0.6	0.6	0.4	0.5
Odisha	0.3	0.2	0.1	0.2
Punjab	0.2	0.2	0.6	0.3
Rajasthan	0.3	0.3	0.3	0.3
Tamil Nadu	0.9	0.9	0.8	0.9
Uttar Pradesh	0.8	0.8	0.9	0.8
Uttarakhand	0.2	0.1	0.7	0.3
West Bengal	0.8	1.7	0.9	1.1
Agriculture Infrustructure				
Africa Average	9.2	15.3	13.2	12.6
Benin	12.5	9.1	12.3	11.0
Burkina Faso	15.4	21.3	23.3	20.3
Ethiopia	21.5	22.3	26.7	23.3
Ghana		23.3	22.6	22.9
Kenya	7.3	14.5	12.6	12.1
Malawi	7.4	9.1	14.3	10.5
Mali	39.7	26.8	29.0	31.9
Rwanda		41.5	40.7	41.0
Senegal		20.1	21.0	20.5
South Africa	13.8	12.7	13.9	13.4
Tanzania		6.6	4.7	5.8
Uganda	10.6	10.2	10.7	10.5
India State Average	28.6	23.2	21.2	24.3
Andhra Pradesh	43.3	37.5	27.6	36.2
Assam	28.1	30.1	27.1	28.5
Bihar	22.4	31.1	19.7	24.4
Chhattisgarh	28.9	19.4	16.0	21.4
Gujarat	40.0	33.9	32.7	35.5
Haryana	19.3	17.9	14.4	17.2
Himachal Pradesh	30.0	23.2	26.6	26.6
Jammu & Kashmir	19.4	27.2	20.9	22.5
Jharkhand	31.3	26.2	29.5	29.0
Karnataka	28.6	25.5	23.1	25.7

Kerala	13.8	10.6	9.9	11.5
Madhya Pradesh	33.3	19.3	27.7	26.8
Maharashtra	38.8	28.9	20.5	29.4
Odisha	41.1	32.7	40.4	38.1
Punjab	15.9	12.6	7.2	11.9
Rajasthan	34.7	13.9	18.0	22.2
Tamil Nadu	7.4	11.0	9.3	9.2
Uttar Pradesh	27.4	19.7	18.9	22.0
Uttarakhand	27.2	24.8	24.4	25.4
West Bengal	19.3	15.0	19.7	18.0
Input subsidies				
Africa Average	9.4	17.5	11.6	12.8
Benin	11.1	15.7	12.8	13.7
Burkina Faso	41.1	42.7	24.7	35.8
Ethiopia	10.1	5.1	2.8	5.8
Ghana		12.5	25.1	20.1
Kenya	8.8	11.2	7.9	9.5
Malawi	59.8	73.9	46.2	60.0
Mali	18.4	40.8	34.7	31.3
Rwanda		20.8	17.2	18.6
Senegal		31.7	25.3	28.5
South Africa	16.9	24.4	23.7	21.3
Tanzania		22.7	7.4	16.1
Uganda	6.3	4.6	12.8	7.2
India State Average	31.1	30.0	24.3	28.5
Andhra Pradesh	35.3	36.5	34.9	35.6
Assam	10.2	8.3	6.4	8.3
Bihar	37.1	19.5	18.8	25.1
Chhattisgarh	18.4	16.6	10.2	15.1
Gujarat	37.6	31.3	26.3	31.7
Haryana	59.6	57.5	51.2	56.1
Himachal Pradesh	5.3	5.0	5.8	5.4
Jammu & Kashmir	7.8	7.0	7.1	7.3
Jharkhand	11.3	8.9	5.8	8.7

Karnataka	33.4	27.9	32.1	31.1
Kerala	15.5	13.5	12.1	13.7
Madhya Pradesh	25.6	32.9	20.8	26.4
Maharashtra	22.5	29.8	26.8	26.4
Odisha	13.1	10.2	7.7	10.3
Punjab	69.7	66.1	43.5	59.8
Rajasthan	36.7	47.6	33.5	39.3
Tamil Nadu	39.1	37.0	32.9	36.3
Uttar Pradesh	34.3	35.6	26.5	32.1
Uttarakhand	17.3	12.2	9.8	13.1
West Bengal	31.5	26.1	20.8	26.1
Irrigation (On farm)				
Africa Average	4.9	10.7	9.5	8.4
Benin	2.1	3.3	3.7	3.2
Burkina Faso	5.7	14.3	19.9	13.9
Ethiopia	15.4	18.6	21.9	18.6
Ghana		10.4	19.0	15.5
Kenya	5.7	13.5	10.1	10.4
Malawi	7.1	6.8	13.2	9.2
Mali	34.5	23.3	26.9	28.2
Rwanda		37.2	27.8	31.3
Senegal		12.0	9.9	10.9
South Africa	0.5	1.2	2.2	1.2
Tanzania		3.9	2.2	3.2
Uganda	3.9	7.1	5.9	5.6
India State Average	23.7	18.7	17.6	20.0
Andhra Pradesh	42.4	37.1	26.8	35.4
Assam	19.8	18.5	17.0	18.5
Bihar	22.4	15.1	11.7	16.4
Chhattisgarh	19.7	15.5	11.6	15.6
Gujarat	38.2	32.4	32.1	34.3
Haryana	19.3	15.1	13.9	16.1
Himachal Pradesh	19.4	18.9	16.3	18.2
Jammu & Kashmir	19.4	15.4	10.6	15.1

Jharkhand	22.2	15.5	19.0	18.9
Karnataka	25.7	24.2	22.8	24.2
Kerala	13.8	8.3	8.3	10.2
Madhya Pradesh	21.5	14.3	22.9	19.5
Maharashtra	38.8	26.0	19.8	28.2
Odisha	24.1	21.8	30.3	25.4
Punjab	13.4	11.3	6.4	10.4
Rajasthan	22.1	11.4	15.5	16.3
Tamil Nadu	7.4	9.1	7.9	8.1
Uttar Pradesh	20.9	18.2	17.3	18.8
Uttarakhand	27.2	15.1	14.0	18.8
West Bengal	11.9	10.4	13.4	11.9

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ISBN 978-93-327-0682-8
9 789332 706828 50000>