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**Pathways from Agriculture to Nutrition in India
Implications for Sustainable Development Goals**

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ABSTRACT

Food security and nutrition policy interventions generally rely on selective measures. Yet recent literature emphasizes the importance of identifying different pathways from agriculture to nutrition for better nutritional outcomes. Using a disaggregated dashboard approach with agriculture, food consumption, and demographic and health survey data, this study examines the progress of Indian states toward the Sustainable Development Goals. There is evidence of both disconnects and linkages among food security indicators along the agriculture-nutrition pathways. Through a broadened and comprehensive approach under one coordinating body with a good set of improved interventions and governance, Indian states can attain food and nutrition security by 2030. Such evidence based policy making is need of the hour to observe impact on the ground, rather than framing policies based on ideologies. At a time when the focus is more and more on impact, the shift to why we do research and what it contributes to solving the problem is increasingly important.

Keywords: agriculture to nutrition pathways, food security indicators, India, SDGs

JEL Codes: C40, I30, Q18, Z18

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1. INTRODUCTION

Achieving the Sustainable Development Goals (SDGs) related to food security and nutrition will require translating agricultural and food production into nutrition security for whole populations. This basic tenet drives the recent search for strategic approaches to improving agriculture-nutrition linkages in developing countries (McDermott et al. 2015). The literature on food and nutrition security highlights several pathways toward food and nutrition-related SDGs. Considering that attaining food and nutrition security is a process that happens at multiple levels, the following pathways are commonly discussed: (1) agriculture as a source of food, (2) agriculture as a source of income for food and nonfood expenditures, (3) agricultural policy and food prices that affect food consumption, (4) women in agricultural intrahousehold decision making and resource allocation, (5) maternal employment in agriculture and its effect on childcare and feeding, and (6) the effect of women's work in agriculture on their own and their children's nutrition and health status (Kadiyala et al. 2014). Although these pathways focus on different channels and are key contributors to ensuring food and nutrition security at different levels, there is little research-based evidence on their effectiveness, nor on the policy, institutional, technological, and resource impediments that exist along them (Pinstrup-Andersen 2015). This paper analyzes these pathways from agriculture to nutrition in the context of India, focusing on the performance of Indian states across different indicators that capture information on the different dimensions of the process of food and nutrition security.

This paper contributes to the literature in two major ways. First, it analyzes the importance of and interdependencies along the major pathways in the context of a large country with high levels of malnutrition. Though some argue that all the pathways are equally important and therefore call for them to be given equal priority in discussions of food security for households and individuals (Ruel and Alderman 2013), others have questioned that broad approach, given the limited resources available for allocation across these pathways. The political economy of policy making, on the other hand, tends to focus on visible indicators and pathways over those that are not so obvious or are ignored in the public debate. Further, there is a lack of coordination among different agencies in the government that focus on different pathways. For example, in India, a developing country with a high level of undernutrition even after 40 years of the Green

Revolution in food production, this disconnect is quite evident from the mandates and actions of the sectoral ministries, the agriculture sector focusing on pathways (1) and (3), whereas pathway (5) is under the purview of the women and child development sector.

Second, the paper demonstrates an innovative use of extant datasets to cope with data inadequacy to analyze such pathways. For example, a major challenge in analyzing the pathways from agriculture to nutritional security in developing countries is the availability of reliable and systematic data to understand the status of and temporal changes in indicators, and the causal factors of nutrition across regions, states, and countries (Carletto et al. 2015).

The primary objectives of this study are (1) to understand the relationships among different agriculture-nutrition pathways as discussed in the literature and (2) to analyze whether focusing on one pathway leads to ensuring other pathways, and whether some are more important than others. This research has important implications for the allocation of funds across different sectors when multiple sectors are involved in and responsible for promoting different pathways. Further, the research provides an opportunity to evaluate whether Indian states recognize the importance of a systematic and coherent food security policy that emphasizes any or all of the pathways, or whether they are inclined toward certain types of policies due to the historical, demographic, geographic, socioeconomic, and political factors at play. The main finding of this paper is a serious disconnect in the performance of states along these different dimensions, which may be the main factor in the country's dismal performance on the Millennium Development Goals (MDGs).

The rest of the paper is organized as follows. Section 2 presents a conceptual framework for identifying selected bridging factors on the agriculture-nutrition pathway. Section 3 provides a case study of Indian states, including background on the evolution of their concepts, programs, and policies related to food security; discusses the data and methodology adopted; analyzes the main results; and provides a detailed explanation of the performance of states according to different indicators over space and time. Concluding remarks make up the last section.

2. A CONCEPTUAL FRAMEWORK FOR IDENTIFYING BUILDING FACTORS ON THE AGRICULTURE-NUTRITION PATHWAY

We use data collected from various sources to analyze the different pathways, due to the lack of systematic and harmonized datasets addressing agriculture and nutrition, especially in the context of developing countries (Carletto et al. 2015). In order to develop a conceptual framework for guiding the analysis presented in this paper, we draw from four different strands in the literature on food security, agriculture, and nutrition.

The first strand relates to the process of food security and the need for a multidimensional approach to implementing policies, especially in developing countries, in the midst of high levels of undernutrition. The process of achieving food security,¹ broadly speaking, has four interconnected dimensions: input, process, output, and outcome. There is a two-way causal relationship between the food system and nutritional status (Pinstrup-Andersen 2007). However, definitions of food security generally do not incorporate its multidimensional aspect, nor do they distinguish between the long-term and short-term indicators of food security along the entire agriculture-to-nutrition pathway.² This disconnect is visible not only in the national-level discussion but also in international-level dialogues. For example, the first MDG³ targeted eradicating extreme hunger and poverty, with two indicators monitoring hunger: (1) the prevalence of underweight children younger than five years (undernutrition), and (2) the proportion of the population with less than the minimum level of dietary energy consumption (calorie inadequacy). This focus has led to global overemphasis in food security policies solely on undernutrition and calorie adequacy numbers (Fukuda-Parr and Orr 2014). Among the newly formulated goals, SDG2 (zero hunger), SDG6 (clean water and sanitation), and SDG12 (responsible consumption and production) are interlinked, focusing on various dimensions of food security recognized along the pathways from agriculture to nutrition. Yet various indicators delineated under the SDGs appear to be independent of each other. Further, though targets are

¹ Achieving food security is a process involving production, distribution, consumer choice and consumption, adequate intake of macro- and micronutrients, and their effective assimilation (Pinstrup-Andersen 2009).

² See, for example, the definition of food security formulated at the 1996 World Food Summit (FAO 1996).

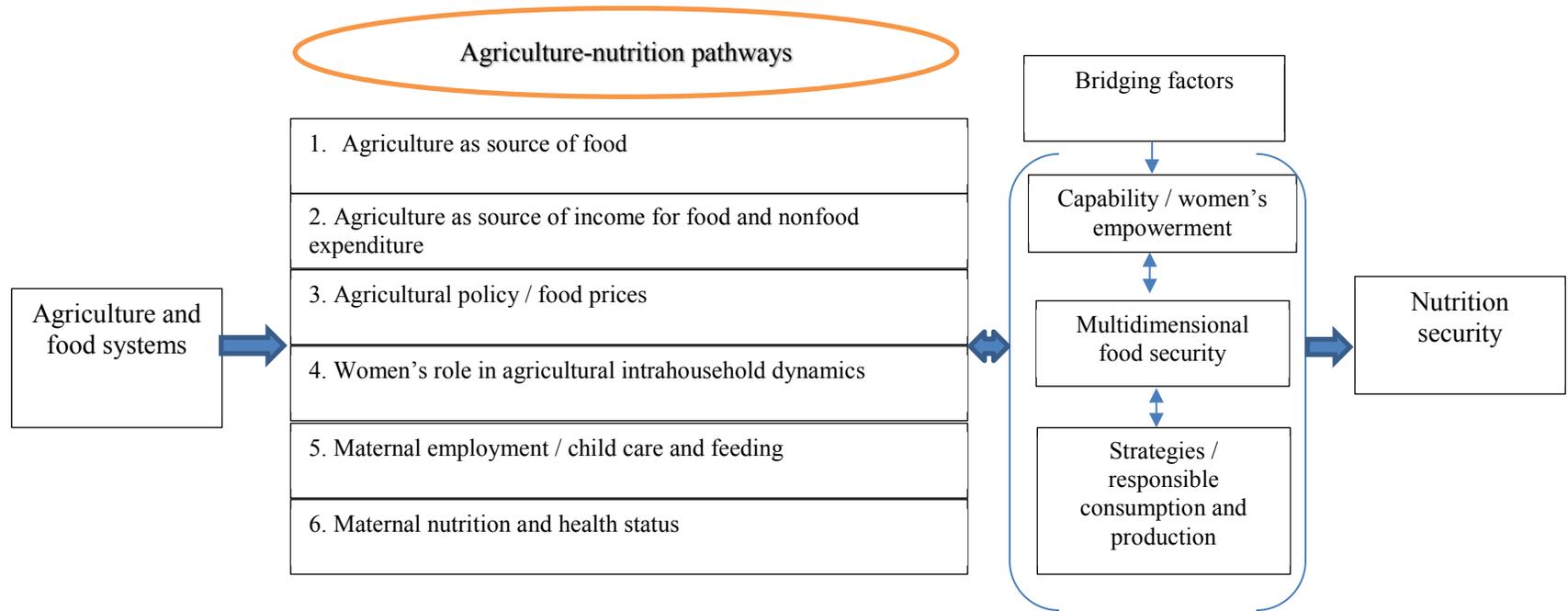
³ For a detailed discussion of the shortfalls of MDGs in the context of agriculture and nutrition, see von Braun, Ruel, and Gillespie (2011).

set, no mechanism or framework is provided to achieve these goals (von Braun, Swaminathan, and Rosegrant 2005). In this paper, to shed some light on their interlinkages and performance, we look at dimensions of the processes and indicators of food security through the lens of pathways from agriculture to nutrition at the subnational level in India.

The second strand of the literature relates to a disconnect between agriculture and nutrition, and how it can be overcome by adopting sustainable bridging mechanisms (Figure 2.1). For example, a large number of poor households in developing countries are composed of subsistence farmers and agricultural laborers. Some argue that to ensure food security and nutritional adequacy among this population, governments should encourage consumption of micronutrient-rich foods and small animals, biofortification⁴ of crops (Qaim, Stein, and Meenakshi 2007), and organic home-based produce for household consumption (von Braun, Ruel, and Gillespie 2011). Further, there has been a shifting focus toward precision agriculture using modern and accessible technologies to reduce waste of resources through improving the nutrient content of food (Gebbers and Adamchuk 2010). These strategies not only ensure better agricultural practices from the point of view of SDG12, responsible consumption and production, but also ensure that the final nutritional outcomes are improved. This study contributes to this strand of the literature by considering spatial differences in the production and consumption of food as well as diversity in the food items consumed.

⁴ The process of breeding food crops that are rich in essential micronutrients is called *biofortification*. For further discussion, see Low and others (2007) and Qaim, Stein, and Meenakshi (2007).

Figure 2.1 Bridging factors on the agriculture-to-nutrition pathway



Source: Authors' conceptualization.

The third strand of literature we reviewed draws on the capability approach, pioneered by Sen (1999) in the context of poverty and deprivation. It can help us understand the pathways from agriculture to nutrition in an integrated manner, with interconnections among entitlement (the right to food), famines and hunger, and human development and well-being to explain the causes of food and nutrition insecurity at the individual and household levels. From this perspective, food insecurity is due to a lack of both access and basic capabilities such as education and healthcare services. This approach highlights that focusing on the consumption of adequate calories alone is not enough to attain adequate nutritional status (George 1999). Diet patterns are dependent on individual and neighborhood characteristics such as the availability, convenience, safety, and price of food; literacy; social networks; and so forth (Ferrer et al. 2014). The capability framework provides a conceptual background to understand the interplay among the factors related to food security. Pathways 4, 5, and 6, identified in Figure 2.1, which focus on the impact of the mother's health status and level of empowerment on the child's nutritional status, characterize the capabilities approach, along with the quality of drinking water, sanitation, and breastfeeding practices (VanDerslice, Popkin, and Briscoe 1994; Burger and Esrey 1995; Checkley et al. 2004; Bryce et al. 2008; Spears, Ghosh, and Cumming 2013).

The last strand of the literature draws on comparative studies analyzing the nature of spatial development from the perspective of food security, agriculture, and child nutrition at the national and subnational levels. Aguayo and colleagues (2014) comparatively analyzed the performance of Indian states and found a negative relationship between economic growth and per capita income, and economic growth and child undernutrition. Further, they found a positive relationship between poverty incidence and child undernutrition across states, observing that 16 out of 28 states had very high levels of undernutrition. Last, they highlighted that child nutrition measured using multidimensional indicators has a negative relationship with child undernutrition. Similarly, a handful of studies have analyzed different aspects of the process of achieving food security in India at the subnational and regional levels (Datt and Ravallion 1998; Shetty 2002; Ghosh 2006). We focus on a set of development indicators and the role of states and their

interventions on these outcomes, especially focusing on women and children, who are particularly vulnerable to malnutrition.

Drawing insights from all of these strands of the literature, we analyze the performance of various states in India on different aspects of achieving of food security. Using data from multiple sources and a scorecard-based approach, this paper investigates whether a uniform, indicator-based policy or a multidimensional approach to the food security process along the pathways from agriculture to nutrition would be better suited for India. Uniformity in food security status may be defined as invariance in a state's rankings on different indicators—that is, under uniformity, the relative ranking of a state based on the absolute values of different indicators remains invariant across these indicators. Heterogeneity in findings will imply that the present uniform approach of providing food grains to all, based on cereal or calorie intake statistics, may not suffice. Further, we can provide evidence that some forms of government intervention and some initiatives of private agents, civil society, and nongovernmental organizations have helped improve the performance of states on a particular indicator. Such evidence may suggest a possible direction for policy making at the subnational level.

3. A CASE STUDY OF INDIAN STATES

Background and Context

In the last two decades, India's remarkable economic growth performance has not been matched with similar performance in the social sectors of education, health, and nutrition. Just after India gained independence, the availability of food grains in the country was a serious concern, so the focus of food security policies was on ensuring adequate availability. The Green Revolution in the 1960s helped the country achieve more than the optimal level of food grain stocks, primarily of rice and wheat, leading to food self-sufficiency at the national level. During that period, the yield per acre of land improved significantly, enabling the country to produce more food without any increase in the area of land cultivated. Yet this approach was in contrast to the definition of food security promulgated by the Food and Agriculture Organization of the United Nations (FAO): "ensuring that all people at all times have both physical and economic access to the basic food they need" (1983). In addition, the internationally used definition and scope of food security has been expanding since then to incorporate various dimensions—food security is now about not only food availability at the national level but access and utilization at the household and individual levels. Recognizing this trend, India slowly evolved its policies over time to incorporate the different dimensions of food security. However, despite common knowledge of the multidimensionality of food security, planning bodies and government departments still worked in silos.

The Food Corporation of India was set up in 1965. Its multifaceted role was to oversee the distribution of food grains, protect the interests of farmers, maintain adequate buffer stocks, and regulate the market price of food grains. To ensure better food access and delivery mechanisms for all types of households, the government adopted a major intervention called the Public Distribution System (PDS) to improve the provision of staple food grains. The PDS itself underwent reform in 1992 and again in 1997, becoming more targeted. The Antyodaya Anna Yojana program was introduced in 2000 to target the poorest of the poor. During this phase, the focus of food security policies in India shifted from the national and household levels to the individual level. Thus, in-kind transfers played a major role in improving cereal

intake in the country. Kumar and colleagues (2014) documented the success of the PDS in tackling the twin problems of poverty and undernourishment.

This development in ensuring food security was also complemented by programs focusing on other dimensions of the process. The Integrated Child Development Services (ICDS) program and the Mid-day Meal Scheme (MDMS) were started as large-scale initiatives for preschool children (younger than six years old), pregnant women, and adolescent girls. The ICDS was launched in 1975 as a supplementary nutrition program. The objective was to provide food, education, and healthcare facilities to reduce mortality, morbidity, and malnutrition, and improve school enrollment. The MDMS was implemented nationally in 1995 to provide free meals to children enrolled in primary and upper primary classes. Despite the presence of such large-scale food distribution programs, however, there was no improvement in the nutritional status of either children or adults, an outcome that can be attributed to a lack of focus on factors that improve the absorption of nutrients, such as water and sanitation facilities. One important factor was that the government missed out on specifically targeting children younger than three years old, even though most brain development, growth, and nourishment takes place during the first three years. A major challenge of these programs is the poor quality of the diet consumed, which is inadequate in protein, fat, vitamins, and minerals. This issue is evident from the simultaneous presence of under- and overnutrition as well as micronutrient deficiency diseases, known as the “triple burden of malnutrition” in the country (Popkin 2001; Gómez et al. 2013). Further, an appreciation for the linkages between agriculture and nutrition was missing in the implementation of this gamut of food security policies.

Cereal or calorie intake, in the absence of any integrated food security framework, remains the main focus of food security policies in India. The recently enacted National Food Security Act of India (2014) adopts a similar approach whereby the policy recommendations are based on a single indicator of food security (calorie intake). However, the salient question is whether a uniform policy prescription of distributing subsidized food grains is valid when food security itself is a multidimensional concept and the food security profile across Indian states is heterogeneous. One of the solutions to this problem is analyzing the input, process, output, and outcome indicators of food security in an integrated framework

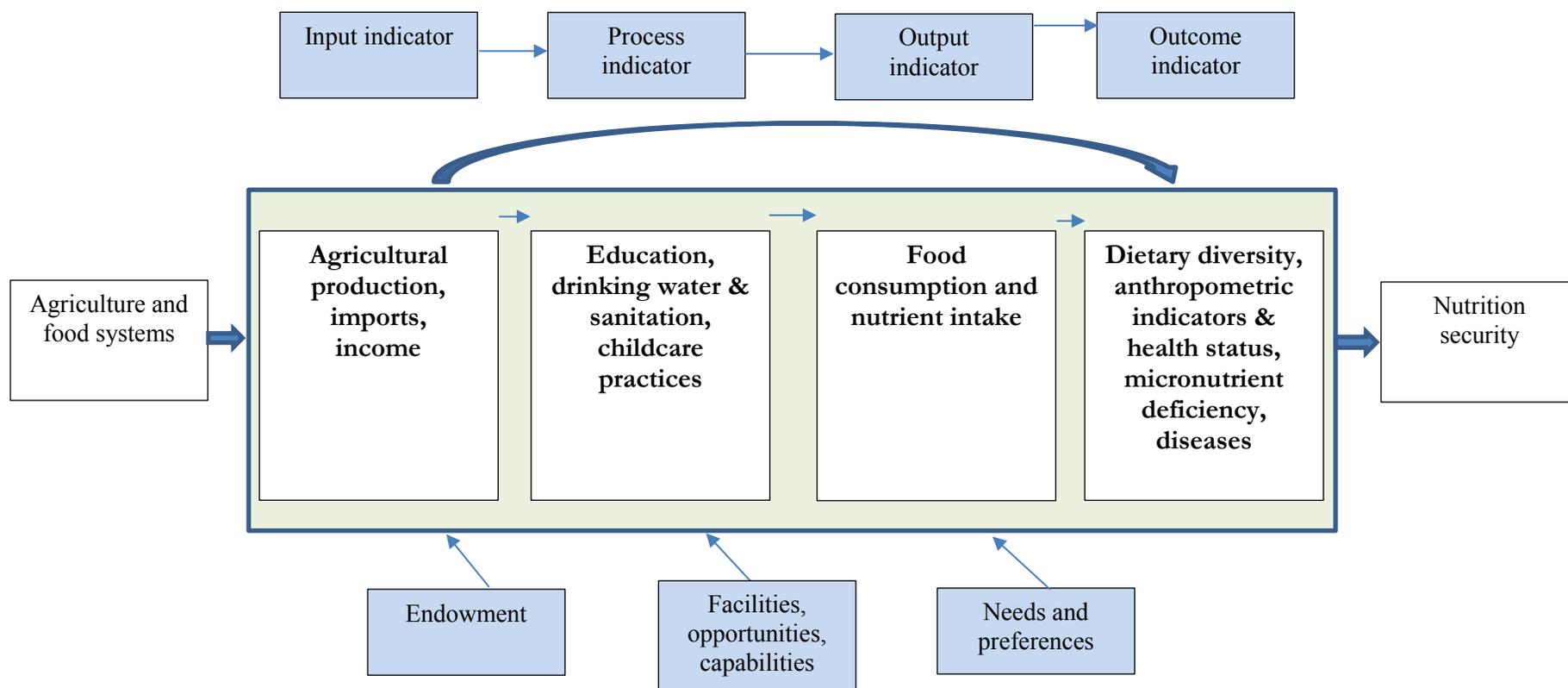
(Suryanarayana and Silva 2007). Vaidyanathan (2003) and Deaton and Drèze (2009) pointed out that an analysis of nutrition security is incomplete if it is based only on an assessment of calorie intake. In fact, food security policies in India are not forward looking, nor do they contain any provision to face sudden shocks and protect the vulnerable. Food security and nutrition monitoring systems in India have remained disconnected from policy implementation (Babu 1997). Often, if the information content of an indicator belonging to one particular dimension of the process overlaps with that of other indicators, then it is irrelevant which indicator is used for policy purposes. However, this precept may not hold in the face of heterogeneous food security profiles, such as those that exist across Indian states.

This discussion brings us to the main question we ask in this paper. To better understand these issues and inform both academia and policy makers, there is a need to analyze the linkages and disconnects among the various dimensions of food security in India. This paper synthesizes information from different sources over the past few decades to depict the channels of agriculture and nutrition linkages, paving the way for informed, structured, and targeted policy making.

Data and Methodology

The food security framework presented in Figure 3.1 provides the conceptual background for our analysis. Table 3.1 maps data on various food security indicators pertaining to the different dimensions and pathways—including those measuring agricultural production, consumption expenditure, sanitation and hygiene facilities, care practices, health, and anthropometric status—across contemporary surveys, noting the sources of data. An ideal dataset would provide information at the individual level on different dimensions and indicators, as discussed above, over a period of time. In total, we examined 20 indicators for the purposes of this analysis. The *input* dimension is measured by indicators such as income and per capita availability and import of food grains. The level of education; access to clean drinking water, hygiene, and sanitation facilities; and childcare practices relate to the *process* dimension. Indicators of the *output* dimension include share of food in expenditures; consumption from the PDS; dietary diversity; and nutrient intake, measured in both calories and grams. Nutritional status is the *outcome* indicator.

Figure 3.1 Food, agriculture, and nutrition security framework



Source: Adapted from Pinstrup-Andersen and Watson (2011); Babu, Gajanan, and Hallam (2017).

Table 3.1 Food security profile and data sources

Dimension	Broad indicators	Specific indicator	Type of indicator	Source	Timeframe
Availability	Food production and availability	Agricultural production	Input	RBI DBIE	2005–2006
				NSS	2004/2005, 2009/2010
Access	Income	Monthly per capita expenditure, Public Distribution System (PDS) participation		NSS	1972/1973–2011/2012
	Education	Literacy rate		Census	1990, 2001, 2010
Health and sanitation	Sanitation	Drinking water, sanitation facilities	Process	DLHS, CES	2002–2004, 2007/2008, 2009, 2011/2012
Care practices	Healthcare practices Childcare practices	Immunization Breastfeeding practices, women's empowerment			
Food consumption	Food intake, dietary diversity	Share of food in expenditures, food group share and Shannon diversity index, consumption from PDS	Output	NSS	1972/1973–2011/2012
	Nutrient intake	Calories, protein, fat			
Food utilization by the body	Anthropometric indicators	Weight for age	Outcome	NFHS	1992/1993, 1997/1998, 2005/2006
	Micronutrient deficiencies	Iron-deficiency diseases, vitamin A deficiency		NNMB	2003–2006

Source: Authors.

Note: For our present analysis data sources are as follows: Census = India National Census (India, ORGCC 2001); CES = Coverage Evaluation Survey (UNICEF 2009); DLHS = District-Level Household and Facility Survey (IIPS 2010); NFHS = National Family Health Survey (2007); NNMB = National Nutrition Monitoring Bureau (India, NNMB 2008); NSS = India National Sample Survey (India, MOSPI 2004-05); RBI DBIE = Reserve Bank of India Database on Indian Economy (RBI 2006); Online database: India Time Series (EPWRF 2013). For each indicator, we have also examined the performance of states since seventies for our understanding. However, discussion on the same is beyond the scope of this paper. Table 2.1 thus lists all the years for which data is available for the different indicators.

The data are mapped according to whether the indicators are long-term or short-term in nature. Thus, data for long-term indicators at the state level are mapped with those on short-term indicators conducted in the previous year. For example, for examining the food security profile for the year 1992/1993, the consumption and nutrient intake data (output dimension) correspond to the year 1993/1994, and the data for the rest of the indicators correspond to the year 1992/1993.⁵ Our present analysis is for 2005/2006. Our

⁵ The mapping exercise across different datasets was conducted for different years and involved many limitations, as discussed above. Long-term indicators such as health and nutritional outcomes need to be matched with short-term indicators such as agricultural production and consumption patterns. For illustration purposes, let us consider the correlation matrix for two periods—1992/1993 and 2005/2006. For the year 1992/1993, the following relations hold:

- (1) Positive and significant correlation between output (protein intake) and outcome (anthropometric) indicators; between the presence of a toilet facility and final outcome indicators; between monthly per capita expenditure (MPCE) and fat intake (output indicator); between literacy (primary) and presence of toilet/latrine facilities; and between exposure to mass media and presence of toilet/latrine facilities.
- (2) Negative and significant correlation between the output (per capita food expenditure and food share) and final outcome indicators, and between infant mortality and presence of a toilet facility.

For the year 2005/2006, the following relations hold:

choice of indicators pertaining to different dimensions is supported by evidence from the literature and by policy relevance. Haddad, Kennedy, and Sullivan (1994) offered an economic explanation of the choice of indicators: the ratio of the cost of collecting data to the cost of not collecting data. However, factors such as location and level of aggregation also matter. The authors concluded that simple indicators are the best for identifying food-secure and food-insecure entities at the individual, household, and regional levels. Some of the indicators chosen for our analysis in fact are the ones listed by Haddad, Kennedy, and Sullivan (1994), such as number of unique food items consumed, vaccination status, and drinking water and sanitation facilities. In fact, the choice of indicators depends on the factors that have been neglected yet are crucial for ensuring proper child nutrition. They include, for example, breastfeeding, sanitation, and hygiene facilities. It is quite surprising to note that indicators identified as very important for determining a child's nutritional status are still not included in policy making on related issues in India.

We use a disaggregated dashboard approach to depict the performance of states on the different indicators (Table 3.2). ⁶This approach provides a visual representation, which permits a comparison of absolute values across indicators that is usually not possible due to differences in units of measurement. There may or may not be an ideal attainment value for all indicators. For example, one cannot decide a benchmark for agricultural production or availability of food grains from the PDS. In such cases, we resort to the performance of various government interventions to understand the status of food security pertaining to that particular indicator. Based on the quartile values of the indicators, we classify states into four quartile groups. Still, a state's presence in the highest quartile group for a particular indicator does not imply that in an absolute sense the state is performing above average. However, in the final table on uniformity, no instances arise in which all states are above or below the average level of performance. Wherever possible

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- (1) Positive and significant correlation between drinking water facility and anthropometric indicators, and between drinking water and anemia.
 - (2) Negative and significant correlation between MPCE and food grains production, between MPCE (food) and food grains production, between food share and food grains production, and between presence of toilet facilities and infant mortality rates.

There is a plethora of evidence supporting interdependency between the final nutritional outcome and different input, process, and output indicators, primarily using regression techniques. However, the performance of individual states on the various indicators needs to be measured and verified for an understanding of uniformity in multidimensionality

⁶ Similar to the approach in Sachs et al. (2016).

we refer to benchmarks; for example, in the case of nutrient intake, the minimum requirements are well defined.

The data on each indicator are jointly analyzed for the rural and urban sectors.⁷Data on the different indicators correspond to the year in which the relevant survey was last conducted, as outlined in Table 2.1. States are then classified into different quartile groups; see the legend for interpretation of the colors.

⁷Detailed results are available on request.

Table 3.2 Performance of selected Indian states on different food security indicators

	STATE	INPUT				PROCESS								
		Total production	Rice	Wheat	Coarse cereals	Pulses	Income	Educa-tion	Immuni-zation	Drinking water	Sanita-tion	Vitamin A dosage	Breast feeding	Women's empowerment
EAST	ASSAM	WP	AA	WP	WP	WP	BA	BA	WP	WP	BP	WP	BP	BA
	WEST BENGAL	AA	BP	BA	BA	WP	AA	BA	AA	AA	BP	BP	BA	AA
	BIHAR	BA	BA	AA	BA	AA	WP	WP	WP	BA	WP	BA	WP	WP
	ORISSA	WP	AA	WP	WP	BA	WP	AA	AA	BA	WP	BP	BP	BA
CENTRAL	MADHYA PRADESH	AA	WP	AA	AA	BP	BA	WP	WP	BA	WP	WP	WP	WP
NORTH	UTTAR PRADESH	BP	BP	BP	BP	BP	WP	BA	WP	AA	BP	WP	WP	WP
	PUNJAB	BP	BP	BP	BA	WP	BP	BA	BP	AA	BP	AA	AA	BP
	HARYANA	AA	BA	BP	BA	BP	BP	BA	BA	BP	BA	WP	WP	AA
	RAJASTHAN	BP	WP	AA	BP	BP	WP	WP	WP	BA	BA	WP	BA	WP
WEST	GUJARAT	BA	WP	AA	AA	AA	BA	BA	BA	AA	BA	BA	AA	BP
	MAHARASH-TRA	AA	BA	BA	BP	BP	BP	AA	AA	WP	BA	AA	AA	AA
SOUTH	TAMIL NADU	BA	AA	BP	AA	BA	AA	AA	BP	AA	BA	BP	BP	BP
	KARNATAKA	BA	BA	BA	BP	AA	AA	BA	AA	BA	BA	AA	AA	AA
	KERALA	WP	WP	n.a.	WP	WP	BP	BP	BP	WP	BP	BA	BP	BP

Table 3.2 Continued

STATE	OUTPUT				OUTCOME			
	PDS	Vegetables	Fruits	EFM	Nutrient intake	Anthropometric indicator	Anemia	
EAST	ASSAM	WP	BB	WP	BP	BA	BA	WP
	WEST BENGAL	WP	BP	BA	BP	BA	AA	BA
	BIHAR	WP	AA	WP	BA	WP	WP	WP
	ORISSA	BA	AA	WP	AA	BP	AA	WP
CENTRAL	MADHYA PRADESH	BA	WP	WP	BA	BA	WP	AA
NORTH	UTTAR PRADESH	BA	BA	BA	WP	AA	WP	AA
	PUNJAB	WP	BP	AA	WP	BP	BP	WP
	HARYANA	WP	BP	AA	WP	WP	BP	BA
WEST	RAJASTHAN	WP	WP	BA	WP	BP	WP	AA
	GUJARAT	WP	AA	BA	WP	WP	AA	AA
	MAHARASHTRA	AA	BA	AA	BA	AA	BA	WP
SOUTH	TAMIL NADU	AA	WP	BP	AA	BA	BP	BP
	KARNATAKA	AA	WP	AA	AA	WP	AA	BP
	KERALA	AA	BA	BP	BP	AA	BP	BA

Source: Authors.

Note: EFM = Egg, fish and meat; n.a. = not applicable; PDS = Public Distribution System; Q_x = quartile x ; V_i = Value.

Color	Ranking	Range
	Worst-performing (WP)	$V_i \leq Q_1^i$
	Below average (BA)	$Q_1^i < V_i \leq Q_2^i$
	Above average (AA)	$Q_2^i < V_i \leq Q_3^i$
	Best-performing (BP)	$Q_3^i < V_i \leq Q_4^i$

What follows is a brief discussion of the states' performance on the various indicators, based on the available data sources mentioned earlier as well as findings in the literature, summarized across states. We discuss the performance of states on the four dimensions, highlighting linkages and disconnects along the different pathways.

Results and Discussion

Input Indicators

Food production and availability. The role of agricultural production as an important indicator in food security can be explained as follows. Agricultural growth has a positive and significant relation to reducing poverty in India (Ahluwalia 1985). Further, with the introduction of the Green Revolution in the mid-1960s, there was a remarkable improvement in the self-sufficiency of food grain production. Conversely, however, the most recent economic survey (India, MOF 2016) pointed out that the Green Revolution was detrimental to farmers in the sense that it focused mainly on cereal production. The dire need of the hour, then, is to shift the policy focus from cereal to more diverse food items such as pulses, dairy products, and so forth. Another concern is the delivery mechanism of this agricultural production to end users.

On total agricultural production, Uttar Pradesh, Punjab, Haryana, Rajasthan, and Madhya Pradesh perform better, whereas Kerala, Orissa, Assam, Tamil Nadu, and Bihar are relatively worse performing. For the staple cereals—wheat and rice—the ranking remains largely the same, with southern and eastern states focusing more on rice production, whereas northern states are abundant in both rice and wheat. As for coarse cereals, Uttar Pradesh, Maharashtra, Karnataka, and Rajasthan are the best performers. Madhya Pradesh, Uttar Pradesh, Haryana, Rajasthan, and Maharashtra are the best-performing states overall.

Process Indicators

Care practices. The first 1,000 days after conception are a “critical window of opportunity” for ensuring the child's growth and development, not only in the short run but also in the long run (Arabi et al. 2012). Damage due to poor health and nutrition during this period is mostly irreversible. Thus, ensuring good health of both the mother and the child is important. The health status of the mother and the care practices

she adopts (pre- and postnatal) are crucial to the child's health and nutritional status (Engle, Menon, and Haddad 1999; Haddad 1999; Variyam et al. 1999; Shroff et al. 2011). Oddy and colleagues (2006) found that a longer duration of breastfeeding had a positive impact on child health outcomes. A comparison of District-Level Household and Facility Survey data for 2002–2004 and 2007/2008 shows an increase at the national level in children younger than three years old who were breastfed within one hour of birth, from 27.8 percent to 40.5 percent (IIPS 2010).

Antenatal care is also an important indicator to be examined. During antenatal care visits, the mother is advised on how to take proper care of an infant, which has a positive impact on the child's health status (Halim, Bohara, and Ruan 2011). Southern states of India had better antenatal care practices than northern states in 2005/2006 (Rani, Bonu, and Harvey 2008). Punjab and Tamil Nadu were the best performers in immunization; the worst were Assam, Bihar, Madhya Pradesh, Uttar Pradesh, and Rajasthan.⁸ Assam, Madhya Pradesh, Uttar Pradesh, Haryana, and Rajasthan were the worst performers in intake of Vitamin A; West Bengal, Orissa, and Tamil Nadu were the best. Breastfeeding was best practiced in the states of Assam, Orissa, Kerala, and Tamil Nadu, and worst in Bihar, Madhya Pradesh, Uttar Pradesh, and Haryana. Kishore and Gupta (2004) found a positive association between the level of women's empowerment and nutritional status. Kerala, Tamil Nadu, and Punjab had the best record of women's empowerment; Rajasthan, Uttar Pradesh, Madhya Pradesh, and Bihar had the worst.

Education. Literacy rates have improved across all states over time. The highest literacy rates are in Kerala, Himachal Pradesh, Assam, Punjab, and Tamil Nadu, the lowest in Andhra Pradesh, Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh (India, ORGCC 2006). The mother's level of education and women's empowerment in general also determine the quality of childcare practices adopted. Bihar, Madhya Pradesh, Uttar Pradesh, Rajasthan, Assam, and Orissa have the lowest women's empowerment, which is reflected in the poor nutritional status of children in these states.

⁸ The Coverage Evaluation Survey conducted in 2009 also showed similar results. Rajasthan, Bihar, and Uttar Pradesh were the worst performers, whereas more than 90 percent of households in Andhra Pradesh, West Bengal, and Tamil Nadu took advantage of at least one antenatal care service (UNICEF 2009).

Drinking water and sanitation. It is well established in the literature that the quality of drinking water, sanitation, and hygiene is important for a child's growth and development (Dillingham and Guerrant 2004; Bartram et al. 2005). Based on a study of Kenyan children, Onyango, Esrey, and Kramer (1999) found that children with a longer duration of breastfeeding gained more weight and height. The impact was greater for households with inadequate sanitation and a poor water supply. Smith and Haddad (2015) found that differences in stunting rates across countries could be explained by access to safe water and improved sanitation. On household access to improved sources of drinking water, Punjab outperformed all the other states, followed by Tamil Nadu, Uttar Pradesh, and Haryana. An evaluation of the Rajiv Gandhi National Drinking Water Mission (India, MOF 2010) found that 93 percent of participating households were satisfied with the quality of water and had access to it, demonstrating the importance of village water and sanitation committees. A rapid survey of the Swachh Bharat Mission found that 13 percent of the villages in India had access to community toilets; 56 percent of the wards had a sewer connection for disposal of liquid waste; 78 percent of the wards had street cleaning; and sanitary toilets were present in 45 percent of rural households and 88 percent of urban ones, the usage being more than 95 percent for both types of households (India, MOSPI 2016).

Output Indicators

Food and nutrient intake. Studies conducted in India have shown a decline in calorie intake along with a rise in food and per capita consumption expenditure over time (Suryanarayana 1995; Deaton and Drèze 2009). Given this background, it is important to focus on consumption of a diverse diet (Das 2014). A diverse diet is important for improving nutritional quality and child growth, as found in a growing body of epidemiological studies (Ogle, Hung, and Tuyet 2001; Ruel 2002; Arimond and Ruel 2004). Preferences and habits determine an individual's consumption and thus his or her diet diversity profile. Dietary diversity across states is dependent on local availability, consumer preferences (some states, such as Gujarat and Rajasthan, have a larger proportion of vegetarians), imported food products, income, and so on. At the all-India level, the share of food in expenditures decreased from almost 73 to 54 percent from 1972/1973 to

2009/2010. Only for cereals, however, has this decrease been steady since 1972/1973, as compared with the other food groups. Consumption of pulses has not improved over time. States such as Madhya Pradesh and Gujarat had a higher share of expenditure on pulses than the other states. The share of expenditure on milk and milk products shows a decline (by almost 15 to 20 percent) in rural India, except for Punjab and Rajasthan, which can be attributed to the fact that the majority of the population in these states consumes a vegetarian diet, as well as to the greater local availability of a variety of pulses and milk products. Assam, West Bengal, Punjab, and Haryana have a higher share of expenditure on vegetables. Tamil Nadu and Kerala spend more on consumption of fruits. Assam, West Bengal, and Kerala spend the most on consumption of eggs, fish, and meat products. Madhya Pradesh and Uttar Pradesh perform the worst, with the lowest shares of expenditures on vegetables; fruits; and eggs, fish, and meat.

Khera (2011) classified states into three categories based on the performance of the PDS. The first is that of the “languishing” states, with per capita purchases of PDS grain of less than 1 kg/month, consisting of Haryana, Punjab, Rajasthan, Assam, Bihar, West Bengal, and Gujarat (the only states with a decline in purchases over the last decade). The “reviving” states are those whose per capita purchases were less than 1 kg/month initially but improved thereafter: Orissa, Madhya Pradesh, and Uttar Pradesh. The last are the “functioning” states of Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, and Maharashtra.

Outcome Indicators

Health and nutritional status. Studies have attributed the persistence of malnutrition in the presence of high economic growth to poverty, low factor productivity, growth in incomes in the agricultural sector (Svedberg 2008), women’s empowerment and gender equality, difficult-to-access public health services, breastfeeding, and childcare practices (Kumar 2007). Bhargava (2015) rightly identified the lack of focus on environmental factors in policy making to tackle malnutrition and proper child growth, especially cognitive growth. Lack of consumption of a diverse diet leads to an increase in the proportion of malnourished people and those with deficiency diseases (Johns and Sthapit 2004; Block et al. 2004; Torlesse, Kiess, and Bloem 2003). Thus, all the different pathways are constantly at play, influencing both

intermediate and final nutritional outcomes. The poorer states of Bihar and Uttar Pradesh have high levels of share of expenditure on food, and also a high proportion of underweight, stunted, and wasted children. These states also have the highest mortality rates for infants and children younger than five years. The prevalence of undernourished children varies across states. More than 50 percent of children are underweight in Bihar, Madhya Pradesh, and Jharkhand. The poorest-performing states are Madhya Pradesh and Haryana.

Only 33.7 percent of children from one to five years old in rural Kerala are affected by iron deficiency diseases (IDDs). This number is more than 60 percent in Karnataka, Andhra Pradesh, West Bengal, and Orissa (India, NNMB 2008). In fact, 92.4 percent of children in rural Orissa have IDDs. Turning to subclinical vitamin A deficiency (VAD), more than 50 percent of the population in all states except for Tamil Nadu are affected. Kerala and Madhya Pradesh are the worst performers, with 79.4 and 88.0 percent of the population, respectively, affected by VAD. The prevalence of anemia is very high not only among children but also among women, even in the high-income states. Almost 66 and 53 percent of children 6–59 months old and women, respectively, were anemic in Punjab in 2011/2012.

Main Findings

Table 2.2 broadly summarizes the performance of states along the different indicators of food security.⁹ Overall, the high-income states of Haryana, Kerala, Punjab, and Tamil Nadu are the best performers on majority of the indicators. Moving on to intrastate stories, we find contrasting evidence for Uttar Pradesh and Kerala. Though the former performs well on input indicators and poorly on outcome indicators, the opposite holds for Kerala. Haryana and Kerala lag behind poorer states such as Orissa on indicators such as early initiation of breastfeeding, a finding that can be attributed to lack of knowledge and social inhibitions. Kerala and Punjab rank high in nutritional status but also in the proportion of the population suffering from micronutrient deficiency diseases such as anemia; this can be attributed to consumption of a less diverse diet than elsewhere. Households with higher incomes are expected to have better diet quality

⁹ Dashboard analysis for 2014-2015 is under progress given the recent release of the NFHS – 4 survey data.

and diversity; however, a state like Gujarat, with high levels of income, does not perform well with respect to both input (such as production), and output (such as nutrients) indicators. The poor nutritional status of children in Bihar and Orissa can be attributed to poor sanitation and hygiene facilities. To conclude, our analysis of the various pathways, though constrained by data limitations, reinforces our a priori hypothesis that a focus on just one pathway—say, agriculture as a source of food or childcare practices—will not ensure the desired nutritional outcomes.

Based on the specific discussions above, let us reexamine the Gordian knot in Kerala. The state is one of the best performing with respect to calorie intake and nutritional status, which can be attributed to adequate import of food grains, successful implementation of the PDS,¹⁰ and wide marketing by the government and active private-sector players in the grain market. But the state is not self-sufficient in the production of food grains (for example, at least not the staple items such as rice and wheat, even though an increase in tapioca production has been an important source of calories in Kerala) and thus cannot fulfill the consumption demand of its citizens without importing food grains from other states. This brings up the multidimensional aspect of the process of achieving food security. If the government's focus is on outcome indicators, this state ranks as the best performing, but a shift in policy toward input indicators of production would reveal an altogether different picture. Despite the best performance on final nutritional status, 48.5 percent of Kerala's children were anemic 2011/2012, suggesting that even though the food requirements were met, there was no focus on improving the diet quality or micronutrient security.

Some states, such as Assam and Orissa, have both low levels of production and poor nutritional status.¹¹ This combination can be attributed to the failure of food distribution systems and other indicators related to the process dimensions as measured by income, education, and levels of women's empowerment. The proportion of the population suffering from micronutrient deficiency diseases is also quite high in these two states. On the other end of the spectrum is Madhya Pradesh, one of the largest food grain-producing

¹⁰ For further details on the performance of the PDS in Kerala, see Suryanarayana (2001).

¹¹ The performance of states on different indicators is positively correlated with the successful implementation of the respective welfare programs. For example, states with a well-functioning PDS will have higher consumption from the PDS than from other sources after adjusting for quality differences in the food items sold. Other such programs are the Total Sanitation Campaign and the ICDS, which improve the performance of process indicators such as availability of toilet facilities and antenatal care practices, respectively.

states in India but a poor performer on all the other indicators, quite contrary to what we observed in Kerala. Madhya Pradesh is one of the least developed states in India. Similarly, Uttar Pradesh, though a major food grain-producing state, ranks low on calorie intake and final nutritional status, a situation attributed to low levels of women's empowerment and poor sanitation and hygiene conditions. Women's empowerment leads to greater decision making power and knowledge of childcare practices, both of which are important for acquisition of good health practices, not only by the child but by all members of the household.

Policy Implications

First, *sufficient food and agricultural production alone may not improve nutrient intake and assimilation*. However, major agricultural states (for example, Uttar Pradesh and Madhya Pradesh) have paid limited attention and allocated limited funds to the other pathways or dimensions. The complexity of the food system has not been fully recognized due to this narrow focus on food production as the goal of food security efforts. For ensuring sustainable food and nutrition security, equal emphasis on the different dimensions is required. As discussed in Section 2, the MDGs failed due to their disjoint focus and emphasis on achieving the final target. A similar approach in the space of food and nutrition security in India has plagued the system with distortions. For example, agricultural policies should promote consumption of a more diverse diet (Headey, Chiu, and Kadiyala 2012) through interventions including improving research and development on nutrient-rich food crops, reducing subsidies on staple crops, encouraging diversity in the crop production of small and marginal farmers, encouraging homestead gardening as an income diversification strategy, enacting gender-sensitive policies, and so on.

Second, our findings are important in the context of recent debates on *cash versus in-kind transfers and the substitutability of employment guarantee and food distribution programs*. Households in regions where the PDS or agricultural markets are well developed may prefer in-kind transfers. The contrary holds for households in regions where such systems are not well functioning or the government undertakes minimal price stabilization initiatives, the latter an under researched area. In kind transfers may be a quick solution to uplift the masses from poverty and hunger, especially the vulnerable groups subject to varisities

of income, health, climate or other catastrophic shocks. However, overemphasis on such related schemes or programs may not be appropriate for all regions or households. Thus, convergence in nutritional outcomes may be observed depending on the varying importance of price and income, and how households adjust to this variation. Cash transfers may shift households' consumption from staple food items toward a more nutritious and diverse diet (Jha et al. 2009, 2013; Svedberg 2012; Khera 2014; Gangopadhyay, Lensink, and Yadav 2015). However, transfers may not always be used for the purpose for which they are doled out, an eventuality quite evident from the prevalence of nutrient deficiency diseases in high-income states. Gujarat, Punjab, and Haryana rank high in income, but their intake of foods rich in vitamins and minerals is poor, as reflected in the poor ranking on deficiency diseases.

Third, *good performance on process indicators does not necessarily translate into good performance on outcome indicators* (an example is Orissa), and the opposite need not hold true (as in Kerala). It is to be noted that though policy interventions may be successful and achieve desired outcomes, the performance of the input and process indicators still may not be at the desired level. The performance of input indicators in the eastern states (such as Assam) is very poor.¹² PDS performance is poor in the eastern, western, and northern states. Thus, states that successfully implement the PDS may also need to focus on other dimensions of the process. For example, although the PDS is a success in Kerala, the state performs poorly on provision of drinking water facilities. Thus, the government's focus should be on allocating funds to priority sectors or departments, which may require more funds to improve performance on related dimensions. This can be made possible only if all ministries work in a unified manner. A cost-effective solution would be to focus on all the different pathways, possibly by amalgamating the functioning and budgeting exercises of the different ministries concerned with food security, ensuring no duplication of work.

¹² For purposes of this discussion, states are grouped by location into the following categories: west: Rajasthan, Maharashtra, Gujarat, Punjab, and Haryana; east: Orissa, Bihar, and West Bengal; north: Uttar Pradesh; south: Karnataka, Andhra Pradesh, Tamil Nadu, and Kerala; and central: Madhya Pradesh.

Finally, southern states perform better on anthropometric indicators and have low levels of micronutrient deficiency diseases. One immediate conclusion that can be drawn from the main findings is that the southern states have *better governance* in ensuring food security, as is evident from their performance on the different indicators. How poor governance leads to poor service delivery is well documented in the literature (World Bank 2003). Good governance in the southern states is evident in their successful policy interventions across different pathways. Other states should draw lessons from them.

4. CONCLUDING REMARKS

This paper analyzed the performance of different food security indicators along agriculture-nutrition pathways in the context of Indian states. The key finding is a general lack of uniformity in food security status as measured by the different indicators along the pathways. This heterogeneity implies that a food security policy with a singular focus is not appropriate, given that there are more disconnects prevailing along the agriculture-to-nutrition pathways than linkages. In a way, this explains why food security policies in India have failed to reduce the high rates of malnutrition for decades and failed to help the country attain the MDGs. In addition, serious data gaps hinder efforts to tackle the problem of malnutrition. An integrated framework for measuring food and nutrition security, and implementing and monitoring relevant policies, is missing. Innovations in survey methodology are required to capture the different dimensions of food and nutrition security. More integrated and comparable surveys are required to draw sound policy conclusions. Policy interventions need to be more evidence based and should incorporate both short-term and long-term indicators of food security, going beyond calorie security. Without such comprehensive approaches, attaining the SDGs could be seriously compromised.

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