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Supported by the CGIAR

IFPRI Discussion Paper 01085

May 2011

Agriculture's Role in the Indian Enigma

Help or Hindrance to the Undernutrition Crisis?

Derek Headey

Alice Chiu

Suneetha Kadiyala

Development Strategy and Governance Division

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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IFPRI gratefully acknowledges the generous unrestricted funding from Australia, Canada, China, Denmark, Finland, France, Germany, India, Ireland, Italy, Japan, the Netherlands, Norway, the Philippines, South Africa, Sweden, Switzerland, the United Kingdom, the United States, and the World Bank.

AUTHORS

Derek Headey, International Food Policy Research Institute
Research Fellow, Development Strategy and Governance Division
D.Headey@cgiar.org

Alice Chiu, International Food Policy Research Institute
Research Analyst, Development Strategy and Governance Division

Suneetha Kadiyala, International Food Policy Research Institute
Research Fellow, Poverty, Health and Nutrition Division

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ABSTRACT

In recent decades India has achieved one of the fastest economic growth rates in the world, yet its progress against both child and adult undernutrition has been sluggish at best. While this Indian variant of the so-called Asian enigma presents many puzzles, one of the puzzles pertains to agriculture's role. In this paper we reassess agriculture's role in the Indian enigma by exploring two key pathways, an income–consumption pathway and an employment–time use pathway, linking agricultural conditions to nutrition outcomes. On the income–consumption front, we assess whether rising incomes are improving diets and how agriculture and income growth are influencing the Indian diet. In terms of time use, we explore whether agricultural livelihoods hinder childcare practices and the health status of mothers. We conclude with a brief overview of nonagricultural constraints to improved nutrition and some analysis of the implications of our findings for agricultural policies in India.

Keywords: adult and child undernutrition, agricultural growth, rural development, India

1. INTRODUCTION

In the ultimate analysis, the nutritional status of our population will largely depend on the nutritive quality of diets in individual households across the country.

—"The Current National Nutrition Scene: Areas of Concern," C. Gopalan (2008).

The key to South Asia's high rates of child malnutrition is not to be found in the obvious…. For most poor families, the real food problem is not lack of food on the table but the inordinate costs—in money, time, and energy—of putting it there…. Food availability is not usually the issue…. Good nutrition, in the early months of life, is more usually determined by feeding practices—whether the right food is given at the right time and in the right way—and by the frequency, severity, and duration of disease.

—"The Asian Enigma," V. Ramalingaswami, Urban Jonsson, and Jon Rohde (1996).

Above all, India's high levels of child malnutrition reflect the continuing neglect of health, the inadequate reach and efficacy of health and childcare services, and the failure of strategies to reach newborn children and those under the age of three.

—"Clues to the Puzzle of Child Malnutrition in India," A. K. Shiva Kumar (2007).

From 1998/99 to 2005/06, the average Indian gross domestic product (GDP) per capita grew at unprecedented rates, expanding by 40 percent in just seven years. Yet over the same period, according to the National Family Health Surveys (NHFS) (IIPS 2007), the proportion of Indian children that were stunted declined only from 51.0 percent to 44.9 percent, and the proportion that were underweight declined from 42.7 percent to 40.4 percent. Adult women fared no better; over the same seven-year period the proportion of underweight women declined from 41.1 percent to 39.9 percent, and the prevalence of anemia actually rose quite sharply from 50 percent in 1998/99 to 57 percent in 2005/06. Calorie consumption in India also appears to have declined, from 2,150 kilocalories per day in rural and urban areas 1999/2000 to 2,050 kilocalories per day in 2004/05 in rural areas and just over 2,000 kilocalories per day in urban areas. These changes appear to be much more sluggish than the nutritional improvements in the 1970s and 1980s, when economic growth was significantly slower. Hence the much-discussed "South Asian enigma" (Ramalingaswami, Jonson and Rohde 1997) has, if anything, become more enigmatic in the Indian context: Why is nutritional progress stalling just as economic progress is accelerating?

There are undoubtedly many parts to this puzzle (Deaton and Dreze 2008). Nutrition outcomes are determined by a complex interaction of food intake, water quality, care practices, disease burdens, sanitation, and health services, as well as the deeper social, economic, and political processes that drive these intermediate outcomes (UNICEF 1990). But one part of the puzzle surely relates to the role of the agriculture sector. As we outline in Section 2, however, there are both positive and negative linkages between agriculture and nutrition. On a positive front, a wide range of studies have found agricultural growth to be *the* driving force in poverty reduction (Bezemer and Headey 2008, Christiaensen, Demery and Kühl 2006, de Janvry and Sadoulet 2010, World-Bank 2008), including studies in the Indian context (Datt and Ravallion 1998, Ravallion and Datt 1996, 2002). Agricultural growth presumably has profound impacts on diets, potentially influencing both macro- and micronutrient intake. Hence in terms of income–consumption linkages there are two key questions (Sections 3 and 4): First, has agricultural growth been fast enough and pro-poor enough to reduce poverty and—via poverty—to reduce undernutrition as well? Second, has agricultural growth contributed to improved diets?

Although income–consumption linkages should mostly be positive, there may be negative impacts of agricultural growth on nutrition via employment and time use (Section 5). Agriculture is still India's largest source of employment, including employment for women, but the employment of women in agriculture has ambiguous linkages to nutrition. Agricultural activities—including time allocation patterns, physical exertion, and exposure to health risks and weather shocks—could exert significant harm on adult health, including the health of pregnant women and mothers of young children, which in turn affects their children's health. Indeed, existing studies suggest that low birth weight, which is primarily influenced by the nutrition status of mothers, is very prevalent in South Asia. Given the persistent effects of low birth weight, this variable could perhaps account for as much as half of the region's prevalence of underweight preschoolers and a third of its stunting (Victora, et al. 2009). While these two channels show the potential of agricultural development to influence nutrition outcomes, empirical inquiry into the agriculture–nutrition linkages in India is sparse at best. This is in part due to the analytical disconnect between studies of agriculture and economics on the one hand and those of nutrition and public health on the other: Nutrition surveys omit agricultural information (and often food consumption information), and agricultural and economic surveys typically omit anthropometric outcomes. Where economists do consider nutrition it is often defined by what they can measure—calorie availability, an input into nutrition—rather than anthropometric outcomes. This has resulted in a certain calorie fundamentalism, especially in the Indian context, which in turn carries over into policy debates, such as the Public Distribution System (PDS) for rice and wheat. Yet on the more crucial issue of how agricultural and food policies influence nutrition outcomes there are scarcely any substantive investigations.

In view of this analytical disconnect, the goal of this paper is to explore the role of agriculture in determining consumption patterns and nutrition status outcomes in India. However, we emphasize up front the exploratory nature of our study. Because of the empirical disconnect between agricultural and nutrition variables in large datasets, we are mostly forced to rely on somewhat circumstantial evidence, both from the existing literature and from fresh analysis of existing datasets (mostly the National Family Health Surveys, NFHS, the Indian version of the Demographic Health Survey) that are imperfectly suited to the question at hand[1]. A second caveat is that we do not focus on linkages that may be important in the future but are thus far relatively unexploited, such as the biofortification of food crops (Bouis 2000).

Finally, as we noted above, there are many interacting determinants of nutrition outside agriculture (for example, health policies). While we cannot ignore these interacting factors even in a study of agriculture and nutrition, we cannot do them full justice either. However, in our concluding section we do briefly explore the hypothesis that the constraints to improving nutrition in India lie outside the agriculture sector (Section 6). On that front we rely chiefly on the existing literature and available data.[2] Ultimately, however, what is really needed is a more comprehensive multisectoral assessment, with different sectors working together to identify key drivers and their roles and responsibilities in tackling them.

[1] The NHFS is conducted jointly by the Macro International (the standard implementers of Demographic Health Surveys) and the Indian Institute of Population Studies (IIPS). However, the 1992/93 NHFS was carried out by a number of different partners, so concerns are occasionally raised about the quality of that particular round. In general, however, the NHFS of 1998/99 and 2005/06 have not been seriously questioned. The surveys are nationally representative and representative at the state level and at rural and urban levels. More on the design of the surveys can be found at the DHS and IIPS websites.

[2] Since the DHS and NFHS data contain a wide range of health-related measures, nearly all studies utilizing these data explore the health dimensions of the nutrition problem.

2. THEORETICAL LINKAGES BETWEEN AGRICULTURE AND NUTRITION IN INDIA, AND SOME INDICATIVE FACTS

In this section we outline a theoretical model of the various channels through which agricultural development influences nutrition outcomes of Indian women and children. While there are a number of frameworks outlining the determinants of malnutrition, only a few specifically focus on the complex linkages between agriculture and nutrition (for a rare example, see Millard, Ferguson, and Khaila (1990)). The framework we outline here is more "agro-centric" and India-specific than more generic frameworks such as the widely used UNICEF (1990) model. Figure 2.1 shows that our model contains a household component that aggregates into a macroeconomic component, as well as a broader socioeconomic component containing a wide array of India-specific factors, such as gender inequality and caste, tribal, and economic factors, that drive consumption patterns.

Despite the potentially positive agriculture–nutrition channels detailed in Figure 2.1, agriculture's limited role in influencing nutrition outcomes of women and children in India could be due to some important "leakages" along the main pathways through which agriculture influences nutrition. By *leakage* we mean any reduction in agriculture's impact on nutrition that takes place along the causal pathways. There are a number of deep, country-specific socioeconomic factors that create these leakages, including changes in taste, inter- and intrahousehold inequality and the policies and institutions that drive these inequalities, and public health policies that can obviously constrain nutrient uptake and utilization.

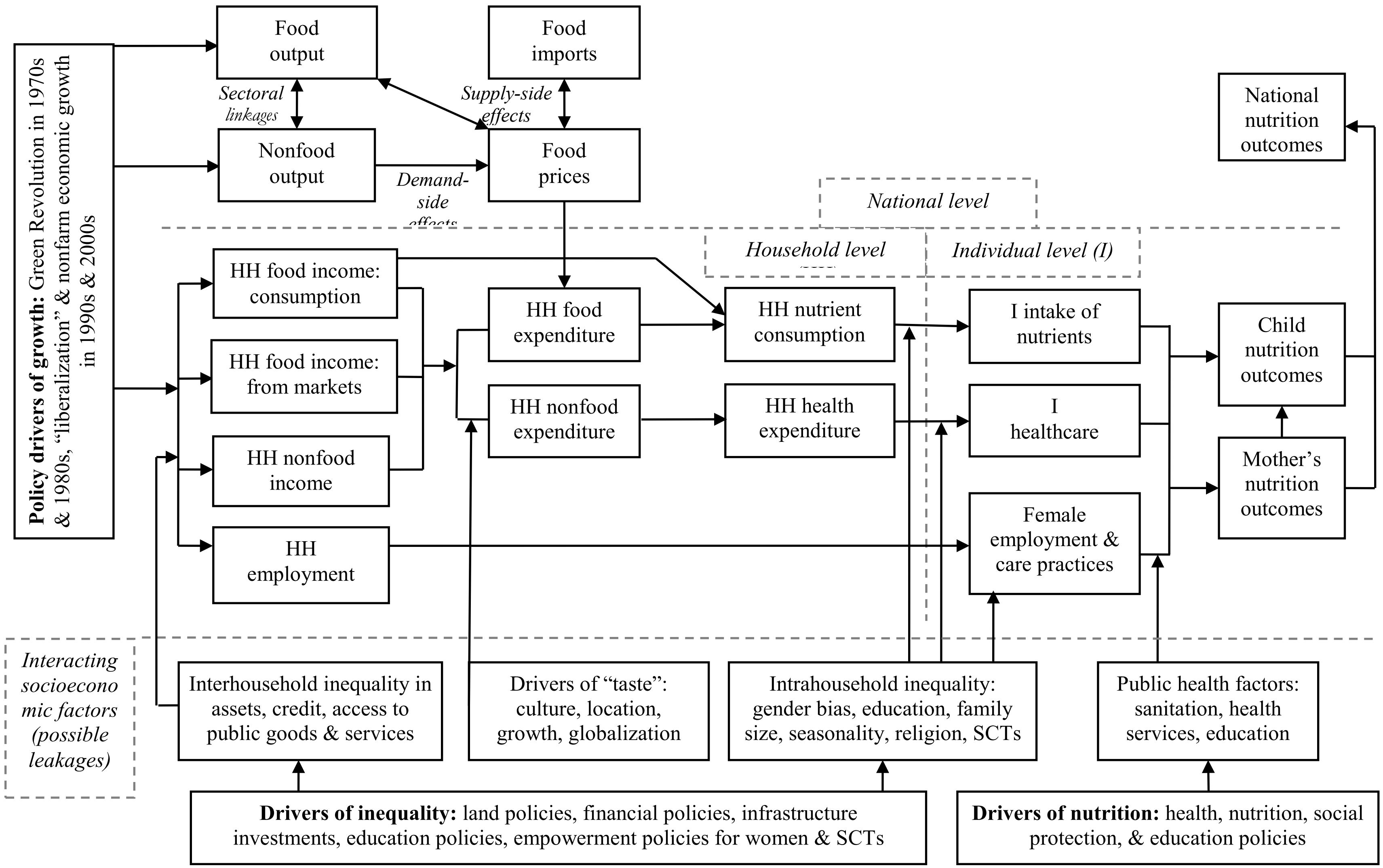
At the national level the pattern of agricultural growth can also be characterized by leakages. To begin with, agricultural growth patterns obviously have important macroeconomic effects on food prices and rural incomes, but growth could be too slow, too uneven, or too volatile to promote good nutrition, or it could result in changes in food consumption (for example, via relative price changes) that have little impact on nutrition (for example, by decreasing dietary diversity). At the household level, marginal food budget shares[3] determine the amount of extra income spent on food (potential leakage 1). The composition of the food budget then determines the total household intake of macro- and micronutrients (potential leakage 2). Then the intrahousehold division of nutrients determines individual food intake (potential leakage 3). Finally, individual food intakes partially determine anthropometric outcomes, with health, sanitation, and childcare and feeding practices being factors that may limit the efficiency of nutrient uptake (potential leakage 4).

Another important point of note in this framework is that we distinguish between the nutrition outcomes of children and those of mothers while also noting the positive relationship between the two. This distinction is important for several reasons. First, the nutritional outcomes of children (and even of adults) is largely determined in the first 1,000 days of life, from the womb to around two years of age. Hence the direct contribution of increased household incomes and household food availability to the nutrition outcomes of children under two *may* be somewhat muted, considering that breast milk is an important part of the diet of children under two and that their calorie requirements are relatively small (a one-year-old requires about 1,000 calories per day, much of which can come from breast milk). Second, the indirect linkages could be much stronger. In addition to the impact of household income on the mother's time use (via employment and education), maternal undernutrition is an important determinant of child undernutrition, especially in India (and South Asia in general), where birth weights are particularly low. Finally, although maternal undernutrition is important, several important outcomes of nutrition are still determined in the first few years of a mother's life (for example, her height). Hence the capacity to significantly improve maternal undernutrition over the short to medium term is quite limited because of the lagged effect between female infant nutrition and the eventual improvement in the

[3] For farmers, food budget shares are calculated after factoring in their own consumption.

nutritional status of mothers. Existing evidence does show that interventions on antenatal nutrition (for example, food or vitamin and mineral supplements for pregnant mothers) can have significant impacts on children's anthropometric outcomes (Bhutta, et al. 2010). While these technical issues are beyond the scope of this paper, it is important to bear them in mind in the discussion that follows. Indeed, as much as possible we try to distinguish between maternal and child undernutrition, and to explore the linkages between the two.

Figure 2.1—Explaining the agriculture-nutrition disconnect in India: Where are the leakages?



Source: Constructed by authors.
Note : SCTs refers to scheduled castes and tribes..

3. NATIONAL- AND STATE-LEVEL TRENDS IN INCOME, AGRICULTURAL PRODUCTION, AND NUTRITION: IS THERE REALLY A DISCONNECT?

India's overall economic growth pattern can broadly be categorized into two periods. During the state-led growth period running from independence to the mid-1980s, growth rates were sluggish, but the government did significantly contribute to the success of a Green Revolution in agriculture. Since the mid-1980s economic growth has accelerated, largely on the back of private sector–led growth in services and industry. Yet in this latter period the agricultural economy was largely unaffected by any new government policies or reforms, leading to mixed performance with private sector–led growth in some sectors (certain high-value foods) and regions, and a combination of government and private-sector neglect in others (pulses, coarse grains). The question we ask in this section is how this pattern of income and food production growth has influenced nutrition outcomes.

As befits its name, the Green Revolution transformed much of Indian agriculture over its heyday (1965–1985), eliminating the specter of large-scale famines and making national food security possible. Over that period irrigated area doubled, fertilizer use rose sixfold, yields in high-potential areas often increased fourfold, and national cereal production nearly doubled. But while the work of Freebairn (1995) and others generally showed quite favorable poverty impacts, many observers of the Green Revolution have become increasingly concerned about its environmental sustainability, particularly with regard to excessive use of water resources, fertilizers, and pesticides, all of which are related to government subsidies and weak regulatory systems (Hazell 2009). These factors—along with low international prices and some unfavorable weather—eventually led to stagnation in cereal production in India for most of the 2000s (see Table 3.1). Another important impact of the Green Revolution's focus on growth in cereals has been the relative decline of other food crops, notably pulses (Bhalla and Singh 2009). The national per capita availability of pulses, often called the "poor man's meat" in India, declined considerably, as shown in Table 3.1.

Table 3.1—Annual recent change in agricultural production, 1961–1985 and 1986–2008

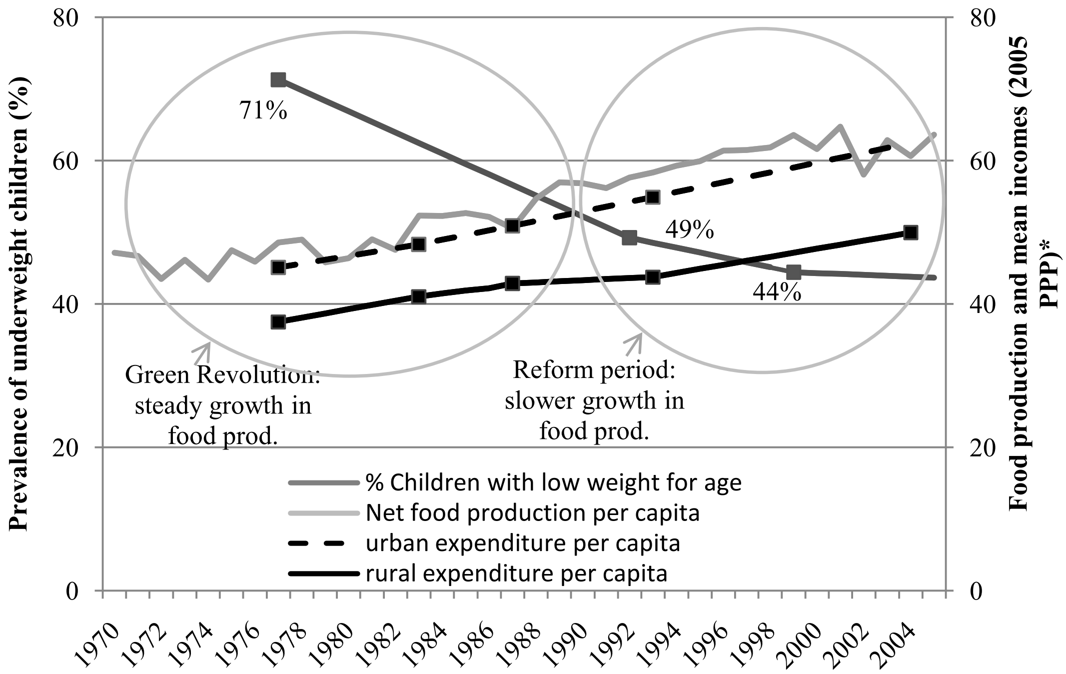
	Population[a]	*Cereals*[b]	*Coarse Grains*	*Pulses*	*Roots & tubers*	*Vegetables*[c]	*Fruits*[c]
1961–1985	2.8	3.8	0.5	-0.3	9.7	5.5	3.6
1986–2008	2.3	2.8	2.1	0.7	7.6	3.5	5.9
	Tree nuts	*Oil crops*[d]	*Fiber crops*[d]	*Eggs*	*Meat*	*Milk*	*Sugar*
1961–1985	6.0	2.3	2.3	17.6	3.6	4.8	2.3
1986–2008	8.1	5.2	4.9	8.5	5.1	6.2	4.7

Source: FAO (2009).
Notes: [a]. Average annual population growth during 1961–1985 averaged 2.8%, while over 1986–2008 it averaged 2.3%. [b]. Cereals are measured as milled rice equivalent. [c]. Vegetables include melons, which are excluded from fruits. [d]. Oil and fiber crops are related to primary production rather than processed.

As a result of the waning impact of Green Revolution technologies on cereal production and the acceleration of nonagriculture sectors, agriculture's role in the Indian economy has shrunk considerably. From 1995 to 2005, agricultural growth averaged around 2.5–3.0 percent per year while other sectors experienced average growth rates in excess of 6 percent per year from 1985 to 1999 and in excess of 7.5 percent from 2000 to 2008. As regards nutrition, this pattern of growth had two important features. First, from 1996 to 2003—a period very relevant for the second and third rounds of the NFHS (1998 and 2005, respectively)—growth in food production per capita—the major component of agricultural production—was characterized by extreme volatility and zero growth on average (after three decades of steady growth). Second, the much stronger growth in nonagriculture sectors was not labor-intensive and thus resulted in the so-called jobless growth phenomenon, which seems to partly explain why household survey data yield much lower income growth rates than national accounts data (Deaton and Kozel 2005).[4]

These two trends are depicted in Figure 3.1, which shows food production per capita, rural and urban expenditure per capita, and long-term child nutrition data. The data come with plenty of caveats (see the figure notes), but if anything they show relatively little disconnect between agriculture and nutrition at the national level: The underweight prevalence declined by around 22 percentage points over the Green Revolution period (1977–1992), but as food production per capita slowed in the 1990s, so too did nutritional improvements.

Figure 3.1—Trends in the prevalence of underweight children, per capita food production, and per capita expenditure



Sources: Nutrition data are from DHS (Measure DHS (2009) for the last three observations, while the National Nutrition Monitoring Bureau (NNMB) survey of 10 states (Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Gujarat, West Bengal, Orissa, Maharashtra, Uttar Pradesh and Madhya Pradesh) is the source of the 1975 observation (sourced from Smith and Haddad (2000)). Hence the 1975 observation should be treated with caution. Net food production data are from FAO (2009). Rural and urban expenditure data are from World Bank (2010) but are based on India's National Sample Survey (NSS).

Notes: * Food production per capita and expenditure per capita are both measured in 2005 purchasing power parity (PPP) units, but the former is the FAO's measurement of PPP whereas the latter is the World Bank's measure of PPP. However, we have rescaled the FAO data to be expressed in 2005 units.

In India, however, trends at the national level are uninformative at best, and deceptive at worst, because of regional heterogeneity. In this context growth and nutrition trends at the national level mask important variations across states and regions. In Table 3.2 we compare a range of indicators of economic progress with improvements in child and adult female nutrition. The economic indicators are total GDP per capita, agricultural GDP per agricultural worker and likewise for nonagriculture, and a wealth index constructed from the three NFHS surveys (IIPS 2000, 2007). Note that all indicators are measured as

[4] Another explanation is that survey data do not pick up the full rise in inequality because the data underrepresent the very rich (Banerjee and Piketty 2005, Deaton 2001).

percent changes, and for ease of interpretation, positive values always indicate progress, negative values regress. We then group together states with similar patterns of progress and regress on the agriculture–nutrition front.

Table 3.2—Comparison of economic progress with nutrition improvements: Percentage changes, 1992–2005

	Total GDP per capita	Agric. GDP per worker	Nonagric. GDP per worker	Wealth index-1[a]	Underweight children 0–3 years	Stunted children 0–3 years	Low-BMI women
Type 1: Modest or strong agricultural growth with significant improvement in one or more nutrition indicators							
Goa	93%	123%	29%	29%	14%	53%	39%
Kerala	99%	79%	44%	87%	-1%	38%	59%
Bihar	26%	74%	-24%	26%	3%	26%	-14%
Maharashtra	70%	66%	24%	33%	24%	18%	18%
H. Pradesh	89%	56%	8%	73%	15%	29%	9%
A. Pradesh[b]	92%	52%	49%	20%	27%	1%	16%
Tripura	138%	48%	166%	25%	13%	45%	-6%
Tamil Nadu[b]	92%	45%	63%	44%	31%	14%	18%
Assam	21%	29%	-26%	45%	24%	29%	-29%
Type 2: Modest or strong agricultural growth with little or no improvement in nutrition indicators							
M. Pradesh[b]	38%	72%	-12%	7%	-5%	13%	-6%
Sikkim[c]	39%	55%	-12%	4%	-16%	-7%	3%
Meghalaya	75%	29%	1%	24%	-15%	0%	76%
Nagaland	23%	29%	-27%	55%	-9%	-8%	5%
Gujarat	75%	27%	43%	40%	0%	5%	9%
Type 3: Poor agricultural performance with strong improvements in one or more nutrition indicators							
Uttar Pradesh	24%	16%	-2%	23%	23%	18%	3%
Karnataka	84%	8%	69%	23%	23%	21%	17%
J. & K.	35%	7%	85%	29%	45%	36%	2%
Punjab	33%	-1%	22%	25%	59%	29%	15%
Orissa	62%	-3%	53%	25%	17%	21%	18%
West Bengal[b]	85%	-3%	109%	17%	28%	12%	11%
Manipur	33%	-17%	124%	53%	12%	11%	25%
Type 4: Weak agricultural performance with mixed improvements in nutrition indicators							
Arun. Pradesh	47%	-16%	53%	26%	5%	34%	-36%
New Delhi	71%	-91%	67%	8%	26%	17%	-9%
Rajasthan	42%	5%	24%	42%	-11%	10%	5%
Haryana	74%	-17%	117%	17%	-12%	19%	-11%
Average	*62%*	*27%*	*42%*	*32%*	*13%*	*19%*	*10%*

Sources: Authors' calculations from IndiaStat (2010) and DHS (Measure DHS (2009) data on undernutrition and wealth. IndiaStat (Datanet India 2010) data are taken from various government sources.

Notes: All indicators are measured as percent changes between 1992 and 2005, or 1998 and 2005 in the case of adult BMI. Note that nutrition indicators are inverted so that positive values represent reductions in undernutrition. [a.] Wealth index-1 is an equally weighted average of the ownership of various household durables. [b]. Stunting in these states is measured from 1998 to 2005 only, since data were not available for 1992. [c.] All data for Sikkim pertain to 1998–2005 because Sikkim was not included in the NFHS-1 survey for 1992/93.

For example, in the first group we observe nine states that experienced fairly rapid agricultural growth and significant improvement on the nutritional front (that is, states where there is no obvious disconnect). The larger states in this group include Andhra Pradesh, Maharashtra, and Tamil Nadu. Note, however, that even in this group improvements were not uniform across nutrition indicators. Andhra made no improvement against child stunting, Kerala made no improvement against underweight prevalence in children, and Assam and Bihar apparently experienced a sharp increase in the prevalence of women with a low body mass index (BMI).

In the second group we find five states with strong to moderate agricultural growth and very poor nutrition outcomes—states where there is apparently a disconnect between agricultural progress and nutritional progress. This group includes Madhya Pradesh and Gujarat. We note, however, that the disconnect in these states from 1998 to 2005 was particularly sharp. In Gujarat agricultural GDP per worker increased by 17 percent from 1998 to 2005 while the prevalence of underweight children rose by 5 percentage points over that period (from 45.1 percent to 50.1 percent) and stunting rose by 2.3 percentage points (from 43.6 percent to 45.9 percent). Only female BMI improved slightly over this more recent period in Gujarat. We also note that Gujarat experienced strong growth in the nonagriculture sector (particularly manufacturing). In Madhya Pradesh agricultural GDP per worker grew by 40 percent but, as in Gujarat, the prevalence of underweight children increased by around 5 points and the prevalence of females with low BMI scores increased by about 3 points. Only stunting prevalence witnessed an improvement, on the order of 6 points. However, in contrast to Gujarat, the nonagriculture sector in Madhya Pradesh actually performed very poorly over this period (except for Gujarat, this was also true of all other states in this group).

The third group also presents further evidence of a weak association between agricultural growth and nutrition, but of the opposite variety: weak or even negative agricultural growth accompanied by strong nutritional improvements. This group includes some of India's largest states, such as Uttar Pradesh, West Bengal, Orissa, and Karnataka. Interestingly, nonagricultural growth rates were generally quite strong in this group, the only real exceptions being Uttar Pradesh and Punjab. Finally, the fourth group includes two states—Haryana and Rajasthan—characterized by very poor agricultural outcomes and very mixed nutrition outcomes, namely some modest progress against stunting but a losing battle against underweight prevalence.

In Table 3.3 we repeat this exercise for food grain production instead of agricultural growth. In other words, we are omitting the cash crop sector and including higher-value food products. A justification for this might be that improvements in non-grain agricultural products have less impact on calorie intake, especially in rural areas (though not necessarily on dietary diversity). Indeed, the little existing research on the impact of commercialization on nutrition gives a rather gloomy picture on this front (von Braun 1995). The issue is also important in the Indian context because some states have experienced very strong growth in cash crops with little or no growth in staple grains. Indeed, a notable feature of Table 3.3 is that it looks rather different from Table 3.2. This is because the correlation between agricultural growth and growth in grain production across Indian states is actually negative (and significant, at -0.45). This also changes our picture of the disconnect. For example, in Table 3.2 we saw that Gujarat and Madhya Pradesh have had strong overall agricultural growth and no nutritional improvements, but in Table 3.3 we see that both states had very weak performance in grain production (Gujarat's agricultural growth, for example, has been driven by rapid growth in cotton production and some higher-value foods). Indeed in Table 3.3 the only sizable state in which there is a disconnect between grain production performance and nutritional improvements is Haryana. Conversely, some states with weak agricultural performance overall have shown quite healthy performance in grain production, including West Bengal, Uttar Pradesh, Orissa, and Karnataka. And in both tables we still see that neither agricultural growth nor grain production growth looks like a necessary condition for nutritional improvement in India: There are a number of states with relatively weak agricultural performance that still saw improvements in nutrition (although this is not to say that faster agricultural growth could not lead to faster improvements on the nutrition front).

Table 3.3—Comparison of growth in grain production with nutritional improvements: Percentage changes, 1992–2005

	Grain production	Underweight children 0–3 years	Stunted children 0–3 years	Low-BMI women
Type 1. Strong growth in grain production and significant nutritional improvements				
Karnataka	58.7%	18.6%	17.4%	14.2%
Andhra Pradesh[a]	45.4%	21.4%	1.0%	13.9%
Manipur	43.7%	11.0%	9.8%	19.9%
Orissa	24.5%	14.6%	17.4%	15.0%
West Bengal[a]	26.0%	21.8%	11.1%	9.8%
Punjab	25.9%	37.0%	22.3%	13.3%
Type 2. Moderate growth in grain production and significant nutritional improvements				
Arunachal Pradesh	23.9%	5.0%	25.6%	-55.6%
Mizoram	23.9%	7.8%	16.9%	24.0%
Tripura	23.8%	11.3%	31.1%	-6.1%
Bihar	17.3%	2.9%	20.5%	-16.4%
Uttar Pradesh	15.9%	18.8%	15.0%	3.3%
Type 3. Strong growth in grain production and mixed nutritional improvements				
Haryana	26.8%	-13.7%	15.6%	-12.7%
Meghalaya	26.1%	-17.4%	-0.2%	43.1%
Type 4. Modest growth in grain production and no nutritional improvements				
Gujarat	13.8%	0.0%	4.8%	8.4%
Sikkim[b]	10.6%	-18.9%	-7.9%	3.2%
Type 5. Stagnation in grain production and significant nutritional improvements				
J. & K.	7.1%	31.0%	26.5%	1.7%
Goa	7.0%	12.3%	34.8%	28.2%
Assam	6.7%	19.0%	22.4%	-39.9%
Himachal Pradesh	-1.5%	13.0%	22.3%	8.6%
Maharashtra	-13.9%	19.6%	15.3%	15.4%
Tamil Nadu[a]	-26.7%	23.9%	12.6%	14.9%
Kerala	-42.5%	-1.1%	27.4%	37.2%
Type 6. Stagnation or regress in grain production and little nutritional improvement				
Rajasthan	-0.3%	-11.8%	9.0%	4.5%
Madhya Pradesh	-21.9%	-5.1%	11.8%	-6.7%
Average	*13%*	*9%*	*16%*	*6%*

Sources: Authors' calculation from Reserve Bank of India (2010) and DHS (Measure DHS (2009) data on undernutrition and wealth.

Notes: All indicators are measured as percent changes between 1992 and 2005, or 1998 and 2005 in the case of adult BMI. Note that nutrition indicators are inverted so that positive values represent reductions in undernutrition. [a]. Stunting in these states is measured from 1998 to 2005 only, since data were not available for 1992. [b]. All data for Sikkim pertain to 1998–2005 because Sikkim was not included in the NFHS-1 survey for 1992/93.

Based on Tables 3.2 and 3.3, it would not be surprising to find that more sophisticated econometric tests unearth few significant associations between agricultural growth rates and changes in undernutrition. But to explore this more thoroughly we carried out a barrage of tests for the three anthropometric indicators and seven measures of welfare changes, including three agricultural measures (Table 3.4). In each test we regressed the percent change in the anthropometric indicators (g_n) over 1992–1998 and 1998–2005 (except for adult female BMI, which includes only one wave, from 1998 to 2005) against percent changes in the welfare indicators (g_w), as well as initial undernutrition (n_0):

$$g_n = b_0 + e_w g_w + b_n n_0 + \text{residual}. \tag{1}$$

Since nutrition and welfare changes are measured in percentage terms, the derived coefficients are elasticities, or percent changes in anthropometric outcomes resulting from a one percent change in a welfare indicator.[5] However, because we wish to test both agricultural and nonagricultural growth, we also run a variation of this model based on share-weighted growth rates, or the "participation effects" of each sector. Basically, the idea is that the growth rate of each sector ought to be weighted by its share in GDP or employment. Otherwise, agricultural growth in New Delhi would be expected to have the same impact on nutrition as agricultural growth in Bihar. Hence we run two variations of this model. In the first, agricultural GDP per agricultural worker and nonagricultural GDP per nonagricultural worker are weighted by agriculture's initial share of total employment in each state. In the second, agricultural and nonagricultural GDP per capita are weighted by agriculture's initial share of GDP in each state. This second model therefore take the following form:

$$g_n = b_0 + e_w s_a g_{wa} + e_w s_n g_{wn} + b_n n_0 + \text{residual}, \qquad (2)$$

where *s* is the share of agriculture (subscript *a*) or nonagriculture (subscript *b*) in employment or GDP, and subscripts *wa* and *wn* denote agricultural and nonagricultural welfare indicators, respectively.

Table 3.4—Estimated elasticities between undernutrition and welfare indicators based on regressions in percentage differences (medium run effects)

			Dependent variables		
Model	Weight	Welfare indicator	Underweight	Stunting	Low BMI, women
(1)	None	Wealth index	0.24	0.09	-0.45#
(1)	None	Land productivity	0.03	0.03	-0.29
(1)	None	GDP per capita growth	0.17	0.08	-0.63#
(2)	Employment	Agric. GDP per worker	-0.10	-0.20#	-0.44*
(2)	Employment	Nonagric. GDP per worker	-0.08	-0.14#	-0.29*
(2)	Value-added	Agric. GDP per capita	0.13	-0.01	-0.20
(2)	Value-added	Nonagric. GDP per capita	0.05	-0.03	-0.04
	No. Obs.		47	45	25

Source: All macroeconomic indicators are from IndiaStat (2010), while the (2009) are the source of data on undernutrition and wealth. Wealth index is the DHS wealth index (Measure DHS 2009 provides details).
Notes: These are ordinary least squares (OLS) at the state level for percent changes in two periods (1992–1998 and 1998–2005), except in the case of adult female BMI, which pertains only to the latter period. Land productivity is the value of agricultural output per hectare. Per worker denotes workers in agriculture or nonagriculture, respectively, while per capita denotes the total state population. See the accompanying text for more details. *, **, and *** indicate significant differences from zero at the 10%, 5%, and 1% levels, respectively, and # indicates marginal insignificance at the 10% level. Standard errors were adjusted for heteroskedasticity and significant outliers were removed, although outliers did not materially influence results. Elasticities are indicated at mean levels. In the case of agricultural employment shares, the mean level over 1992 and 1998 was 0.57. Also note that a Wald test for differences between the coefficients on nonagricultural GDP per worker and agricultural GDP per worker did not indicate a statistically significant difference.

Table 3.4 shows that only in the case of the prevalence of low-BMI adult women do welfare indicators seem to have a consistent and significant association with changes in undernutrition, and this despite the very small sample (just 25 observations). Apart from the female BMI measure, stunting indicates some possible connection with sectoral growth rates, but the elasticities are very low and only marginally significant. So at best, it would appear that economic growth is only consistently important for adult nutrition (in a very small sample).[6] This may not be so surprising given that child nutrition is

[5] See Heltberg (2009) for analogous regressions of equation (1) at the cross-country level in the growth–nutrition context. For analogous regressions of equation (2) see Christiaensen, Demery, and Kühl (2006).

[6] Note that we also ran several variations of these regressions. For example, we used changes in rural malnutrition as the dependent variable, under the assumption that agricultural growth might matter only for rural populations. We also included the

determined less by sheer food consumption and more by prenatal and infant health and care practices (Victora, de Onis, Curi Hallal, Blössner and Shrimpton 2009).

On the other hand we obviously need to stress the limitations of these regressions. For one thing, the sample sizes are very small. For another, tests for the effects of changes in health and sanitation variables (not reported) also tended to yield mostly insignificant coefficients (fertility rates being a key exception), and obviously Table 3.4 suggests that the disconnect with nonagricultural growth is just as prominent. Similarly, a recent study by Subramanyam and colleagues (2011) also found a weak association between overall economic growth and nutrition, while Headey (2011) found that agricultural growth improves nutrition in all developing regions except Indian states. So as a basic set of stylized facts, Tables 3.2, 3.3, and 3.4 at least provide enough grounds to believe that there could indeed be a number of leakages between agricultural growth (and overall income growth) and child nutrition.

A final note: It is sometimes claimed that agriculture and nutrition are linked because states with higher agricultural productivity (as measured by yields or value per hectare) tend to have lower undernutrition. In Table 3.5 we show that this is indeed the case for agricultural GDP per agricultural worker, overall GDP per capita, and the DHS asset poverty index. However, nonagricultural GDP per nonagricultural worker has an insignificant relationship with the nutrition indicators, and grain output per capita has a perverse positive relationship. Household survey data in India also show that undernutrition decreases as income or wealth increases (Himaz, Galab and Reddy 2008, Kanjilal, et al. 2010). But even if an income indicator does possess the expected sign and statistical level of significance, a cross-sectional relationship between income or wealth and undernutrition is of no use in gauging the impacts of growth over the medium term, because cross-sections—at best—represent long-run outcomes. At worst, a cross-section does not indicate any causality whatsoever because of serious endogeneity problems, including reverse causation (that is, nutrition outcomes can improve agricultural productivity). This is why the regressions above focus on changes in nutrition and changes in agricultural incomes, rather than levels-on-levels regressions.

Table 3.5—Cross-sectional correlations between economic indicators and undernutrition outcomes (long-run relationships)

	GDP per capita	Nonagric. GDP per capita*	Agric. GDP per capita*	Asset poverty	Grain output per capita*
Low BMI, women	-0.28	-0.16	-0.31	0.18	0.18
Stunting	-0.49	-0.09	-0.46	0.42	0.44
Underweight	-0.38	-0.16	-0.36	0.29	0.19

Sources: Authors' calculation from Reserve Bank of India (2010) and DHS (2009).

Notes: *Nonagricultural and agricultural GDP per capita are sectoral outputs relative to sectoral employment estimates. Grain output per capita is the logarithm of grain output per capita.

volatility of growth rates as a control variable. Neither of these alterations produced significant results, although we did find that nonagricultural growth had a negative and marginally insignificant effect on changes in rural stunting prevalence.

4. AGRICULTURE'S INFLUENCE ON HOUSEHOLD FOOD CONSUMPTION PATTERNS

Food consumption patterns obviously directly determine the intakes of macro- and micronutrients, which in turn are a key determinant of nutrition outcomes, along with health-related factors. However, at the outset it is important to reiterate that household food consumption patterns may not equate to the dietary patterns of children, as we stressed in Section 2. So in this section we first focus on the overall dietary situation in India and its relationship to market trends and other factors, turning then to the more narrow question of the diets of young children.

The Causes and Consequences of Dietary Changes in India at the National Level

Bearing these caveats in mind, in this section we try to trace the causes and consequences of India's dietary changes. The significance of changes in the Indian diet obviously depends on the initial status of that diet, specifically the nature of dietary deficiencies in India. The Indian diet has always been deficient in both macro- and micronutrients and highly undiversified. In terms of macronutrients, calorie, protein, and fat deficiencies are all important sources of undernutrition. Using data for 1995 and normalizations for wasting and stunting, Hopper (1999) estimated that while calorie deficiencies were *relatively* small, with average calorie deficiency just 25 percent below requirements, protein deficiencies were just 58 percent of requirements, while fat intake for children was 30–50 percent of recommended levels. Micronutrients are obviously also important for both physical and cognitive development, and recommend levels of vitamins for young children in India are generally a small fraction of recommended levels.

Given the multiple dimensions of dietary deficiencies in India, it is an open question as to whether the average Indian diet has improved or deteriorated over the last 25 years. Data from India's National Sample Survey (NSS) and National Nutrition Monitoring Bureau (NNMB) show declining calorie and protein intakes over the last 25 years (Deaton and Dreze 2008), but FAO (FAO 2009) data show a slight increase. It is actually difficult to gauge which source is correct. FAO data have well-known weaknesses (for example, it is very difficult to estimate wastage), but household survey data could also miss important trends, such as the increasing amount of food consumed outside of the home. However, all three data sources show large increases in fat consumption. Indeed, FAO data show a 27 percent increase from 1990 to 2007, while NSS data show a 40 percent increase from 1989 to 2005.

What explains these patterns and trends? There is a wide variety of econometric analysis of dietary changes, much of it focused on deriving calorie elasticities.[7] However, a more direct method of understanding the changes underlying these trends is to first look at the proximate causes of changes in macronutrient consumption by linking nutrient availability changes back to changes in various food items. To that end, in Table 4.1 we use the FAO food balance sheets (FAO 2009), which show changes in quantities of individual food items and food groups, as well as total changes, in terms of calories (kilocalories per capita per day), proteins (grams per capita per day), and fats (grams per capita per day). FAO data confirm the well-established fact that coarse grains are chiefly responsible for the decline in cereal consumption and calorie availability as a whole, although rice consumption has also declined somewhat. Wheat consumption has increased, and there have been modest contributions from vegetable oils as well as fruits and tree nuts. In terms of protein availability, coarse grains and rice are again responsible for the largest declines, while increased wheat and milk consumption have counterbalanced this somewhat. However, over the longer run (1960–2007) the 50 percent decline in pulse consumption is the largest driver of decreased protein availability, closely followed by coarse grains. Indeed if pulse and

[7] It should be pointed out that there are major inconsistencies between different sources of data on food consumption trends. Neither FAO, NSS, nor NNMB produce estimates that are fully consistent with each other in levels or in trends, and in some instances the differences are staggeringly large. Moreover, NNMB data suggest that intake of a number of micronutrients has declined in recent decades, including calcium, iron, thiamin, niacin, and folic acid (GOI 2007).

coarse grain consumption had remained at 1960 levels, then daily intake of protein would be more than 10 grams (or 17 percent) higher than current intakes. Increased fat consumption is chiefly driven by increased consumption of vegetable oils and animal fats (butter and ghee). The bottom of Table 4.1 also shows that these patterns have resulted in moderate increases in dietary diversity, as measured by the declining share of cereals in total energy and protein intake, and the rising share of animal fats in total fats.

Table 4.1—Changes in average individual food consumption at the national level, 1990–2007

	Calories (kcal/day or %)	Protein (grams/day or %)	Fats (grams/day or %)
All food items, percent change	5.9%	7.1%	21.3%
All food items, change	132	3.8	8.5
All vegetal products	94	2.2	5.8
All animal products	38	1.5	2.5
Changes in individual food groups			
All Cereals	-10	0.6	-0.4
Wheat	**159**	**4.6**	0.7
Rice	**-78**	**-1.5**	-0.2
Coarse grains	**-90**	**-2.5**	-1.0
Pulses	-3	-0.2	0.1
Starchy roots	11	0.3	0.0
Fruits & tree nuts	**28**	0.4	0.4
Oil crops	10	0.8	0.6
Vegetable oils	**46**	0.0	**5.1**
Meat	-4	-0.3	-0.2
Animal fats (butter, cream)	**33**	0	**3.7**
Milk	4	**1.2**	**-1.3**
Eggs	4	0.3	0.3
Fish, seafood	3	0.4	0.1
Sugars, spices, stimulants, alcohol, other	7	0	0
Indicators of dietary diversity			
Cereals as share 1990	63.4%	61.0%	16.0%
Cereals as share 2007	59.4%	58.0%	12.4%
Animal fats as share of total fats, 1990			26.8%
Animal fats as share of total fats, 2007			37.6%

Source: Authors' calculation from FAO (2009) food balance sheets.

Since the dietary changes in question pertain to just a handful of food groups, it is relatively easy to dig deeper for explanations of consumption and production trends for specific foods, albeit in a nonrigorous fashion. In the case of calorie and protein changes, for example, Table 4.1 shows that this is chiefly due to the decline in consumption of coarse grains. Although coarse grains are more nutritious than rice or wheat, the switch away from coarse grains largely pertains to taste (such grains are often called "inferior cereals" for this reason), since rice and wheat are invariably preferred to coarse grains, especially in India. Taste—together with rising income—also accounts for much of the switch toward greater fat consumption.

A second explanation for why calorie consumption might have declined is the declining calorie requirements of the Indian population due to the substitution of mechanical power for human power, and the occupational shift from agriculture to less arduous, nonagricultural jobs (Deaton and Dreze 2008, Rao 2000). Table 4.2 shows how profound are some of the technological changes that have taken place in India by presenting the number of households reporting ownership of goods or access to improved infrastructure that may have substituted for human calorie expenditure from 1992 to 2005. Some of these changes are large indeed. In rural areas alone, television ownership increased by 20 percentage points, bicycle ownership by 12 points, motorcycle ownership by 7 points, flush toilet ownership by 13 points, access to electricity by 17 points, and access to piped water by almost 9 points. The figures for urban areas are commensurately large or larger, except in the case of electricity and piped water (since urban access was already high in 1992). The mechanization of agriculture has also been a prominent trend (although rates of mechanization vary across regions). Athreya and colleagues (2008) reported that the number of tractors per 1,000 hectares increased from 0.7 in 1971/72 to 13.8 in 2000/01 and power tillers per 1,000 hectares from 0.010 to 0.65. And while the number of tractors and tillers is still low relative to the total population employed in agriculture, these machines are typically shared or rented, so their potential to have reduced calorie requirements is substantial, at least in the more mechanized areas of rural India.

Table 4.2—Percentage of indian households reporting ownership of assets or access to infrastructure, 1992–2005

	Rural areas			Urban areas			Possible channels of impact
	1992	*2005*	*Change*	*1992*	*2005*	*Change*	
Television	8.9	30.1	21.2	51.7	73.2	21.5	More sedentary lifestyle
Telephone[a]	2.5	8	5.5	20.1	26.7	6.6	Substitute for travel
Refrigerator	1.7	6.6	4.9	20.1	33.5	13.4	Reduced cooking and shopping requirements
Bicycle	39.7	51.6	11.9	47.5	50.1	2.6	Substitute for walking
Motorcycle	3.8	10.8	7	19.2	30.5	11.3	Substitute for walking, cycling
Private car	0.3	1	0.7	3.2	6.1	2.9	Substitute for walking, cycling
Piped water	19.3	27.9	8.6	69.5	71.1	1.6	Less energy for fetching water; better health = better appetite and calorie absorption
Time to water, minutes	6.2	4.7	-1.5	0	0	0	Less energy for fetching water
Flush toilet	6.9	20	13.1	60.1	78.7	18.6	Better health = better appetite and calorie absorption
Electricity	38.7	55.7	17	82.8	93.1	10.3	Substitute for collecting fuel

Source: DHS (2009).
Note: [a.] Telephones are actually measured for 1998 because data were not available for 1992.

The occupational shift out of agriculture is also important. Agriculture's share of total employment dropped from about 65 percent in 1991 (just before NFHS-1) to about 55 percent in 2006 (at the end of NFHS-3), whereas for the previous decade (1981–1991) the employment structure of the Indian economy was essentially unchanged. Table 4.3 shows that in rural areas male agricultural employment dropped from 79.2 percent of total employment in 1981 to just under 66 percent in 2006. Deaton and Dreze (2008) noted this shift but argued that "the shift out of agriculture within the rural sector has been modest" (p. 52) and therefore too small to account for the calorie decline. Yet below we show that this shift has had impacts that are far from insignificant, potentially reducing the calorie requirements for rural males by around 3 percent. Moreover, if we attempted to crudely factor in the effects of the mechanization and more sedentary lifestyles, then it is easy to show that all of these changes could plausibly account for any apparent decline in calorie consumption. If FAO data are used as an alternative measure of calorie consumption, then adjusting daily calorie requirements for rural males would show that calorie deprivation has even decreased in the last few decades, as one would expect given the significant growth in incomes observed in India.

Table 4.3—Could occupational shifts and technological changes explain declining calorie consumption among rural men?

	Workforce structure	Calories consumed: Alternative sources		Recommended daily allowances (RDAs) adjusted for lifestyle changes[b]		Calories consumed as ratio to adjusted RDAs	
	Agriculture jobs (% total rural jobs)	Calories consumed (kcal/day): FAO,[c] all areas	Calories consumed (kcal/day): NSS, rural	Scenario 1: Occupation shift only	Scenario 2: Occupation shift, mechanization of agriculture, other lifestyle changes	Scenario 2: FAO calorie data	Scenario 2: NSS calorie data
1981	79.2%	2,045	2,240	3,284	3,284	68.2%	62.3%
1991	77.5%	2,341	2,153	3,271	3,199	67.3%	73.2%
2001	69.7%	2,294	2,018	3,213	3,077	65.6%	74.6%
2006[a]	65.7%	2,313	2,047	3,183	3,018	67.8%	76.6%
Change 1981–2006	*-16.9%*	*+13.1%*	*-8.6%*	*-3.1%*	*-8.1%*	-0.6%	+23.0%

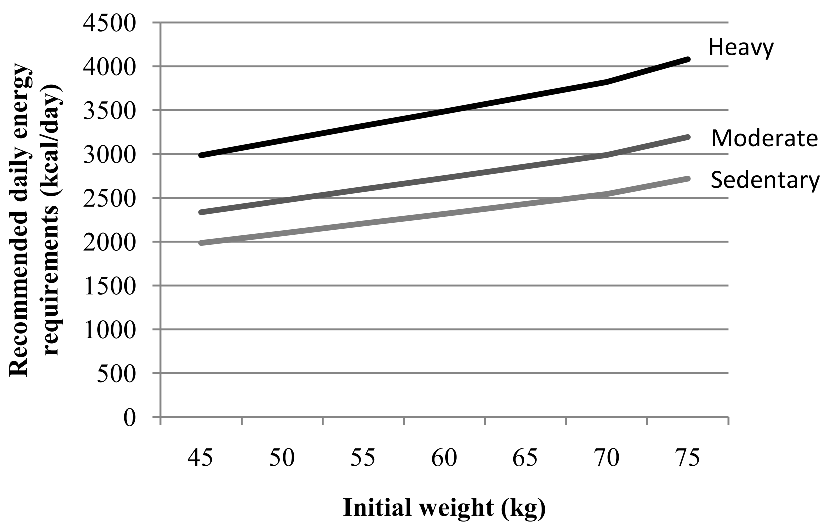
Source: Occupational data refers to primary occupation only and is drawn from IndiaStat (2009). Calorie consumption data is drawn from Deaton and Dreze (2008). Calorie requirements for "heavy" agricultural workers and "moderate" rural nonfarm workers are drawn from the ICMR and NIN guidelines (ICMR/NIN 2008), annexure 4.1).

Notes: [a.] 2006 estimates of the agricultural workforce ratio are based on linear projections of the 1991–2001 trend. [b.] Scenario 1 estimates calorie requirements as the weighted average of agricultural and rural nonfarm calorie requirements, with weights equal to the share of agricultural versus nonagricultural jobs (column 1). We assume that nonagricultural workers have "moderate" calorie requirements of 2,490 kcal per day, while agricultural workers have "heavy" calorie requirements of 3,440 kcal per day. Both values pertain to a typical rural male weighing 60 kg and of median age. Scenario 2 estimates assume the same as 1 but also assume that mechanization of agriculture and other technologies (for example, cars, electricity) reduce calorie requirements for agricultural workers by 2.5% per decade, while nonagricultural technologies reduce calorie requirements of nonagricultural workers by 1% per decade.

Specifically, what we do in Table 4.3 is to estimate how daily calorie requirements (or recommended daily allowances, RDAs) might have changed over time. We assume that rural nonfarm workers have "moderate" calorie requirements of 2,490 kilocalories per day while agricultural workers have "heavy" requirements of 3,440 kilocalories per day (see the notes on Table 4.3 for more details), based on the recent revision of daily calorie requirements by the Indian Council of Medical Research and India's National Institute of Nutrition (ICMR/NIN 2008). This differential, together with the occupational shift out of agriculture, suggests that calorie requirements could have gone down by 3.1 percent for rural males (column 4, Table 4.3). In a second scenario we assume that calorie requirements also declined for agriculture workers by 1.5 percent per decade due to mechanization, and that both farm and nonfarm workers' calorie requirements declined by 1 percent per decade due to other technologies (for example, electrification, improved transport, infrastructure, telephones, and other technologies reported in Table 4.2). Incorporating these admittedly arbitrary assumptions suggests that calorie requirements could have fallen by 8.1 percent from 1981 to 2006, which is roughly the same as the 8.6 percent drop in calorie consumption observed in the NSS. This therefore leaves the ratio of calories consumed to calories required unchanged between 1981 and 2006. Moreover, if one prefers the FAO's estimates of calorie consumption (which are available only for all India rather than restricted to rural areas) then the ratio of calories consumed to calories required increases significantly.

It is important to emphasize that the assumptions and calculations made in Table 4.3 are obviously only conjectures: We make no claims regarding their accuracy. Nevertheless these back-of-the-envelope calculations demonstrate that estimates of calorie deprivation—in both levels and trends—are extremely sensitive to assumptions about recommended daily allowances (RDAs). These RDAs are updated only infrequently (before 2008 the last update in India took place in 1988) and with relatively sparse information on the key variables of interest. Even so, the updates do matter. For example, the recent ICRM and NIN (2008) assessment found that the adjustment made for heavy work in the 1988 guidelines was excessive, such that the more recent guidelines downgraded that adjustment by around eight percent. But even if the levels are accurate, there is very little information on how many Indians are actually engaged in heavy, moderate, or sedentary work, and what little data there is suggests that relatively few Indian workers are engaged in "heavy" work (Borgonha, Shetty and Kurpad 2000). This could mean that estimates of hunger levels over-apply the heavy work calorie requirements, thus overestimating calorie deprivation in India. That data gaps on actual energy expenditures are important is evident from Figure 4.1: There is a huge difference between the energy requirements of "heavy" workers and "moderate" workers, so allocating individuals into these categories in an accurate manner is essential for deriving plausible estimates and trends in calorie deprivation.

Figure 4.1—How male calorie requirements vary with weight and activity levels



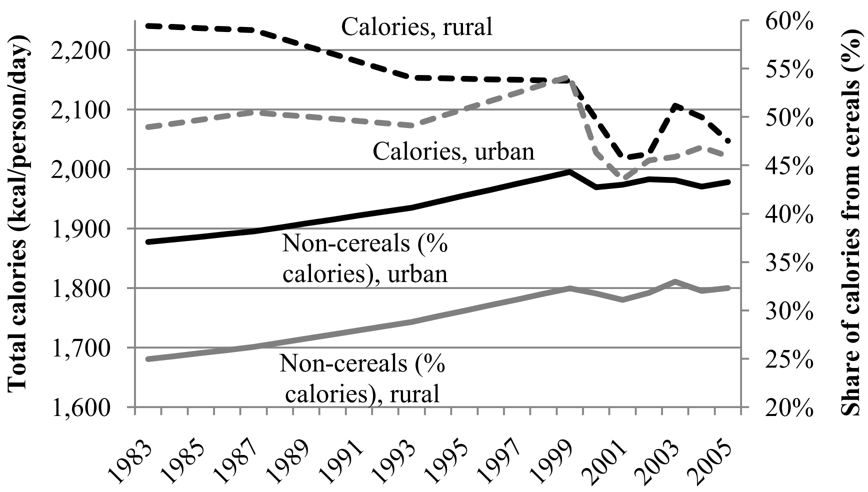
Source: ICRM and NIN (2008), annexure 4.1), guidelines for adult males aged 18–30 years.

Figure 4.1 also points to another challenge in measuring calorie deprivation in surveys that do not record the weights of individuals, such as the NSS surveys. Figure 4.1 shows that calorie requirements vary greatly by body weight. For example, a man weighing 50 kilograms needs 10 percent fewer calories than one weighing 60 kilograms (Figure 4.1). Yet when measuring calorie deprivation for individuals in a household survey it is common practice to compare individual calories to the calorie requirements for men of mean weight (for example, 60 kilograms). But since many Indians are underweight because of their short stature—which is a product of malnutrition in early childhood rather than in adulthood—these Indians are classified as undernourished because their calorie consumption falls short of RDAs that apply to heavier individuals. Yet for these lighter individuals their observed calorie consumption could be adequate for their height. This mismeasurement of calorie-based indicators of undernutrition is not just important from a methodological standpoint, but it also reinforces the existing bias toward calorie-based solutions to India's malnutrition problem, rather than a more comprehensive list of early childhood factors, of which sufficient calorie intake is just one. [8]

[8] It is beyond the scope of this paper to go in substantive details on why calorie deprivation is not well measured in India, but the list of reasons for why this might be the case is extensive, and includes these: the increasing calorie content of foods; the decision to use RDAs instead of estimated average requirements, which are much lower; the fact that calorie requirements are not fully adjusted for body size and skeletal mass, both of which are generally lower in India than in other parts of the world; the fact that calorie expenditure might have decreased due to improved thermoregulation (improved heating in winter and more use of fans and air conditioners in summer); and a reduction in the caloric penalty due to declines in infectious morbidity and better treatment of infectious illnesses. One indirect piece of evidence that would seem to support these observations is that the prevalence of overnutrition—and related morbidities—is increasing rapidly in India, even in rural areas. These factors could mean that the calorie requirements used for the last four decades in India were too high then and are too high now. This is not to

More theoretical and empirical support for the relative unimportance of declining calorie consumption in India comes from Jensen and Miller (2010). They argue that the non-calorie share of staple foods (such as cereals) is a better indicator of nutrition-relevant welfare that calorie intake. Their argument is twofold. First, calories are a poor indicator because calorie requirements are unobservable (as we discuss above), especially at the individual level. Second, if a person's calorie requirement (or "hunger") is reduced then he/she will switch from cheaper to more expensive (tastier) sources of cereals. Conversely, a switch to more expensive sources of calories reveals declining hunger. In Figure 4.2 we show calorie trends in rural and urban India along with the share of calories sourced from non-cereals. As one would these two series show opposite trends for both rural and urban populations.

Figure 4.2—Trends in average calorie intake versus trends in non-cereal calorie shares

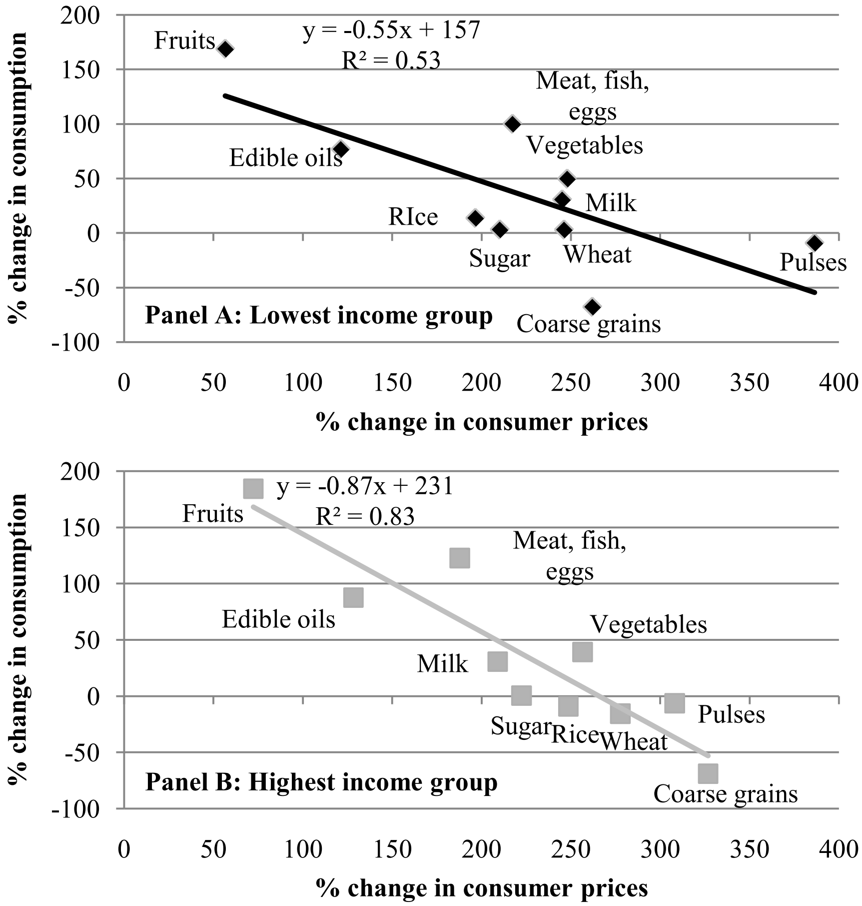


Source: Authors' construction from NSS data sourced from Deaton and Dreze (2008).

Another explanation of India's dietary changes is changes in prices, which are in turn related to a variety of government policies. While Deaton and Dreze (2008) established that food prices as a whole did not change much relative to nonfood prices, the prices of individual food items have changed relative to each other. Jha and Gaiha (2010) and Mittal (2007) showed that various own- and cross-price elasticities for food groups are statistically significant, but what specifically needs explanation is how price changes have produced some of the specific dietary outcomes discussed in Table 4.1, such as the decline in pulse and coarse grain consumption, and the increased consumption of animal fats, vegetable oils, dairy, and fruits. Figure 4.3 shows that that there is a very strong relationship between changes in the prices of various food items from 1983 to 1999/2000 and changes in consumption of those items. The relationship is particularly strong for the highest-income group in India, with a correlation of 0.90. The slope coefficients are also suggestive of highly price-elastic consumption patterns in India. Moreover, the scatter shows that nominal food price changes were lowest for fruits followed by edible oils (consumption of which increased fastest), and greatest for coarse grains and pulses (consumption of which declined or stagnated). Perhaps because of measurement error, great dependence on food in kind, own-farm consumption, and the public distribution system (PDS) for rice and wheat, the correlation for the lowest income groups is weaker (0.73), but still highly significant. Poorer households also consumed slightly less coarse grain than expected (perhaps because of poor flavor and regional factors) and slightly more pulses than expected.

say that undernutrition is not a problem, merely that levels and trends in this data are likely to be somewhat inflated. We thank Professor H. P. S. Sachdev for these insights.

Figure 4.3—Changes in consumption and prices for the lowest and highest income groups, 1983–2000

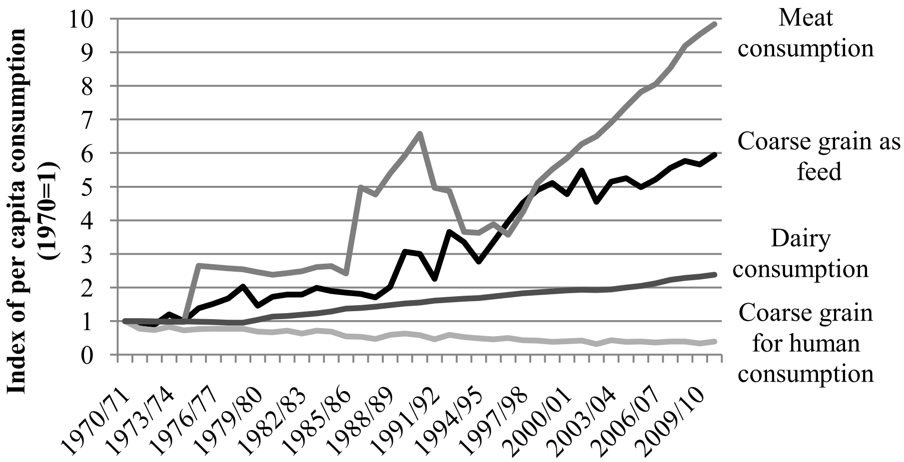


Source: Authors' calculations from NSS data reported in Kumar and Mruthyunjaya (2007).

Of course, price changes tell only a superficial story: Demand- or supply-side factors are the deeper explanation of the price changes themselves. In the case of rice, wheat, coarse grains, and pulses—which are relatively close substitutes—there are good grounds to think that policies have played a critical role in driving relative price changes. For pulses, Tuteja's (2008) in-depth study of government policies toward pulses showed that both lack of investment and a policy bias toward wheat and rice (for example, large allocation of research and development funds, fertilizer and water subsidies, and inclusion of rice and wheat in the PDS) led to the marginalization of pulse production in India, even though India has a comparative advantage in pulses.

Coarse grains suffered a somewhat similar fate, with less promising research and development and greater dependence on rainfed agriculture. But another likely factor in the relatively steep rise in coarse grain prices is the greater use of coarse grains in the production of livestock. This in itself stems from rising incomes and the increased demand for higher-value foods, such as meat and dairy products. Figure 4.4 shows trends in coarse grain use and meat and dairy consumption from 1970 to 2009, with each indicator measured relative to its 1970 levels. While coarse grain consumption by humans decreased by 50 percent from 1970 to 2001, coarse grain use as feed increased by 500 percent, largely as a result of increased consumption of meat (which increased tenfold) and, to a lesser extent, dairy (which increased by 240 percent). In conjunction with inferior taste, the steeper rise in coarse grain prices relative to rice and wheat prices (see Figure 4.2) must have rendered coarse grains increasingly unattractive to the average Indian consumer. There is arguably also an important regional story in regard to consumption of coarse grains, since they are grown mostly in drier, rainfed areas, and since four states—Gujarat, Rajasthan, Maharastra, and Karnataka—consume much more of them than do other states (Kumar and Mruthyunjaya 2007). However, research to date does not seem to have explored regional variation in cereal consumption trends.

Figure 4.4—Dietary diversification and the shift of coarse grains to feed use



Source: Authors' calculations from USDA (2011) data.

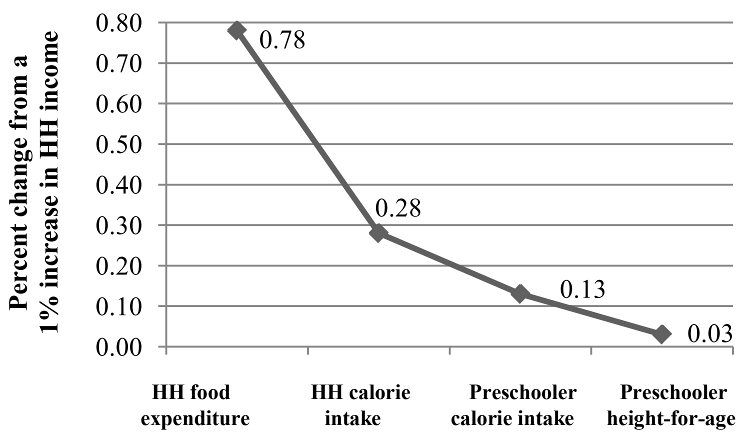
Implications of Income Growth and Dietary Trends for Infants and Young Children

The previous subsection suggested that the dietary changes that have taken place in India over the last 25 years seem to be adequately explained by rising incomes, more sedentary lifestyles, taste-related factors, and changes in relative food prices. From the economic point of view, these changes point toward rising welfare rather than any immiserization of the Indian population. Whether these trends indicate improved nutrition for both adults and children, however, is open to debate, especially in the absence of more rigorous evidence linking food consumption to anthropometric outcomes at the individual level. Nevertheless there are some grounds to think that the reduction in cereal consumption has not been very costly (especially since cereal consumption for the poorest quintile has gone up).

Sharma (2006), for example, observed very weak correlations between calorie intake and nutrition outcomes at state and substate levels. For example, Kerala, Tamil Nadu, and Andhra Pradesh have lower calorie intakes but have lower undernutrition rates and better health outcomes than Punjab and Haryana. Moreover, with more disaggregated data that linked NSS consumption data to anthropometric data, Sharma found that although dietary intake variables are indeed significant determinants of anthropometric outcomes, they are less important in magnitude than demographic and living environment variables. Gaiha and Kulkarni (2005) also found that the price of cereals is negatively correlated with stunting, suggesting that when cereal prices go up (and are presumably consumed less), stunting is reduced. Of course, it is not clear what the pathway might be. Rising cereal prices may induce a switch to coarse grains, which are in fact more nutritious than wheat or rice, or even a switch to other foods that also have more favorable impacts on nutrition. Yet this is only a speculation.

An even more emphatic piece of evidence comes from Bangladesh, where diets and nutritional conditions are very similar to those in large parts of India. In an unusually detailed survey, Ahmed (1993) measured income, household calorie availability, individual (child) calorie consumption (by weighing food consumed), and individual (child) anthropometric outcomes among poor rural Bangladeshi households. Hence the study was able to trace each step of the pathway from household income to household calorie expenditure to individual calorie intake and finally to individual anthropometric outcomes. The cumulative elasticities for each of these steps is shown in Figure 4.5. Ahmed (1993) found that the largest leakages were related to the unequal division of household calories (that is, the calories allocated to preschoolers) and the low impact of calories on anthropometric outcomes among preschoolers. Moreover, these leakages resulted in an extremely low elasticity between household income and preschooler nutrition: A 1 percent increase in income improved the preschoolers' height-for-age scores by just 0.03 percent.[9] Another unusual observation made during the survey process was that young children often did not finish their meals, despite the families' being very poor. Ahmed suggested that this was related to poor health and sanitation (which inhibited appetite), poor diets (overconsumption of rice, which is too heavy for small stomachs), and the infrequency of feedings (again related to the small stomachs of children).The last explanation perhaps also suggests that parental time constraints are important in that they may explain the infrequency of feeding (an issue we explore in the next section). Finally, it also worth noting that while there are relatively few recent studies linking individual calorie intake to nutrition outcomes, those that do exist seem to consistently show weak association (for example, Sahn and Alderman's (1997) study of urban households in Mozambique). Overall, then, it is not obvious that calorie availability is a binding nutritional constraint for most Indian households. The policy implications of this observation are important—especially given the federal government's subsidization of rice and wheat—and are therefore discussed in the concluding section.

Figure 4.5—Leakages from household (HH) income to individual child nutrition outcomes in poor rural Bangladeshi villages



Source: Ahmed 1993.

This covers cereals, but what about the nutritional consequences of trends in protein, fat, and micronutrient consumption? The decrease in protein consumption is also related to reduced cereal consumption, but the proteins derived from cereals are relatively short on essential amino acids. With an increased share of noncereal sources of protein, it is likely that amino acid intake has increased. Nevertheless, the protein deficiency in the Indian diet is still large, and there are good grounds to think that the long-term decline in pulse consumption has been especially damaging to India's protein status. In terms of fats, these are important for children because calorie-dense fats help them to achieve adequate calorie intake despite small stomachs, and fats generally facilitate the absorption of various nutrients and assist brain development. Finally, although we have not touched much on micronutrients, the increased consumption of fruits, milk, meat, fish, eggs, and vegetables are all indicative of increased micronutrient consumption.

While we cannot say how much dietary diversity has increased for children, we can use cross-sectional results from the most recent NFHS (IIPS 2007) round (2005/06) to see whether income levels (proxied here by wealth quintiles) are indeed significantly associated with the dietary diversity of

[9] For weight-for-age scores, the impacts were half again as small.

children, as we do in Table 4.4. We follow World Health Organization (WHO) guidelines in measuring dietary diversity as the number of food groups consumed by a child in the previous 24 hours. We also follow these guidelines in not comparing breast-fed children with those not breast-fed, so in the results below the latter group is excluded (about 15–25 percent of the sample), though results are available on request.[10] Seven food groups are measured, but only yes/no answers are recorded, with no information on quantities consumed.[11] We take a count of four food groups or more as an indicator of diversity in a child's diet. We then regress this indicator against NFHS wealth quintiles, maternal characteristics, religion dummies, and location dummies, with the sample disaggregated by three age brackets (again, as per WHO guidelines).

Table 4.4—Linkages between household wealth and dietary diversity

Regression number	1	2	3
Dependent variable	Dietary diversity dummy	Dietary diversity dummy	Dietary diversity dummy
Estimator	OLS	OLS	OLS
Number of observations	4,419	3,995	3,428
Age bracket	6–11 months	12–17 months	18–23 months
Constant	0.024	0.083**	0.060
Maternal characteristics			
Mother's education level (0, 1, 2, 3)[a]	0.012	0.042**	0.058***
Mother's age	0.001	0.000	0.003**
Mother in professional work	0.059	0.16	0.256**
Mother in clerical work	0.004	0.362**	0.239**
Mother in sales work	0.017	-0.055	-0.040
Mother in services work	-0.015	-0.051	0.107
Mother in manual work	0.010	0.031	0.014
Mother in agricultural work	0.005	0.025	-0.001
Wealth effects (base = 1st quintile)			
2nd quintile	0.017	0.032*	0.052**
3rd quintile	0.019*	0.061***	0.078***
4th quintile	0.037***	0.110***	0.112***
Richest quintile	0.076***	0.160***	0.168***
Location effects (base = rural)			
Capital city	0.009	0.01	-0.006
Small city	0.007	0.054	-0.006
Rural town	0.016	0.026	0.033
Dietary diversity dummy			
R-square	0.085	0.126	0.123

Source: Authors' estimates from NFHS-3 (IIPS 2007) data (2005/06) of all children 6–23 months of age with the requisite information.

Notes: These are OLS regressions in what is typically referred to as a linear probability model, since the dependent variables are dummy variables. Results therefore reflect the percent change in the probability of the outcome's occurring. The dependent variable is equal to 1 if the child consumed at least 4 different food groups in the previous week. *, **, and *** indicate significant differences from zero at the 10%, 5%, and 1% levels, respectively. Results are OLS estimates with errors adjusted by sampling probability weights. Other independent variables were included but omitted for the sake of brevity. These include dummies for state, religion, number of children under 5 in the household, and gender of the child. [a.] Education levels pertain to the highest level attained: 0=none, 1=primary, 2=secondary, 3=tertiary.

[10] In general we find very weak relationships between wealth and dietary diversity for non-breastfed children. This holds for other variables, too, although it may be related to the small sample size.

[11] The food groups are these: grains, roots, and tubers; legumes and nuts; dairy products (milk, yogurt, cheese); flesh foods (meat, fish, poultry, organ meats); eggs; vitamin A–rich fruits and vegetables; other fruits and vegetables.

As it turns out, the relationship between household wealth and dietary diversity is highly significant and relatively strong. For children aged 12 to 23 months, for example, a child in the richest wealth quintile is 16–17 percent more likely to have a diverse diet than a child from the poorest quintile. Moreover, these wealth effects easily swamp out the mostly insignificant effects of location, religion, gender, and mother's employment (although the latter is in any case an indirect indicator of wealth).[12] We can also use the NFHS-3 to measure the impact of this dietary diversity measure on nutrition outcomes since preliminary research by Aguayo and colleagues (2011) used the NFHS-3 and the same measure of dietary diversity to find that children with more diverse diets were 23–24 percent less likely to be stunted or underweight.[13] So the wealth effect on stunting via dietary diversity can be calculated as the product of these two percentages. For example, moving from the poorest quintile to the middle quintile reduces the probability of stunting due to dietary diversity by just under 2 percent, while moving from the poorest to the richest quintile reduces stunting by 4 percent ($0.16 \times 0.24 = 0.04$).

Summary of Dietary Changes and Their Likely Nutritional Consequences

Table 4.5 summarizes the dietary changes that have taken place at the aggregate level in India over recent decades, outlines the likely causes of these changes, and conjectures the consequences. The disputed reduction in calorie consumption is of potential concern, but there are grounds to think that any reduction in calorie consumption is substantially related to decreased energy requirements and that lack of dietary diversity is at least as big a problem, if not more so.

[12] The only other variable with a sizable impact is the mother's education. A woman with a tertiary education, for example, is also around 16–17 percent more likely to give an 18- to 23-month-old child a diverse diet than a woman with no formal education.

[13] Note that our own estimates of the impacts of dietary diversity on stunting and underweight prevalence derived results very similar to those of Aguayo and colleagues (2011). We thank the authors for sharing their results with us.

Table 4.5—Summary of changes in nutrient intake and their causes and consequences

Trends in nutrient intake	Proximate causes in terms of food consumption patterns	Ultimate socioeconomic causes	*Likely* impact on undernutrition
Calories: Survey data record a decline in calorie consumption, especially in rural areas, but not for bottom quartile. FAO (2009) data record slight increase at national level.	Declining consumption of coarse grains with modest and declining substitution into wheat.	Rising income, more sedentary lifestyles, poor taste of coarse grains, and diversion of coarse grains for use as feed for livestock (and thereby linked to dietary diversification).	Impacts on children's nutrition probably very weak (Gaiha and Kukarni 2005, Ahmed 1993). Sharma (2006) also found weak correlations between nutrient intake and undernutrition at state and substate levels. Even for adults, impact may be weak since cereal content of diet is already very high.
Proteins: Survey data record a decline in protein consumption in both rural and urban areas. FAO data record slight increase at national level.	Decline in coarse grains and over the longer run (1960–2007), a 50% decline in pulses. Increased milk consumption contributed to some increase in protein intake.	For coarse grains, see explanations above. For pulses, declining consumption is because of high price due to their marginalization in food production and food policy. Increased milk consumption can partly be attributed to marketing reforms.	Decline in pulses is problematic because they provide essential amino acids. Protein deficiencies are even larger than calorie deficiencies.
Fats: All sources report sharp increase in fat consumption.	Sharp increases in vegetable oils and animal fats.	Rising incomes, tastes.	Potentially beneficial for children since fats are dense in calories, facilitate nutrient absorption, and help brain development.
Micronutrients: Consumption of most micronutrients has probably increased somewhat.	Increased consumption of fruits, meat, fish, milk, butter, oils, and some vegetables.	Rising incomes, tastes, marketing reforms in the case of milk.	Beneficial for children and adults, including pregnant mothers.

Source: Authors' construction.

5. EMPLOYMENT IN AGRICULTURE AND WOMEN'S NUTRITION STATUS AND CHILD CARE OUTCOMES

In addition to the production–income–consumption linkages discussed above, agricultural conditions could obviously have an important impact on parental time use, via household- and market-based demand for labor. In 2004/05, there were 149 million female workers in India, with a majority of them employed in the agriculture sector (72 percent versus 49 percent of male workers) (Indiastat 2010). Time series data also suggest that India is witnessing a feminization of the agricultural workforce as men shift more rapidly into nonfarm sectors. In this section, therefore, we look at existing and new evidence on the impacts of female employment in the agriculture sector on two female nutrition outcomes (BMI and anemia), women's time use, and ultimately, preschooler nutrition outcomes. However, our analysis is only exploratory because of the paucity of time-use data.

Agricultural Employment and Maternal and Child Nutrition

Maternal undernutrition has profound effects on the health and nutrition outcomes of both pregnant women and their offspring. It significantly influences intrauterine growth retardation, child undernutrition, the emergence of chronic diseases, and other outcomes (Victora et al. 2009). Approximately one-third of all babies in India are born with low birth weight, and pregnant women in India gain only half of the recommended weight. Maternal undernutrition is therefore a prominent suspect in explaining the Indian enigma. But the deeper question is how to explain maternal undernutrition in India. Part of the answer is circular—maternal undernutrition outcomes (particularly adult height) are partly the product of the nutrition processes that influenced mothers in their own childhoods—but post-childhood factors also matter, including micronutrient intake; calorie intake; and socioeconomic factors such as the age at giving birth, which is in turn related to the age at marriage. Since all of these factors are related to women's status in general, gender inequalities have long been a prominent explanation of undernutrition in India. In this section, however, we focus on the significance of female agricultural employment for women's nutritional status. In rural areas, 83 percent of working women are employed in the agriculture sector, so agricultural employment conditions are potentially an important influence on women's nutrition status as well as on important determinants of child nutrition such as intrauterine growth, birth weight, and time allocation to self- and childcare.

As with other determinants of women's nutritional status, working conditions for Indian women are partly an outcome of gender inequalities. Some authors report that rural women work about twice as many hours as rural men. Coonrod (1998) reported the results of a study in the Indian Himalayas that found that on a one-hectare farm, a pair of bullocks works 1,064 hours, a man 1,212 hours, and a woman 3,485 hours in a year. In Andhra Pradesh, Mies, Kumari, and Kumari (1986) found that the workday of a woman agricultural laborer during the agricultural season lasts 15 hours, from four a.m. to eight p.m., with an hour's rest during the day. Another study found that women supply 70–80 percent of the labor for transplanting, 70–80 percent for weeding, more than 60 percent for harvesting, and 25–40 percent for threshing (Agarwal 1983). Moreover, women have benefited less from mechanization, which has implications not only for productivity but also for women's time use and energy expenditure.

As for the effect on nutrition, early work by Rajagopalan, Kyrnal, and Pei (1981) found that in Tamil Nadu, birth rates peaked just before the start of the heaviest period of agricultural work. They suggested that this may adversely affect infant nutrition by limiting the time available for breast-feeding. Moreover, the tasks performed by women are often those that require them to be in one position for long periods of time, which can adversely affect their reproductive health. A study in a rice-growing belt of coastal Maharashtra found that 40 percent of all infant deaths occurred in the harvest months of July to October, the rice transplanting months, when women work long hours in squatting positions (Agarwal 1983). In Andhra Pradesh, Gillespie (1989) found that 65 of 67 children under five years old in a tribal village actually lost weight during the transplanting month of July. While there is a dearth of more recent evidence on female employment and nutrition outcomes, it seems likely that many of these earlier findings are still relevant today.

Seasonality and income volatility is also a widely researched issue in the Indian context, although very few studies have examined the impacts of shocks on women's time use. A historical econometric study by Bhalotra (2010) found that the infant mortality of girls in rural areas is affected by income shocks, with the elasticity in relation to state-level income shocks being about -0.60 (quite large). She argued that the most likely channel relates to the effect of recessions on increased labor market participation of mothers (which reduces childcare and healthcare seeking for children) and gender biases in food distribution, which have been found to be highly sensitive to income and agricultural shocks elsewhere in the Indian literature (Babu, Thirumaran and Mohanam 1993, Behrman 1988, Mishra, Roy and Retherford 2004). Bhalotra (2010) also found that exposure to poor conditions in the fetal and neonatal period appears to have a larger effect on infant mortality than similar exposure in the post-neonatal period. A recent report on the Young Lives survey in Andhra Pradesh also found that the occurrence of drought increased the chances of stunting and underweight by around 6 percent (Himaz, Galab and Reddy 2008). The same study also found that droughts led to a high participation in child labor. So while the evidence of effects of seasonality and income volatility on nutrition outcomes is rather scanty in the Indian context, what evidence there is points to the link's being quite strong, especially in rural areas.

Recent studies have also examined the effect of women's employment and occupation on female nutrition outcomes, notably BMI. Griffiths and Bentley (2001) found that low adult female BMIs were 4.21 times as likely in rural areas compared with large cities in Andhra Pradesh. In a more extensive specification that included occupation categories as well as controls for diet, standard of living, and education, women engaged in agricultural employment were 1.52 percentage points more likely to be underweight. Barker and colleagues (2006) studied six villages of the Pune district in Maharashtra and found that young women had significantly lower BMI than their male peers. In this agricultural community, women in farming households were much thinner than those in nonfarming households (BMIs of 18.3 versus 20.3), although this difference was not observed among men. This may be because women were more likely to work full time in farming than men and also to carry the burden of household chores including heavy activities such as washing clothes and fetching water. Using the same survey, Rao and colleagues (2003) classified mothers' activities into light, moderate, and heavy activity categories. They found that maternal activity did not influence the incidence of prematurity or stillbirth, or the duration of gestation, but was inversely related to maternal weight gain during the first 28 weeks of gestation. Higher maternal activity in early as well as mid-gestation was associated with lower mean birth weight, smaller neonatal head circumference, and smaller mid-arm circumference (after adjusting for the effects of major confounding factors). Those findings suggest that excessive maternal activity during pregnancy is associated with smaller fetal size in rural India.

Although the results of the studies cited above are certainly indicative of important linkages between a mother's health, her employment, and her children's nutrition outcomes, none of these studies specifically tests for these linkages with nationally representative data, and many of these studies are rather dated. Hence, we test for these linkages with the NFHS-3 (IIPS 2007) data (2005/06) by first regressing mother's BMI against various occupation categories (with controls) before entering mother's BMI in regressions on child undernutrition outcomes. In testing the effects of occupation on adult BMI, it is obviously important to have a well-specified regression, including controls for individual-, household-, and community-level characteristics that could be closely correlated with both occupational choices and nutrition outcomes. For example, agricultural households are much more likely to live in areas that are isolated from health, education, water, and sanitation facilities. We also know that agricultural workers are generally poorer than people in other occupations. Indeed, existing studies find that rural–urban differences in undernutrition exist precisely because of differences in the levels of these kinds of determinants (Smith, Ruel and Ndiaye 2004). For these reasons we specify cluster-level fixed-effects regressions and a large number of control variables pertaining to these kinds of factors. Our goal here is to estimate the pure effect of occupation on nutrition outcomes rather than any conflated effect pertaining to the fact that agricultural households are simply poorer or more isolated than other households.[14]

The first-stage regressions in Table 5.1 confirm that agricultural workers have lower BMIs than nonagricultural workers, even after controlling for wealth, health, education, and location. In terms of the size of the differences, agricultural workers have the lowest BMIs of any profession, although the differences between agricultural workers and unskilled manual workers are quite small and, in the case of women, statistically insignificant. This may be because both agriculture and unskilled manual work (such as construction) require larger calorie intakes than other occupations, which could imply larger calorie deficits and hence lower BMIs for these manual occupations.

The next question is whether these estimates are large enough to warrant further attention. Taking the point estimates as given, moving a woman from agriculture to unskilled manual labor activities improves her BMI by just 0.08, while moving her to services yields a BMI increase of 0.27 and moving her to sales yields an increase of 0.29. These effects are fairly moderate but comparable in size to many other effects in the regression. For example, moving from a rural area to a small town improves female BMIs by 0.51. Moving from the lowest wealth quintile to the next highest improves BMI by just 0.24.[15] And raising a mother's education from none to having completed a primary education improves her BMI by 0.31. However, since there are obvious linkages between location and access to education and health services, and between occupational choices and wealth, the total effect of switching from a rural to an urban lifestyle is quite large. Indeed, existing evidence has found that even urban slum dwellers have better nutrition outcomes than rural people. For example, Guha-Khasnobis and James (2010) report NFHS-3 results that show underweight prevalence of adults at around 23 percent in the slum areas of eight Indian cities, whereas the underweight prevalence in the rural areas of those states was closer to 40 percent. If agriculture is viewed as a component of a broader rural livelihood, then livelihood characteristics do seem to have a sizable adverse effect on adult BMI. Regression 2 in Table 5.1 confirms that very similar results hold for father's BMI.

[14] We also note that occupational choice could technically be considered endogenous because nutrition outcomes might influence occupational choice, rather than vice versa. For example, people with very low BMI might be unsuited to the physical demands of agricultural or other manual labor. This could mean that the coefficients on agricultural employment might be biased downward, although we suspect that this bias is relatively small: Most of the very poor people who work in agriculture are born into it or work in agriculture because they have virtually no other options.

[15] However, this could be because the wealth index is not very good at distinguishing welfare levels among poorer groups (Chaudhury, Hammer and Pokharel 2008).

Table 5.1—First-stage effects of occupation on parents' BMI and second-stage effects of parents' BMI on their children's nutrition outcomes

Regression no. Fixed effects Regressor Dependent variable	1 Cluster OLS Mother's BMI	2 Cluster OLS Father's BMI	3 Cluster OLS Child's HAZ[a]	4 Cluster OLS Child's WAZ[b]
Occupation				
Professional (base)				
Not working	-0.08	-1.08***		
Clerical	-0.31	-0.20***		
Sales	0.33*	0.07		
Services	-0.35***	-0.12		
Unskilled manual	-0.54***	-0.41***		
Agriculture	-0.62***	-0.67***		
Location[c]				
Rural (base)				
Capital	0.92***	1.07***	-0.08**	-0.12***
Small city	0.56***	-0.26***	-0.10**	-0.06
Town	0.51***	0.46	-0.08**	-0.02
Wealth quintiles				
Poorest (base)				
Poorer	0.24***	0.37***	0.18***	0.12***
Middle	0.70***	0.69***	0.21***	0.22***
Richer	1.43***	1.29***	0.40***	0.33***
Richest	2.91***	2.49***	0.72***	0.53***
Mother's education				
None (base)				
Primary	0.31***		-0.02*	0.06***
Secondary	0.40***		0.05**	0.12***
Higher	0.37***		0.08**	0.28***
Father's education				
None (base)				
Primary		0.27***	0.01	0.03
Secondary		0.53***	0.04	0.07***
Higher		1.07***	0.23***	0.14***
BMI effects				
Mother's BMI			0.030***	0.060***
R-square	0.33	0.33	0.33	0.34
Observations	74,374	68,789	18,758	18,758

Source: Authors' estimates from NFHS-3 (2005/06) data (IIPS 2007).

Notes: These are OLS regressions with cluster-level fixed effects and errors adjusted with sample weights for surveyed women. The sample pertains to mothers who reported working in the last 12 months. *, **, and *** indicate significant at the 10%, 5%, and 1% levels, respectively. Other controls include water source dummies, toilet facility dummies, age brackets, religion and caste dummies, female household head dummy, a gender inequality proxy, household size, number of children ever born, age at marriage, and a dummy equal to one if distance to a health facility is a constraint in access to medical care. However, not all of these variables were available or pertinent to the male BMI regressions. [a.] HAZ, height-for-age z-scores. [b.] WAZ, weight-for-age z-scores. [c.] Estimates of location effects are not based on cluster fixed effects but on state-level fixed effects, since cluster-level effects produced multicollinearity.

Although explaining a mother's BMI is important in its own right, we are obviously interested in whether a mother's BMI also affects the nutrition outcomes of her children. In columns 3 and 4 of Table 5.1 we look to see whether the mother's BMI has a significant effect on height-for-age z-scores (HAZ) and weight-for-age z-scores (WAZ), respectively, for all children under the age of three. Normally, we would enter predicted BMI values from the first-stage regression into the second stage, but in this case the predicted values were insignificant, possibly because the estimates were inconsistent. Hence, in the second stage we entered the original BMI scores. For height-for-age, the effects are significant but rather small. Increasing mother's BMI by 1 increases the HAZ by only 0.03. The impact is slightly larger for WAZ scores, but still only 0.06. This means that the total effect on child undernutrition of a mother's working in agriculture rather than services, for example, on her child's WAZ score is only 0.016 standard deviations (0.27 × 0.06). Moreover, additional robustness tests aimed at controlling for endogeneity by specifying household fixed effects result in even lower estimates of the effects of mother's BMI on child undernutrition.[16] Overall, then, it would appear that more general rural livelihood problems matter more than occupations per se.

Maternal Employment in Agriculture and Childcare

Existing studies note the importance of care practices as a determinant of child undernutrition, although this channel of effect is less well explored than many others. However, the indirect evidence cited above on how hard women work in agriculture would seem to indicate that this may lead to the neglect of children or even to very young children's joining their mother while she carries out farm or household work. On the other hand, rural households tend to be larger than urban households, providing the possibility for other adults or older children to take care of infants or to free up mothers for time with their children (Khare 1984). While these substitutes may be highly imperfect during infancy—when breast-feeding is important—these types of caregivers may be adequate for somewhat older children. The time women allocate to childcare has also been found to be influenced by local labor market conditions. Skoufias (1993) used a time allocation survey of a four-year panel of households from six villages in semiarid parts of India, although time allocations were broken up only into "market," "home activities," and "leisure," with childcare falling under "home activities." Somewhat counterintuitively, he found that women allocated more time to home activities when male wages were low and female wages were high, when farms were more valuable, and when there were more boys and more adult and older women but fewer elderly women in the household.

Kishor and Sulabha (1998) used data from the 1992/93 NFHS to estimate the effect of mother's employment status on child survival rather than child nutrition. Logistic regressions found that the odds of dying between ages 12 months and 47 months were significantly higher when mothers were employed, while the odds of dying at ages 0 to 11 months were higher only if the mother was employed at home or outside the home for cash. The odds of dying did not differ by mother's employment status for female infants but were 12 percent higher for males if the mother was employed. During post-infancy childhood, the odds of dying increased for male and female children if the mother worked. For boys the increase was greatest if the mother worked outside the home for cash and for girls if the mother worked at home. Further, employment of mothers in urban areas had more detrimental effects on infant and child survival than employment in rural areas.

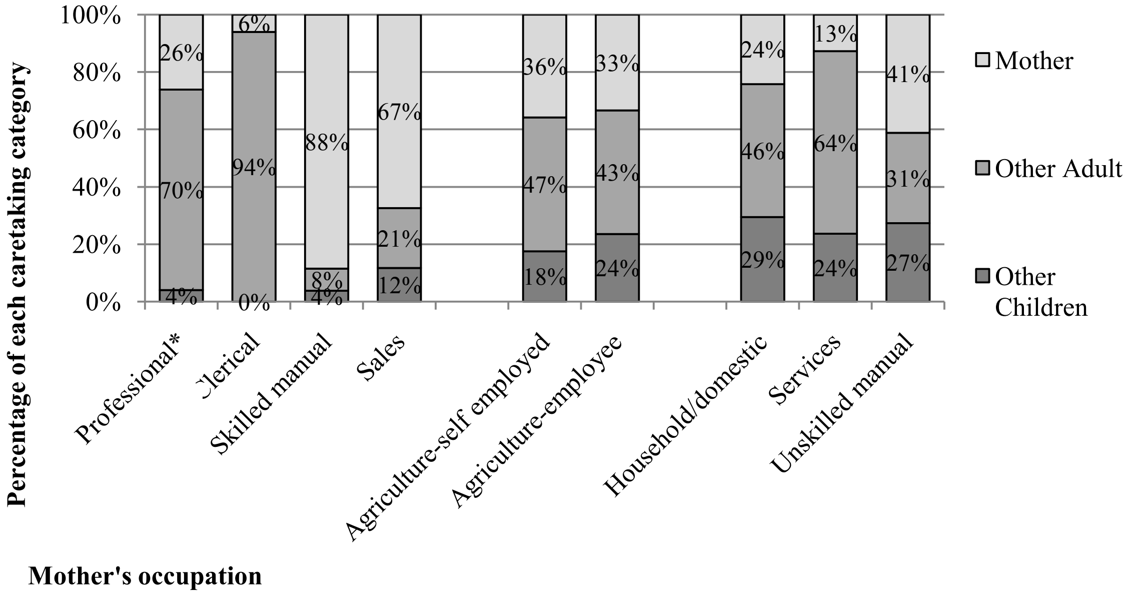
Since the existing evidence is rather sparse and generally rather weak, we investigate a possible impact of mother's occupation on childcare using the NFHS-2 (1998/99) (IIPS 2000) data on those mothers who reported being employed in the last 12 months[17] and who answered a question as to who took care of their children. Although there were 10 such categories, the most frequent answers fell into three broader groups: the respondent herself, another adult in the household (the husband, another relative, or a household servant), and other children in the household. In Figure 5.1 we plot breakdowns by mother's occupation to look for prima facie evidence that women employed in agriculture take care of their own children less often than other women. However, we do not find strong evidence of this because, if anything, other relatively unskilled occupations—such as household or domestic employee or service employee—tend to show even higher rates of preschoolers being cared for by other children or other adults (with the exception of unskilled manual workers). Of course, these measures are quite imperfect:

[16] In unreported regressions analogous to those in Table 5.1 we controlled for household fixed effects because mother's BMI could be correlated with children's nutrition outcomes because of common household factors that impact the nutritional status of everyone in the household, such as household consumption patterns, genetic characteristics, or intrahousehold discrimination. Indeed, one piece of evidence that household effects may bias the regressions is that father's BMI has just as strong a relationship with childhood undernutrition as mother's BMI, even though causal channels like intrauterine growth retardation are not relevant in the case of fathers.

[17] The question on who takes care of a child was not asked in the 2005/06 round, hence our reliance on the 1998/99 round.

We have no idea of the specific time allocation between the mother's work and childcare, nor any idea of the quality of childcare (for example, whether she takes care of the child while working) or of the quality of the data (for example, whether there are selection biases).

Figure 5.1—Who takes care of the children? Variations by mother's occupation



Source: Authors' calculations from NFHS-2 (1998/99) data (IIPS 2000).

Bearing these data imperfections in mind, we test for the impact of different caretaker categories on child stunting and wasting in a multivariate context. One point of note is that although the sample is restricted to mothers who answered yes to a question on whether they worked in the last 12 months, the sample appears to be representative of the occupational structure of Indian women (the agricultural occupation share of the question responses is 68.5 percent, compared with 67.5 percent in the labor force census). As for our hypotheses, obviously one would expect that care provided by other children is inferior to adult care. One might expect care provided by mothers to be superior to all other categories, especially for young children who are potentially breast-feeding, but if the mother is taking care of the child while working (even in the household), then this divided attention might be inferior to care provided by other adults.

In Table 5.2, however, we essentially find no difference between the care impacts of mothers and other adults on height-based indicators of nutrition (stunting or the raw z-score), but care provided by other children has an adverse impact on height-for-age. However, we found no impacts on wasting or weight-for-age (results not reported), and the impact of caregiving categories on height-for-age were only moderate and not particularly robust to different samples. For example, the impact of the mother's caregiving relative to that of other children was around 0.18 standard deviations for the HAZ score. And given that mothers employed in agriculture are no more likely to have other children taking care of their infants than mothers in other unskilled occupations, our admittedly tentative conclusion is that there is not much evidence that poor childcare practices are more prevalent or more important in agricultural households than in nonagricultural households. Of course, more accurate time use data might give rather different results, and it is still likely that the labor burden of mothers in all unskilled occupations (agriculture, domestic work, unskilled manual labor, and other services) detracts from appropriate childcare practices.[18]

[18] For the regressions in Table 5.2 we also introduced an agricultural employment dummy and interactions between the employment dummy and the caregiving variables, but none of these variables yielded significant coefficients.

Table 5.2—Testing for impacts of care giving on child stunting

	Prevalence of stunting (< 2 std. deviations)			Height-for-age z-score		
	Children < 36 months	Children < 18 months	Children < 24 months	Children < 36 months	Children < 18 months	Children < 24 months
Care provided by mother	-0.06***	-0.04	-0.05*	0.18**	0.11	0.16
Care provided by other adults	-0.04**	-0.07**	-0.06**	0.13	0.20*	0.17
Care provided by older child (reference category)						
R^2	0.069	0.049	0.054	0.064	0.039	0.044
Observations	4,897	2,566	3,357	4,897	2,566	3,357

Source: Authors' estimates from NFHS-2 (1998/99) data (IIPS 2000).

Notes: These are OLS regressions with errors adjusted by sampling weights for women. The sample pertains to mothers who reported working in the last 12 months. *, **, and *** indicate significant at the 10%, 5%, and 1% levels, respectively. "Care provided by other adults" pertains to the husband/partner, other relatives, friends, servants/hired help, school, or other institutional care. The reference category—"care provided by older child"—pertains to male or female children. The regressions also include 34 control variables pertaining to demographics, parental education, wealth, location, health access, gender inequality, water and sanitation, and mother's BMI.

Overall, then, our review of the effects of female agricultural employment on child undernutrition paints a mixed picture, with three basic findings. The existing case study evidence on livelihoods shows that Indian women in agriculture work extremely hard, to the detriment of their own nutrition and that of their children. However, regression analysis on a nationally representative dataset suggests that, on average at least, there is nothing special about agriculture in this regard because women working in other manual jobs also have lower body mass indexes. Moreover, a substantial part of the problem seems to relate to broader rural service problems rather than agricultural problems per se. The evidence on agriculture's impact on maternal child care is even weaker, but nationally representative data again suggest that there is nothing special about agriculture: Women in the more unskilled occupations are generally more likely to leave their child in the care of others, including older children.

6. CONCLUSIONS

India's stubbornly high rate of malnutrition undoubtedly constitutes one of the country's most dire problems. Moreover, given that undernutrition is partly a health problem and partly an education and information problem, there is clearly an important role for interventions by governments and nongovernmental organizations, especially insofar as undernutrition often has technical solutions of a public-good nature. However, it is less clear what role agricultural policies should play in addressing undernutrition problems. On the one hand, economists have widely argued that agriculture has been the driving force behind the sharp reduction in monetary measures of poverty in India and in other successful developing countries. Yet the apparent disconnect between agricultural development and undernutrition in India presents another puzzle in the already puzzling context of India's persistent undernutrition problem. In this paper we attempted to unravel this puzzle by exploring the two most important theoretical linkages between agricultural development and child and adult nutrition outcomes—income–production–consumption linkages, and employment–time linkages—and explored these hypothesized linkages against both existing and fresh evidence. While much of the evidence is indicative because of data constraints and in some contexts a dearth of recent evidence, our exploration of these two channels points to the following conclusions.

Macroeconomic Growth Effects: Signs of a Disconnect?

Whether there is a disconnect between economic growth and nutritional improvements in India turns out to be highly sensitive to how one measures these variables. Macroeconomic data by state suggest that the relationship between overall economic growth and nutritional improvements has been weak from 1992 to 2005, although there is some evidence that agricultural growth rates are significantly associated with improvements in women's BMI and more tentative evidence that they are associated with improvements in stunting. But when one looks at heterogeneity across Indian states, it is clear that in some states agricultural growth does seem to be associated with improvements in stunting, while in others there is a total disconnect, with Gujarat the outstanding example. Future research could explore such states as case studies. For example, much of the growth in agricultural production in Gujarat stems from cotton production and other cash crops. Is it possible that increased cash crop income has had no systematic impact on nutrition outcomes, as previous research seems to suggest (von Braun 1995)?

Consumption Effects

In terms of *consumption effects* on nutrition outcomes, there are good grounds to think that too much emphasis has been placed on the apparent decline in calorie consumption in India. Even if this trend does exist, all the indications are that the decline in calorie consumption is driven by taste (especially the decline in consumption of coarse grains), dietary diversification, reduced calorie requirements, and changes in prices. Most of the explanations are consistent with welfare improvements in India rather than deterioration. Moreover, cross-regional data show no positive association between calorie consumption and nutrition outcomes, whereas correlations between health-related factors (health services, water and sanitation quality) show much stronger correlations. Household- and regional-level regression estimates also present a similar pattern of weak relationships between calorie availability and nutrition. The more critical concern may be *protein and micronutrient consumption.* The 50 percent decline in pulse consumption since the 1950s—which is critical to protein consumption for India's poor—is very much a concern, one most likely driven by policy neglect of pulse production and marketing. In the case of higher-value foods rich in micronutrients, consumption has been rising, largely on the back of private-sector agricultural development, but for the poor these improvements have come from an extremely low base. The good news in our results is that there are strong cross-sectional effects of wealth accumulation on dietary diversification of children, which in turn has sizable impacts on child nutrition outcomes. However, we still need to know much more about how agriculture influences dietary diversity through other channels, including whether diversification of agricultural production (within the household or within the region) influences the dietary diversity of individuals.

Employment Effects

The impact of *agricultural employment* on nutrition, especially mothers' employment, has certainly been explored before, but in a rather piecemeal fashion. Most of the studies we investigated were quite dated, and most focused on particular communities rather than nationally representative data. Fresh analysis herein of NFHS-3 revealed that agricultural men and women do have slightly worse nutrition outcomes (BMIs) than individuals in most other relatively unskilled occupations. Moreover, if one looks at the bigger picture of rural livelihoods, it is clear that the combination of laborious farm employment and weaker access to education and health services jointly contribute to rural adult nutrition indicators that are substantially inferior even to those of urban slum populations. Yet we did not find conclusive second-stage evidence that mothers' BMI has strong direct effects on their children's nutrition outcomes, although this may be because BMI is a less-than-ideal measure of maternal nutritional status. Future research could use more detailed surveys to look at the impacts of livelihood factors on the nutrition and health of pregnant and lactating mothers.

Finally, while there are again quite a few older pieces of work on the influence of female agricultural employment on childcare practices, we again found that none of these were nationally representative. NFHS-2 data, however, suggest that agriculturally employed mothers are no more likely to work—and if they do work, no more likely to leave young children in the care of other children—than mothers working in other unskilled professions. This is not to say that childcare practices could not be improved for poor Indian households, only that there does not appear to be anything unusual about agricultural employment, at least not at the national level. Of course, more detailed time use data might reveal something different, as could subnational studies focusing on particular communities or agroecological zones. More thought should be given to the implications of mothers' employment on nutrition. In the case of the National Rural Employment Guarantee Act (NREGA), for example, a survey in Tamil Nadu found that 75 percent of mothers with babies less than 12 months old left them at home, presumably without access to breast milk (Narayan 2008). Yet taking a child along during outdoor work can also be detrimental to the child's health and nutrition, especially in extreme weather conditions. In some interventions it may therefore make sense to pay mothers not to work, at least during the most important phase of breast-feeding.

Implications

On the basis of these admittedly qualified conclusions, agriculture obviously plays a nuanced role in influencing India's nutrition outcomes. Hence it is important to ask what the implications are of these various findings.

First, while agriculture can still be an important source of income growth and dietary improvements for India's poor, it should be regarded as only one dimension of a multidimensional nutrition strategy. If there is a disconnect between agriculture and nutrition, it could just as easily be argued that there are even stronger disconnects in other spheres, including nutritional policies themselves as well as education, health, and infrastructure. The nationwide Integrated Child Development Scheme (ICDS) has undoubtedly had a very limited effect on Indian malnutrition because of limited outreach and poor targeting (Gragnolati, et al. 2005), especially in its neglect of interventions during the prenatal and postnatal stages when Indian children really start to fall behind international nutrition norms. Improvements in female education have been very modest in some states, and the evidence appears to show that it is secondary education that makes a difference, not primary education (Headey 2011). Finally, just as there is a right-to-food movement in India, there is also a right-to-health movement that points out that India has the lowest public healthcare expenditure per capita in Asia, and within health expenditures, one of the lowest shares devoted to preventive interventions (Deolalikar 2008, Jha and

Laxminarayan 2009). A plausible hypothesis, then, is that India's undernutrition problems are ultimately characterized by a number of disconnects—including those related to nutrition, health, education, and infrastructure policies—some of which may be significantly more important than the disconnect with agriculture.

Second, even if an agricultural disconnect is only one dimension of the problem, there is a lot to be said for making agricultural and food policies more "nutrition-sensitive." For example, government policies clearly influence the Indian diet, but not always in a favorable way. While there has been some dietary diversification in India, there is still a policy bias that works in favor of rice and wheat and against arguably more nutritious foods such as coarse grains, pulses, and fruits and vegetables. A leading example is the Public Distribution Scheme (PDS), which has favored rice and wheat production, often for wealthier farmers (for example, in the Indian Punjab). The many failings of the PDS are beyond the scope of this paper, but its abysmal targeting record (about 42 percent of subsidized grains reach the target below-poverty-line group) and its huge expense (eating up in excess of 5 percent of the federal government budget) suggest that—as far as undernutrition is concerned—it is a highly inefficient program. In this regard the Indian government's gradual move toward replacing food subsidies with cash subsidies is a welcome step, though ultimately more of the government budget ought to be realigned to healthcare. The other major safety net in India, the NREGA, has a better economic rationale, but it could also be made more nutrition-sensitive by making better accommodation for working mothers and perhaps even subsidizing pregnant or breast-feeding mothers not to work.

Third, given evidence on the impacts of wealth accumulation on child dietary diversity and the impact of child dietary diversity on nutrition outcomes, future research and programmatic thinking about the role of agriculture in improving nutrition should explore linkages between the composition of agricultural production and the composition of diets. This channel can work at the micro level through interventions such as homestead gardening—which has had some success in neighboring Bangladesh (Iannotti, Cunningham and Ruel 2009)—but it can also work at the macro level by reducing the relative prices of more nutritious foods.

Finally, agricultural policies need better coordination with policies in other nutrition-relevant sectors, and vice versa. As a multidimensional problem with strong interactions between dimensions (such as health and diets), undernutrition needs multidimensional solutions. Experience from other countries, such as Thailand (Heaver and Kachondam 2002), as well as the more successful Indian states (such as Kerala and Tamil Nadu), show that multisectoral approaches can have tremendous impacts on nutrition, especially when channeled through community-based development. Indian policymakers therefore need to learn important lessons from their own country as well as their peers.

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IFPRI HEADQUARTERS

2033 K Street, NW
Washington, DC 20006-1002 USA
Tel.: +1-202-862-5600
Fax: +1-202-467-4439
Email: ifpri@cgiar.org

IFPRI ADDIS ABABA

P. O. Box 5689
Addis Ababa, Ethiopia
Tel.: + 251 (0) 11-617-2500
Fax: + 251 (0) 11-646-2927
Email: ifpri-addisababa@cgiar.org

IFPRI NEW DELHI

CG Block, NASC Complex, PUSA
New Delhi 110-012 India
Tel.: 91 11 2584-6565
Fax: 91 11 2584-8008 / 2584-6572
Email: ifpri-newdelhi@cgiar.org

IFPRI ACCRA

CSIR Campus
Airport Residential Area, Accra
PMB CT 112 Cantonments,
Accra, Ghana
Tel.: +233 (0) 21 780-716
Fax: +233 (0) 21 784-752