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Child Underweight, Land Productivity and Public Services: A District-level Analysis for India

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About LANSA

Leveraging Agriculture for Nutrition in South Asia (LANSA) is an international research partnership. LANSA is finding out how agriculture and agri-food systems can be better designed to advance nutrition. LANSA is focused on policies, interventions and strategies that can improve the nutritional status of women and children in South Asia. LANSA is funded by UK aid from the UK government. The views expressed do not necessarily reflect the UK Government's official policies. For more information see www.lansasouthasia.org

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1Abstract

Though India's rank has improved in the Global Hunger Index, contributed largely by the fall in the underweight rates for children, concerns of high level of undernutrition in predominantly agricultural pockets remain. This study aims at linking child underweight rates to agricultural land productivity, a proxy for agricultural prosperity, and to the provisioning of public services, using district-level data.

The study estimates a three-stage least squares (3SLS) model with a log-linear specification. Unlike many earlier studies, the results indicate a possible positive relationship between agricultural land productivity and child underweight rates. It appears that the district-level analysis is able to capture aspects of agro-climatic conditions, agricultural development and its spillover effects, and public services delivery more effectively when compared to several studies based on household-level survey data.

The results clearly show the importance of public health provisioning in terms of vaccination, administration of oral rehydration salts when there is incidence of diarrhoea, government health facilities in rural areas, public provisioning of food, as also maternal health and women's education. Though their elasticity was small, the variables were significant and it is clear that they may have a bigger impact on the deprived sections of the population. For example, a 1 per cent increase in land productivity increases the percentage of nourished children below six years by about .08 per cent. Similarly, use of oral rehydration salts in diarrhoea incidence improves the underweight rate by about 0.08 per cent at the overall district level. In the parts of the country where underweight rates are high, the impact will be more and the overall magnitude of reduction would be high even if the elasticity is low. The study also shows, in an indirect way, the need for a convergence of agricultural development efforts that create on-farm and off-farm employment with public service delivery of health, sanitation and food. The policy implication is that the state governments should strive to achieve administrative convergence of both agricultural development and public provisioning, paying special attention to safe water supply.

2 Introduction

The Global Hunger Index for 2015 shows an improvement in India's rank from 48.1 in 1990 to 29 in 2015 (IFPRI 2015). The decline has been contributed largely by the decline in child underweight rates from 55.5 per cent in 1990 to 43.5 per cent in the early 2000s and 30.7 per cent in 2014. This calls for some celebration but with limited enthusiasm, as India still ranks behind some of its own neighbours like Nepal and Sri Lanka and is way behind several other countries which have either shown similar or even lower levels of economic growth during the past decade.

Underweight in children is a nutritional indicator worth exploring because of its importance for the future. The Hunger Index chose child underweight as a significant indicator of nutritional deprivation. The other important indicator of child malnutrition – stunting – is closely related to child underweight. While calorie deprivation is a short-term indicator of hunger, underweight and stunting in children and body mass index in adults are the outcomes of long-term calorie and nutrient deprivation. The second Sustainable Development Goal (SDG) is 'zero hunger'. Fewer underweight and stunted children would mean a mentally and physically healthier population in the future. As suggested by Richard Morgan, UNICEF advisor on Post-2015 Development Agenda of the United

Nations, there is a need to invest in children for a more equitable world in the future. Underweight in children is a measure of nutritional deprivation. In the absence of reliable district-level data on stunting and wasting, underweight is a good proxy for nutritional deprivation.

The improvements in underweight rates from the late-1990s to the mid-2000s were not promising at all, particularly in rural areas where the underweight rate declined from 45 per cent to less than 44 per cent during this period and was considerably higher than the urban rate at about 31 per cent (Malhotra 2014). The more recent Rapid Survey of Children (RSOC)[1] by UNICEF shows that there has been a larger decline over the earlier period, with the rural underweight rate at 31 per cent and urban at 24 per cent in 2014. Nevertheless, there is a gap of 7 percentage points between the rural and urban rates. The survey further shows that there are huge variations across states, with Kerala's rate at less than 20 per cent while that of Chhattisgarh is about 47 per cent (**Appendix A, Table A1**). If we compare the underweight rates for 2011-2013 with that of 2002-04, we find that in all the large states there has been a decline. This decline is notable among states that had high underweight rates in the previous period, though a few northeastern states show a rise in underweight rates (see **Appendix A, Table A1**).

The inter-regional variations are further enhanced within a state even in the rural areas; in states like Bihar underweight rates ranged from 35 per cent to 47 per cent in 2009, while in Uttar Pradesh it ranged from 26 per cent to 55 per cent[2]. In both these states, the underweight rates were predominantly in the range of 35-40 per cent in most districts. As per the latest RSOC, these states continue to be at the top in child undernutrition, including underweight, rates. That these states are also very populous would imply that a large number of children are under the burden of undernutrition. Based on a Child Development Index for the districts of India wherein child underweight rates from DLHS-2 (GoI 2005) are a component, Dreze and Khera (2012) found that though most of the high values are concentrated in central and eastern India, there were also pockets of lower underweight rates within these regions. Interestingly, adjacent districts belonging to different states showed sudden changes in the underweight values in a further assessment of this study by Viswanathan (2014). This lends one to infer that perhaps state-level characteristics like public provisioning of basic services and agricultural prosperity may be influencing factors.

Agriculture-nutrition linkages assumed added importance in the developing world after the recent experience of food shortages and price shocks. The immediate thrust was on the importance of agricultural production by small farmers (Wolfenson 2013) and special safety nets (HLPE 2012) to ward off undernourishment and undernutrition. The Smart Development Goals post-2015 include agricultural productivity growth by 40 per cent as an important goal. This realisation that agriculture is important for nutritional security has gained credence in the development discourse following a number of studies that show agricultural growth as the single most important factor that has contributed to the reduction in poverty and hunger, both among the rural and urban populations, across the world in the twentieth century (DFID 2004).

Further, the fact that undernutrition is more prevalent in regions that are largely dependent on agricultural activity, which also turn out to be backward regions due to poor service delivery of basic

[1] http://www.wcd.nic.in/RSOC/0.RSOC_India.pdf

[2] HunGaMA: Fighting Hunger & Malnutrition, The HUNGaMA Survey Report – 2011, Naandi Foundation, Hyderabad www.hungamaforchange.org.

amenities and health care, provides the motivation for us to study child nutrition, agriculture and public services together at the district level. Poor service delivery can, perhaps, be largely attributed to a weak administration.

This study revisits the empirical relationship between agriculture and undernutrition in India using district-level data for child underweight rates, agricultural land productivity and provision of public services. Section 2discusses the motivation and design of this study. Section 3 records the evidence on the linkage of child nutrition to agriculture and various aspects of public provisioning of food, health, sanitation, water supply, child care practices and women's education. Section 4 elaborates issues relating to data and methodology. Section 5 presents the results and discusses the implications and Section 6 concludes the study.

3 Study Design and Conceptual Issues

More importance is being given now to decentralised governance with the state governments assuming greater roles and responsibilities in dealing with underdevelopment, in general, and undernutrition among children, in particular.[3] In this context, the administrative division of districts becomes the important unit of service delivery for programme implementation and its monitoring. This gives scope for convergence across government departments involved in programme implementation, leading to better effectiveness Senand thereby an impact in reducing undernutrition among children at a faster pace. District-level analysis can contribute to this process. Further, regional planning and policy-making can take advantage of the geographical features of the region for improving economic development. In this context, agriculture assumes significance and with its dependence on agro-climatic conditions, it becomes imperative to focus on the district as the administrative unit.

One of the reasons for the limited number of empirical studies that try to understand agriculture-nutrition linkages is the lack of agriculture-related information in most household-level survey data, otherwise rich in details pertaining to nutrition intake, nutrition outcome and related information. A district-level study of this nature fills this gap and enables combining of data from different sources. Further, the spillover effects of agricultural prosperity or backwardness on child nutrition can be captured better at the district level rather than at the household level. A study based on state-level data is possible, but that limits the sample size to carry out a meaningful analysis; a district-level analysis addresses this limitation as well.

The demand for public services also depends on the relative prosperity and poverty of the region. For example, if people are relatively well off, they may use better quality private health facilities that are more expensive than the facilities provided by the government. In general, public services are subsidised and meant for the economically-deprived sections of the population. Sometimes, if the public provisioning system works well, or if there is no alternative available (such as drinking water supply), all sections of the population use the public services. Effectiveness of the public services depends on the nature of supply of the services on one hand and the actual use of the services by the people, on the other. A gap exists between the two, either because of the unreliable supply of the public service (in terms of time, frequency and quality) or non-utilisation due to lack of

[3]The Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) and the National Health Mission (NHM) focus on the districts as the point of service delivery.

knowledge. Sen (1992) also points to the reduction of the gap between the availability of the public service and its utilisation by the deprived sections of the population, with an increase in public awareness and increased educational levels. Economically backward regions also tend to have a concentration of less educated people and lower levels of utilisation.

The motivation for using the district as the unit rather than separating it into rural and urban areas is based on several aspects of the current scenario in India relating to agriculture and public services. As agricultural transformation takes place and processing of agricultural products, both food and non-food, gain importance, the traditional break- up into agricultural and non-agricultural, or rural and urban, loses its relevance (Timmer and Akkus 2008). The structural transformation of agriculture in India seems to have spillover effects, which are important drivers of the rural non-farm sector in India (Binswanger-Mkhize 2013). Secondly, due to better connectivity, small towns and semi-urban centres attract trading hubs, processing units, poultry and dairy units and peri-urban agriculture, and they are very much a part of agricultural production and processing. A district is a contiguous agro-climatic region, and the characteristics related to rainfall, water availability, soil type, population density, etc., tend to outline a unique development path to both rural and semi-urban areas. Finally, the public services, especially the fair price shops for foodgrains, the primary health centres, government hospitals, referral services, etc., may be located in small towns (mostly at the district headquarters) and as awareness and affordability and connectivity increase, used by the rural population,, though facilities within the village are important for the deprived sections of society. Hence, there is merit in keeping the district as the unit for the analysis.

It is useful for a study of this nature to link the three components – child underweight, agriculture prosperity and public provisioning – and arrive at some elasticity estimates. It can make a useful contribution to evidence-based policy making to assess and understand the impact of the complementarities of different policy interventions as well as the obsoleteness of some.

In this study, land productivity has been used to capture the role of agriculture in reducing undernutrition. The motivation for using the value of land productivity per hectare of cultivable land to represent relative agricultural prosperity is to include the possibility of intensive as well as extensive use of land resources for dairy, poultry, livestock grazing, fodder collection, etc., in addition to crop production. Ideally, even inland fisheries will have to be included. However, data was not amenable for such analysis.

Production either for self-consumption or for the market, whether mono culture or a diversified cropping system, benefits producers and agricultural wage labourers, in addition to non-agricultural workers linked to agriculture through backward and forward linkages (Timmer and Akkus 2008). This study tries to capture the agricultural system for nutrition as well as for enhanced income in a single indicator, viz., the value of land productivity per hectare at constant prices. Land productivity in this study is the three-year average value (at constant prices) of agricultural gross domestic product per hectare of cultivable land in the district.[4] The value of non-food crop production, food crop production and livestock production (including dairy and poultry) is a part of District Gross

[4] Cultivable area includes net sown area, cultivable waste (permanent and currant fallows) and area under miscellaneous crops not included under the net sown area. This pretty much includes all land used for the production of crops and livestock products.

Domestic Product from agriculture.[5] Land productivity depends on major agriculture-related aspects such as rainfall, irrigation, land inequality, food and non-food production. The study estimates land productivity as a function of factors that influence agriculture.[6]

The focus is on modeling the rate of children with normal weight-for-age, across districts, while allowing for the assumption of possible endogeneity of land productivity, one of the explanatory variables in this model. Land productivity, a proxy for agricultural prosperity, is conceptually endogenous as it influences prosperity of the households, directly or indirectly, which in turn would influence underweight. The suitable econometric technique to estimate this empirical relationship is discussed in Section 4 on data and methodology.

4 Factors linked to Child Undernutrition

4.1 Agriculture-nutrition link

Most of the literature on child nutrition concentrates on child care by women, health aspects of women and children, and access to sanitation and safe water. Few studies have explored the agricultural link. The evidence from literature in India on the influence of food and agriculture on child undernutrition rates is inconclusive. Bhagowalia et al. (2012) using India Human Development Survey (IHDS) data showed that agricultural income did not have any positive impact on poverty reduction or reduction in underweight and stunting. On the other hand, non-agricultural income was associated in rural areas with better nutritional outcomes. Similar conclusions were drawn by some other studies. Galab and Reddy (2012) have indicated that households who sell their produce in the market rather than those who predominantly consume from the market had lower underweight rates among children.

The evidence on linkages between agriculture and nutrition in India was examined across seven pathways under the project 'Tackling the Agriculture and Nutrition Disconnect in India (TANDI)' and was found to be weak (Gillespie and Kadiyala 2011, Kadiyala et al. 2014). The state-level study using a single cross-section data concluded that both overall agricultural growth and foodgrain production growth are not necessary conditions for nutritional improvement in India (Headey et al. 2011). The study however found that, at the state level, agricultural GDP per worker and non-agricultural GDP per worker have significant negative associations with stunting but not with underweight.

A panel data fixed effects model at state level using data for two time periods showed significant negative association of agricultural worker productivity as well as land productivity with the proportion of stunted children and the proportion of underweight children in the rural areas (Vepa et al. 2014). Production of food grains per capita did not show any significant association with stunting rates but showed significant association with underweight rates. On the other hand, agricultural growth in the preceding five years showed a significant negative association with stunting rates but not with underweight rates.

[5] Land productivity, taken as an indicator to represent agricultural prosperity is not amenable to the inclusion of fisheries. In the context of farming system for nutrition, inland fisheries are more relevant but the value of inland fisheries and marine fisheries are not available separately from the data sources for our purpose. Further, the inland water bodies are not included in the land area.

[6] Appendix B elaborates the variables included in the land productivity equation.

Further, a cross-section district-level study shows a significant negative association of agricultural worker productivity with underweight rates for the district as a whole as well as the rural areas. However, the quantile regression analysis shows insignificant association of worker productivity with underweight children, especially after controlling for female work participation rates (Vepa et al. 2016). Agricultural land productivity seems to help reduction in child underweight rates at the district level in all quantiles (Vepa et al. 2015).

The evidence of specific interventions in agriculture meant to enhance nutritional outcomes of adults and children is largely lacking with a few exceptions, primarily due to poor evaluation (Ruel and Alderman et al. 2013). The only success has been that of orange-fleshed sweet potato in improving vitamin A levels in Africa (Nestel et al,.2006). A number of studies that tried to link food production through interventions at the household level with the nutritional outcome of women and children in the developing world did not find a convincing link due to methodological limitations (Girard et al. 2012). However, using IHDS household level data, Viswanathan (2015) has shown that agricultural production diversity could positively impact women's BMI at the household level by improving dietary diversity.

4.2 Public provisioning of food and its link to nutrition

Public provisioning of food is expected to improve calorie intake by the poor and help address child undernutrition; it is however difficult to capture the impact when studied across all income classes. We often find higher levels of undernutrition among users of the public distribution system, who are essentially poor. Kaushal and Muchomba (2013) found that increase in food subsidy after expansion of the targeted public distribution system (TPDS) in 2002 had a negligible to negative effect on calorie and protein intake and no statistically significant effect on fat intake. An earlier study by Kochar (2005) has shown a small effect of PDS subsidy on calorie intake. Some other studies have concluded that PDS did not have much of an impact on calorie consumption. A study on review of existing literature on food-based interventions observed that limited benefits accrued to younger children in the households exposed to PDS services for longer durations (Ruelet al. 2013). The study opined that poor service quality and weak goal setting probably explain the lack of overall nutritional benefits.

However, some studies with more recent data, especially after the food price crisis, found PDS to have positive impact on food consumption. Based on a primary survey in three states, Jha et al (2011) concluded that calorie intake and other nutrient intakes improve with participation in the PDS. Participation in the PDS has been instrumented with other variables satisfying the exclusivity criteria. Khera (2009) found that better access to subsidised rice from fair price shops resulted in major reduction in self-reported measures of hunger in Chhattisgarh. Kaul (2013) estimated that an increase in the value of the PDS subsidy by 1 per cent increases caloric intake by 0.144 per cent, while an increase of 1 per cent in income (expenditure) is associated with an increase of 0.4 per cent in caloric intake. Her projections suggest that implementation of the National Food Security Act will increase the per person caloric intake of the present beneficiaries of the programme by 72 calories per day in urban areas and 66 calories per day in rural areas. It has been realised that calorie-income elasticity varies over a large range – from negligible in Behrman and Deolalikar (1987) to 0.30 - 0.50 in Subramanian and Deaton (1996). Even if calorie-income elasticity is low, the effect on undernourishment may be large if the density of people is high in the neighbourhood of the calorie requirement norm (Ravallion 1990). The suggestion is that, perhaps, the elasticity changes, depending on grain prices and the level of deprivation. Even if calorie-income elasticity is low, there are grounds for optimism about the prospect of eliminating nutritional deprivation by raising incomes of the poor through subsidised PDS grain (Jha et al. 2011). Studies have shown that subsidised grain and effective income transfers could translate into additional nutrient intake. Kishore and Chakrabarti (2015) noted that households in Chhattisgarh used money saved from access to PDS rice to spend more on pulses, edible oil, vegetables, sugar and non-food items.

In the present study, effective PDS implementation by state governments is taken as a variable for all the districts in the state. The percentage of offtake (grain lifted by the state government from the storage houses of the central government) as percentage of the total foodgrain allotment made by the centre to the state indicates the commitment of the state government to distribute the available grain to its poor. With the introduction of the TPDS, offtake was higher for the Below Poverty Line category. The introduction of TPDS has also led to the perverse outcome where allotment of foodgrains was increased to states with weak delivery systems and reduced to those with greater administrative efficiency, since the allotment was based on the prevailing poverty levels in the state. In some states like Bihar, the offtake is very low at 50 per cent of allotment, while in Andhra Pradesh it is close to 100 per cent. Across states and over time, the percentage of allotment to offtake varies (Ministry of Consumer Affairs, Food and Public Distribution).[7]

4.3 Public provisioning of water, sanitation and health (WASH)

Much of the undernutrition currently prevalent in the children of developing countries is attributable to conditioned malnutrition arising from infections (Gopalan 2014). Access to sanitation and safe drinking water has been identified by researchers as a key factor in reducing stunting and underweight (Bhagowalia et al. 2012; Spears 2013). Hammer and Spears (2013) have shown that a gain of approximately 1.3 cm in height is possible in a four-year-old child with the provision of safe sanitation in the child's immediate environment. Improvement in water and sanitation lowers the incidence of diarrhoea by 7-17 per cent and reduces the risk of under-five child mortality by about 50 per cent (Fink et al. 2011). A district-level study has indicated that sanitation represented by the percentage of households using toilets has a significant positive influence on reducing child underweight (Vepa et al. 2016). Even if access only to shared toilets (which are less hygienic than own toilets) is considered, the influence on underweight rates appear to be positive compared to no toilets (Vepa et al. 2015). However, the percentage of population using piped water was found to be either insignificant or had a negative impact on child underweight (Vepa et al. 2016; Vepa et al. 2015).

As per the 2009 UNICEF/WHO report on diarrhoea, the food absorption capacity of children declines with diarrhoeal infections. This may result in undernourishment and underweight. Remedial measures such as administration of oral rehydration salts can substantially prevent survival risks (UNICEF/WHO 2009). District-level studies indicated that both percentage of children with diarrhoea below the age of three (Vepa et al. 2015) and percentage of pregnant women with anaemia increase the underweight rates (Vepa et al. 2016)

Access to health facilities such as primary health centres, doctors and hospitals as well as compulsory maternal and child referral programmes go a long way in improving child nutrition. A number of studies evaluating the National Rural Health Mission (NRHM) felt that it has been ineffective in improving the health service delivery in India (Paul et al. 2011). A critical review of the

[7] http://dfpd.nic.in/allocation-offtake.htm

primary health care system in rural India describes it as dysfunctional (Antony 2014). Another evaluation study of the national rural health programme has noted that lack of functioning primary health centres in the villages as also the distance involved in reaching the centres for referral are deterrents for many women and children to attend the pre-natal and post-natal referral programmes that could improve child health. However, the study also noted that the presence of an accredited social health activist (ASHA) and ICDS *anganwadi* workers in the villages have been effective in spreading health awareness among women about maternal and child care, vaccination, use of oral rehydration salts, etc. (GoI 2011).

Corresponding with the above finding, the district-level study using DLHS-2 data has shown that the presence of any government facility ─ primary health centre, sub-centre, community health centre, referral hospital, government hospital, and government dispensary ─ within the village has positive influence on child underweight rates. The study also showed that vaccination and use of oral rehydration salts for children improve child nutrition (Vepa et al. 2015). Another study based on district health survey data of two rounds DLHS-2 and DLHS-3 has concluded that the safe motherhood programme (*Janani Suraksha Yojana*) that gave cash transfers, conditional on compulsory attendance at the referrals, reduced maternal mortality in India (Lim et al. 2010).

When we consider health, most important is maternal health. The health status of mothers is another important variable that could reduce child underweight. The adverse influence of maternal ill health (such as iron and folic acid deficiencies), especially that of expectant and lactating mothers, on child undernutrition has been evident for a long time now (Viteri 1994).

4.4 Women's education and awareness about health and public services

There is a large body of evidence on the impact of women's education and employment on the nutritional status of children (Mishra and Retherford 2000; Maitra 2004). A district-level study of about 521 districts recorded the positive influence of education at secondary level and above. The quantile regression results also showed women's education above secondary level reduces child underweight rate in all child nutrition quantiles, both in the rural and district samples (Vepa et al. 2016)

Studies focusing on districts as the units of analysis are very few in India (Naandi Foundation 2011 and Dreze and Khera 2012) and among them even fewer have assessed the role of agriculture as an important pathway in reducing undernutrition. This study, unlike earlier studies (Vepa et al. 2014, & 2015 and Galab and Reddy 2012), estimates the elasticity of child underweight with respect to agricultural prosperity and public provisioning of food and WASH.

The available data set provides information only on underweight rates of children below six years of age across these districts; data on two other commonly used indicators of child undernutrition, stunting and wasting, are not available at the district level.[8] The analysis has been carried out for the percentage of children underweight for age, who are above the threshold of two standard deviations

[8]Complete data sets are not yet available from the more recent round for DLHS-4 (2011-2003) and hence the study pertains to district level data for an earlier period (2002-04) covering 593 districts as per the 2001 Census.

of the reference age-specific mean standards of WHO (2006).[9] The next section discusses the data and methodology used in this study.

5 Data and Methodology

As mentioned earlier, the unit of analysis is the district, with focus on the proportion of children who are not underweight (the main dependent variable) in the age group of six years or below, from the second round of District Level Household Facility Survey (DLHS-2) for the year 2002-2004.[10] The data of DLHS-2 pertains to children below the age of six, while most surveys (e.g., IHDS and NFHS) give data on children below the age of five. At the state level, the difference between underweight rates for children below 5 years and below 6 years was not much.

As is found in respect of many cross-country studies, the data for the variables used in the study pertain to different years, though not to different time periods. This cannot be helped in a situation where surveys are not conducted in the same year. However, all the data pertains to the years falling between 2002 and 2004, except the land inequality data that pertains to 2006. The assumption is that year-on-year variations in agricultural data are not important as we average the agricultural data over three years. Land inequality is generally stable for longer time periods. The data on underweight and public provisioning of services pertain to the same year.

Though the common practice is to use underweight rates directly in the analysis, in this study we have preferred to use the percentage of children *above* 2 standard deviations in z-score. This has been referred to in the study as children's normal nutritional status or CNS for short. However, we caution the reader that this normal nutritional status is only with respect to weight and that the nutritional status of the child with respect to stunting, wasting, anaemia, etc., may or may not be normal. Better child weight status helps to reduce the incidence of stunting and wasting. Unfortunately, although this district-level information dates back to more than a decade, it is the most recent data set that provides information on CNS across districts that also covers large parts of India.[11] Despite the limitation of being dated, the relevance of this study remains in documenting empirical evidence that establishes a firm association between agriculture and undernutrition; this has been ambiguous for India in earlier studies based on data on individual children from household surveys.

Though undernutrition rates have shown a slower rate of decline in rural areas and show a higher prevalence rate, we focus on combined rural and urban rates of undernutrition, as improvements in the performance of agriculture is known to have economy-wide benefits in India.

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[9]That is, the focus is on percentage of children who are in the normal range rather than underweight rate as the explained variable.

[10] A child is referred to as low-weight-for-age if its weight is below -2 standard deviations of the reference weight for age as specified by the World Health Organisation (WHO). Thus for a given district the percentage of children whose z-score is below -2 are defined as moderately and severely undernourished. In DLHS-2, children below the age of six years had been considered for assessing the undernutrition rates among children.

[11]The more recent DLHS-4 for the year 2011-2012 contains information for 336 districts for 26 states and excludes 8 Empowered Action Group States (Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Uttaranchal, Orissa and Rajasthan) and the state of Jammu & Kashmir. The fact sheet for the state of Gujarat is also not available from the website; see Appendix table A1. Further, the unit record data has not yet been made available as per the data request form (http://www.iipsindia.org).

The covariates used to explain the variations in CNS are concerned with:

- Agricultural prosperity (represented by land productivity)
- Indicators of maternal health and child health, (percentage of pregnant women with anaemia and incidence rates of diarrhoea in children below three)
- Access to basic amenities of sanitation and water supply (percentage of the rural population with access to toilets and water supply)
- Access of the rural population to any one of the government facilities within the village (percentage of rural population with access to any one of the 7 specified government facilities within the village)
- Adoption rates of recommended child health practices (percentage of children who received full vaccination and percentage of children administered with oral rehydration salts for diarrhoea)
- Implementation effectiveness and commitment of the state governments to public distribution of the foodgrains to the poor (percentage of offtake to allocation)
- Women's education at secondary level or above that helps knowledge of child care as well as utilisation of public services available (percentage of women with education at secondary level or above).

A brief discussion about the data sources and the nature of these variables is in order. The reference period for the data was 2002-2004 or any year close to it when data were not available for the relevant years. Most of the data for the child nutrition equation is from District Level Health Survey-2 with the reference period 2002-04. Agricultural variables are either from the Ministry of Agriculture and Co-operation for the years 2002, 2003 and 2004, or from the Agricultural Census of 2005-06. The data for all the other variables in the equation, except the variable related to agriculture and the public distribution system, are from the DLHS-2.

The three-year average (of 2002, 2003 and 2004) value of land productivity at constant prices per hectare of cultivable area in the district represents agricultural prosperity of the district. The three-year average value of district GDP from crops and livestock products divided by the three-year average of cultivable area (consisting of net area sown, all fallow land and area under miscellaneous crops not included in the net area sown) gives the land productivity per hectare. District GDP data for three years at constant prices are from *Indicus Analytics* that compiles district data from the Central Statistical Organization. Land data for three years are from the Ministry of Agriculture and Cooperation. **Appendix B** gives the details of the variables that explain land productivity at the district level along with the details of data sources.

The proportion of women who have completed education up to secondary level or above captures the role of women in ensuring better child health outcomes in terms of child nutrition status. This represents women's positive agency effect on child nutrition.

Provisioning of basic amenities like sanitation and water reflects not only the economic prosperity of the districts, as better-off households usually have better quality amenities, but also captures the role of the individual state and its quality of governance in making this accessible to a larger section of the population. On the one hand, the level of private household incomes plays a significant role in accessing these facilities, but if certain districts have better administration for the provision of these facilities, then less prosperous households in that region would also benefit. The percentage of population without toilet facilities (open defecation) and the percentage of population with access to public toilets in the districts are the two variables that capture the quality of sanitation facilities. They are important in explaining the variations in CNS.

The percentage of population with access to safe water supply is another variable that could explain the variations in CNS. In India, officially, the term "safe water supply" only means piped water or well water mostly supplied by the public authorities, but the definitions vary from state to state; sometimes they include wells and sometimes they do not. Safe water supply does not refer only to the water treated for safety but also includes untreated water sources. To make the variable uniform, all wells (both public and private) as well as piped water from the government and private sources have been included and referred to as non-natural sources of water.

The percentage of pregnant women reported as moderate to severely anaemic in the district captures mothers' health. The percentage of children (under three) with diarrhoea to the total number of children captures child health status. The prevalence of diarrhoea is known to reduce nutrition absorption and hence lower the nutritional outcome. Since younger children are more prone to diarrhoea, the age of children to assess diarrhoea rates is restricted to below three years (rather than up to six years, the age of the children considered for CNS in this study). We expect both these health-related variables to have a negative impact on inter-district variations in CNS.

As mentioned in the objective, the intention of this study is also to understand the impact of certain intervention policies on CNS captured by the use or access to a government facility or a desirable action promoted by the state. One such variable is the interaction between percentage of children administered oral rehydration salts (ORS) solutions and the rate of prevalence of diarrhoea in that district. The interaction of these two variables is considered as the need to use ORS (which would arise when the child is affected), so that if the interaction coefficient is statistically significant with a positive sign, then it implies that the use of ORS reduces the impact of diarrhoea on CNS after controlling for diarrhoea rate.

The rate of incidence of anaemia among expectant mothers or use of ORS (or the lack of it) for a diarrhoea-affected child, once again occurs as a combination of the use of either a private facility or a public service. Income of the households and their education level, on the one hand, and the awareness created by state agencies in making the households aware about these aspects, on the other hand, result in a positive impact on child nutrition. This changes the situation for the better. Thus, a less- economically prosperous district could have lower prevalence rate of anaemia among pregnant women as well as higher use of ORS (in the presence of diarrhoea) due to the intervention of government awareness programmes through, for instance, ASHA workers or *anganwadi* workers.

Another variable known to reflect effective state involvement is the proportion of fully vaccinated children. All children between the age group of 12-23 months in a district who receive BCG, three shots of DPT and a booster shot, and the vaccination for measles have been considered as being fully vaccinated. The local administration has a role in the provision of better quality health services, as well as better awareness creation on the need for timely vaccinations for children. Hence, this variable is also used in explaining variations in CNS.

Apart from this, any government health facility located in the village provides timely health care to the deprived sections. Any government health facility in the DLHS-2 data refers to the presence of one of the following centres within the village: primary health centre, sub-centre, community health centre, referral hospital, government hospital, government dispensary and *anganwadi* centre. Population with access to any one of these facilities as a percentage of total population has been taken as an explanatory variable that could improve child nutrition. These facilities provide timely care in disease prevention or its timely cure, and hence have an impact on CNS.

Better functioning of PDS in a district implies regular access to subsidised foodgrains through fair price shops. On the one hand, this would impact protein-energy malnutrition due to regular consumption of cereals, pulses and oil as there is access to food at a subsidised price. On the other hand, there is an implicit income transfer to the household due to the subsidised price of these commodities, due to which the households can spend on other essential food and non-food commodities that may also add to the reduction of CNS. However, district-level information on the proportion of households consuming from PDS is not available, though the proportion of households holding a ration card is available from DLHS-3. We preferred not to use access to BPL cards, as that need not reflect purchase of commodities. Instead, we used the percentage of offtake of cereals from the central pool as a proportion of the allocation to the state in which these districts are located, so that one would expect larger distribution across the districts. The data pertaining to the year 2004-05 on the proportion of offtake to allocation is from the Ministry of Consumer Affairs, Food and Public Distribution.[12]

Due to the potential endogeneity of the agriculture variable, we consider estimating the CNS model using three stage least squares (3SLS) that allows endogeneity. The agriculture equation or the first stage equation has six variables as elaborated in the **Appendix B** and 13 agro-climatic regional dummy variables.

The empirical relationship between nutrition and agriculture has been estimated using a two-equation framework as given below:

(1) $CNS_i = \alpha_1 + \beta A_i + \boldsymbol{\gamma X} + e_{1i}$, (2) $A_i = \alpha_2 + \boldsymbol{\delta Z} + e_{2i}$

Where $CNS_{i=}$ Percentage of children (0-59 months) with normal weight for age in the i^{th} district.
$A_{i=}$ Agricultural variable captured by land productivity in the i^{th} district.
X and **Z** are the vector of other covariates that influence CNS and A, respectively, and have been discussed earlier in this section. All the variables are in the logarithmic form so that the estimated coefficients from the regression are interpreted as the elasticity of that variable to CNS (or land productivity). In equation (1), CNS is influenced by agriculture (A_i) and due to its possible endogeneity, equation (2) captures the variables that determine A_i i.e., land productivity. This two-equation model is estimated using 3SLS approach. The 3SLS method accounts for the covariance across equation disturbances while providing the instrumental variable estimates. This modeling framework not only tries to capture the nature of relationship between child normal weight rates and land productivity at the district level after controlling for other variables, but also informs us on some possible factors that influence land productivity. Further, all the variables that are included in the agricultural equation, with the exception of women's education, act on the child nutrition equation only through land productivity of the agriculture equation. Even if efficiency of the district governance is an important input, governance related to agriculture will act only through land productivity. The aim is to study the association of land productivity (assumed to be a proxy for agricultural prosperity) and public provisioning of services with child underweight rates at the district level. The next section discusses the main findings of this empirical analysis.

[12]http://dfpd.nic.in/allocation-offtake.htm

6 Results

In **Appendix A, Tables A2** and **A3** present the descriptive statistics of the variables in the level form and its logarithmic transformation (as used in the regression models), respectively. **Table A4** presents the correlation between the variables used in the model. The magnitude of the correlation rarely exceeds 0.5 and hence the problem of multi-co-linearity is not an issue among the explanatory variables. If the correlation between the CNS rate and other explanatory variables is gleaned (as in the first column), then we notice that districts with lower share of agricultural GDP have a higher percentage of CNS while regions with higher average land productivity have higher CNS. Most of the explanatory variables considered for the analysis have statistically significant pair-wise correlation with CNS.

The results of the agricultural equation given in **Table 1** show that the estimated coefficients behave as expected. Rainfall and irrigation (after controlling for the other one) has an elasticity of about 0.36 and 0.13, respectively. The signs and magnitude in **Table 1** indicate that most areas are still rain-fed and, among them, those with higher rainfall have higher elasticity towards land productivity. As for irrigation, once rainfall is controlled for, the elasticity is almost one-third of that for rainfall. Though inequality in land holding is insignificant, it has a negative relationship with land productivity as may be expected. The proportion of area under non-food production has an elasticity of 0.12 after controlling for other variables. In comparison to this, the triennium average of per capita foodgrain production has a large elasticity of 0.389, implying that productivity gains are higher in regions with higher per capita foodgrain availability; it implies higher yields, which can lead to enhancing income-generating economic activities.. Finally, the elasticity of women's education, which also promotes technology adoption and skill acquisition for expanding agriculture, is significant and positive, and fairly high at 0.37. This co-efficient being a proxy for education of men (as the areas with higher education among women would also tend to have a high level of men's education) also captures men's education. The coefficients of the zonal dummy variable are largely significant, keeping the Central Plateau Hills Region with lowest productivity as the base reference. About 60 per cent of the variation in land productivity is accounted for by the variables chosen. Land productivity in value terms has higher elasticity with respect to rainfall, foodgrain abundance, and education levels.

Table 1 Estimated coefficient of agricultural land productivity across districts of India, 2002-2004

Variable	Coefficient	p-value
Triennnium average annual rainfall (in mm)	0.3658***	0.000
Percentage of area irrigated to total cropped area	0.1354***	0.000
Gini coefficient of operational land holdings	-0.0459	0.754
Percentage of area under non-food crops to total cropped area	0.1238***	0.000
Triennnium average annual foodgrain production per capita (tonnes / capita)	0.3899***	0.000
Percentage of women with secondary education and above	0.3719***	0.000
East Coast Plains & Hills Region	0.5671***	0.000
Eastern Himalayan Region	0.7753***	0.000
Eastern Plateau Hills Region	0.5526***	0.000
Gujarat Hills & Plains Region	0.6815***	0.000
Middle Gangetic Plain Region	1.0040***	0.000
Southern Plateau Hills Region	0.3691***	0.000
Trans-Gangetic Plain Region	0.8263***	0.000
Upper Gangetic Plain Region	0.9756***	0.000
Western Dry Region	-0.5271***	0.001
Western Himalayan Region	0.7546***	0.000
Western Plains & Ghats Region	0.4193***	0.008
Western Plateau Hills Region	0.2242***	0.031
R^2	0.5986	

Note: The dependent variable is logarithm of three-year average of land productivity.

Table 2 reports the results for the second equation, explaining the variations in proportion of normal children. Land productivity is a significant variable in explaining CNS with an elasticity of 0.08; 1 per cent increase in land productivity increases the percentage of nourished children below six year by about .08 per cent. Higher level of women's education has a positive impact while the higher rate of anaemia among pregnant women has an adverse impact on CNS, as may be expected. Higher rates of open defecation contribute to a (negative) elasticity of -0.07, while the coefficient of the percentage of shared toilets is not significant. Since the data on quality of sanitation has been categorised into open defecation, shared toilets and private toilets (which is not included to avoid perfect co-linearity), the insignificance of the coefficient of shared toilets shows that even that could be better in comparison to open defecation. Source of drinking water did matter once other variables are controlled for. It may have been expected that diarrhoea prevalence rate (among 3-year-olds and below) is higher in regions with larger rates of open defecation, so that it may not be significant. However, this is not the case and the magnitude of this elasticity is highest after controlling for other variables.

What is relevant from a policy perspective is that if there is higher rate of use of ORS in the presence of diarrhoea (this is an interaction variable), then it improves the child's nutritional status.

Access to government health facilities also contributes to the reduction in underweight rates with an elasticity of 0.07. Districts in the states with higher PDS offtake also show a better rate of CNS.

Thus, once again, it is substantiated that if policy implementation is better at a sub-national level, it has a clear impact in reducing underweight rates. In the CNS equation, the state dummies were not included as the PDS offtake is at the state level and causes perfect co-linearity. However, when zonal dummy variables were included, most of the coefficients in CNS – except education, anaemia and any government health facility variable, –, were insignificant and the overall goodness of fit of the model also improved. This clearly indicates that regional aspects encompass a large information base that captures institutional features and economic prosperity. Despite its better explanatory power, we do not prefer this model as it provides less information as to what features we could focus on in improving service delivery or programme implementation so that CNS is higher or underweight rates are lower.

Table 2 Estimated coefficients of child nutrition status across districts

Variable	Coefficient	p-value
Land productivity per hectare (value in Rs. /hectare)	0.0822***	0.005
Women with secondary education and above (per cent)	0.0815*	0.065
Prevalence of anaemia among pregnant women (per cent)	-0.0553**	0.037
Households with non-natural water (per cent)	-0.0117	0.859
Households without access to any toilet facility (per cent)	-0.0740***	0.001
Households with access to shared (public) toilet facility (per cent)	-0.0073	0.588
Prevalence of childhood (under 3 years) diarrhoea (per cent)	-0.1211***	0.001
Interaction between ORS and diarrhoea	0.0852***	0.003
Children fully vaccinated (per cent)	0.0622**	0.012
Population with access to any government facility	0.0720**	0.021
State's PDS grain offtake to allocation (per cent)	0.0019**	0.028
Intercept	3.1928***	0.000
R^2	0.2911	

7 Conclusions

Most of the literature on child underweight in India concentrates on child care by women, health aspects of women and children, and education of women. The level of sanitation and availability of safe water have also received attention in explaining child undernutrition. Given a predominantly agricultural setting, and that undernutrition rates are more persistent in rural areas, this study examined the impact of agricultural land productivity in explaining child underweight rates in India. Alongside this, the study also focused on public provisioning of amenities like water, sanitation, and health care facilities as well as the policy of provisioning foodgrains through PDS. It is observed that the variations in access and the quality of services depend primarily on governance and efficiency of the administrative system.

A district-level study as opposed to a household-level study helps capture spillover effects of agriculture and policy issues of public provisioning in a better manner. At the district level, it has been possible to combine the data sets from different surveys pertaining to agriculture, which is not possible at the household level. This study, using district-level variations in underweight rates, has been able to establish the beneficial impact of agricultural prosperity on children's underweight rates across districts of India based on data for the early part of the previous decade.

The major contribution of this study is in establishing the child-nutrition-to-agriculture linkage in the case of India, which was suspected to be very weak. It shows that an increase of 1 per cent in agricultural land productivity with its spillover effects could result in 0.08 per cent improvement in child nutrition, after controlling for factors related to public provisioning, women's health and children's health, and women's education. It appears that the association of land productivity to child nutrition is more obvious in the district context than in the household context. This is because it may be possible to identify convergence of various factors that interact with one another to produce better outcomes at the district level.

As expected, variables in the land productivity equation show large elasticity estimates. As has been explained in **Appendix B**, the variables capture both direct and indirect effects. In this sense, agriculture has an indirect effect largely coming from improvements in net agricultural income or agricultural wages and allied activities due to improved productivity. Economists have already observed the phenomenon in India in the faster growth of rural non-farm employment. The increased productivity would also improve the supply of food so that access to nutrition-dense food such as milk and poultry increases for all. The results seem to suggest that foodgrain abundance and low prices would benefit all, along with wage and non-wage spillover benefits from non-food crops and forward and backward linkages of agriculture to non-farm employment.

At least the 2002-04 data supports this view, though it is not possible to hypothesise that land productivity is the key variable that can capture the agriculture –and-child-nutrition association effectively. More research is needed in this area.

The relevance of public provisioning and the quality of the implementation of services that have a direct impact on children's nutritional status comes out again. The study clearly shows the contribution and convergence of several factors to bring about better outcomes. The results emphasise the points that creation of public awareness in terms of full dose of vaccinations, oral rehydration in emergencies, etc., contribute to better child nutrition. Public health facilities situated within the villages can go a long way in improving child nutrition in the district. Public provisioning is more important for the rural poor and hence the National Health Mission should be taken more seriously. A state's commitment to public distribution of food to the poor has also been found to be relevant for child nutrition.

Considering that the explanatory variables in the second equation do have a significant influence on the proportion of normal children in the district, even lower levels of elasticity — as low as 0.08 and 0.07 — may mean larger gains over time, if the influence is at the margins where the deprivation is high. For example, any government facility in rural areas has an elasticity of 0.072, full vaccination elasticity of 0.06, and use of oral rehydration salts in diarrhoea incidence an elasticity of 0.085. Public provisioning of food, health, water, and sanitation services along with land productivity could bring about substantial improvements in child nutrition, since these variables impact marginal groups with less income and poor health status.

The results of the study also emphasise the need for convergence of the efforts related to economic development along with those of public provisioning for better child nutrition outcomes. States in India are very large and there is substantial inter-district variation within a given state in terms of agro-climatic conditions, level of prosperity of agriculture, urbanisation and socio-cultural features, thereby contributing to large variations in economic and human development between districts.

Consequently, the role of the district administration is increasingly becoming important in the implementation of both central and state schemes that focus either on agriculture or on undernutrition. There is need to pay more attention in linking agricultural development efforts to public provisioning of food, health care, sanitation and water, especially in rural areas where undernutrition rates are more persistent. Improvement of water supply and sanitation remains a major concern at the district level, as pointed out by other studies.

It should be increasingly possible to use child-specific and region-specific information from *anganwadi*s and other health centres to have a better-targeted intervention in pockets of high undernutrition. Regional-level analysis is also useful in policy interventions that focus on improving land and labour productivity, as farming households depend on regional soil and weather conditions. Thus, the results of the study demonstrate the possibility of big gains in child nutrition, where agricultural development efforts converge with public provisioning efforts.

APPENDIX A

Table A1 Child underweight rates in states of India in the decade of 2000

	RSOC$	DLHS-4$	AHS$	NFHS-3$	DLHS-2$	DLHS-2#
	2013-14	2011-13	2012-13	2005-06	2002-04	2002-04
Andhra Pradesh	22.3	27.3@		32.5	43.5	42.3
Arunachal	24.6	27.3		32.5	22.2	20.3
Assam	22.2		30.8	35.4	33.2	32.2
Bihar	37.1		40.3	55.9	54.3	54.6
Chhattisgarh	47.1		39.4	33.9	48.2	47.4
Goa	16.2	29.5		25.0	28.4	30.0
Gujarat	33.6	NA	NA	44.6	44.9	46.0
Haryana	22.7	36.2		39.6	37.2	35.6
Himachal	19.5	28.5		36.5	37.4	36.4
Jammu and Kashmir	15.4	NA	NA	25.6	29.3	22.6
Jharkhand	42.1		45.7	56.4	52.1	52.2
Karnataka	28.9	29.7		37.6	44.1	44.8
Kerala	18.5	20.9		22.9	35.2	35.8
Madhya Pradesh	36.1		40.6	60.0	53.9	55.4
Maharashtra	25.2	38.7		37.0	46.4	47.7
Manipur	14.1	27.4		22.1	15.0	12.6
Meghalaya	30.9	30.5		48.8	36.4	34.9
Mizoram	14.8	27.2		19.9	16.8	15.2
Nagaland	19.5	25.5		25.2	22.8	21.4
Odisha	34.3		38.9	40.1	43.0	42.8
Pondicherry		23.8			26.8	26.8
Punjab	16.0	25.2		24.9	41.5	40.0
Rajasthan	31.2		36.6		61.4	58.3
Sikkim	15.8	23.6		19.7	12.9	9.7
Tamil Nadu	23.3	32.5		29.8	39.9	38.3
Tripura	30.5	27.7		39.0	33.2	30.2
Uttaranchal	20.6		28.0	38.0	59.5	55.3
Uttar Pradesh	34.3		44.9	42.4	57.2	52.6
West Bengal	30.0	37.4		38.7	43.6	44.9

Source:$: 0-59 months; #: 0-71 months (1) RSOC- Rapid Survey of Children for 2013-14 [http://www.wcd.nic.in/]; (2) DLHS-4 District Level Household and Facility Survey for 2012-13 [http://rchiips.org/DLHS-4.html]; (3) AHS:[http://www.censusindia.gov.in/2011census/hh-series/cab.html]; (4) NFHS-3National Family Health Survey for 2004-05 [http://rchiips.org/nfhs/report.shtml]; (5) DLHS-2 Level Household and Facility Survey for 2002-04 [http://rchiips.org/PRCH-2.html]; (6) For DLHS-2 the underweight rates for 0-59 months was calculated from raw data and for 0-71 months was taken from the published reports; (7) NA- Not Available. The numbers for these two states were not reported by either of the two agencies in the respective website.

Table A2 Descriptive statistics of the relevant variables (in level form)

	Sample Size	Mean	Stand. Devn.	Minimum	Maximum
Percentage of normal weight	524	53.78	14.465	4.00	98.20
Percentage of agricultural in district domestic product (DDP)	524	18.86	10.327	0.65	46.90
Triennium land productivity (Rs./hectare)	519	24.97	19.092	0.90	146.00
Triennium agricultural DDP/worker (Rs./person)	524	22.65	28.454	1.00	474.00
Triennium average annual rainfall (mm)	524	1070.92	685.320	137.45	4869.75
Percentage of area under irrigation to gross cropped areas	522	41.36	28.994	0.00	104.56
Gini coefficient of operational land	523	0.48	0.078	0.10	0.83
Percentage of area under non-food crops to gross cropped areas	523	20.25	18.939	0.14	86.43
Triennium average foodgrain production per capita (tonnes/capita)	522	224.74	223.114	2.53	1683.19
Triennium average DDP from livestock	524	0.00	0.001	0.00	0.01
Percentage of women with secondary and above education	524	30.42	13.964	5.84	91.83
Percentage of rural women with secondary and above education	524	21.74	14.977	1.79	91.48
Prevalence of moderate and severe anaemia among pregnant women (per cent)	517	41.84	19.703	0.00	100.00
Households without access to any toilet facility (per cent)	524	58.73	22.295	0.00	94.12
Households with access to shared (public) toilet facility (per cent)	524	2.55	4.362	0.00	51.66
Households with non-natural source of water (per cent)	524	94.82	10.516	3.55	100.01
Children fully vaccinated in age 12-23 months (per cent)	524	46.60	26.044	0.00	98.80
Prevalence of childhood (under 3 years) diarrhoea (per cent)	524	13.69	7.888	0.00	42.07
Percentage using oral rehydration salts	523	34.12	19.690	0.00	100.00
Interaction between ORS and diarrhoea	523	449.92	368.120	0.00	2648.67
Percentage of population with access to *anganwadis*	438	79.72	19.552	2.10	100.00
Percentage of rural population with access to any one of the 7 health facilities	438	48.25	19.154	5.00	100.00
State's offtake from public distribution system to its total allocation(per cent)	524	44.12	19.234	5.88	96.15

Note: See **Table A3** for the descriptive statistics in logarithmic form

Table A3 Descriptive statistics of variables (in logarithmic form)

Variables	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Percentage of normal weight children	3.94	0.302	1.39	4.59
Triennium land productivity (Rs./hectare)	2.96	0.737	-0.11	4.98
Triennium average annual rainfall (mm)	6.81	0.583	4.92	8.49
Percentage of area under irrigation to gross cropped areas	3.36	1.065	-5.24	4.65
Gini coefficient of operational land	-0.75	0.181	-2.30	-0.19
Percentage of area under non-food crops to gross cropped areas	2.07	1.586	-4.40	4.52
Triennium average foodgrain production per capita (tonnes/capita)	5.10	0.840	0.93	7.43
Percentage of women with secondary and above education	3.32	0.437	1.76	4.52
Prevalence of moderate and severe anaemia among pregnant women (per cent)	3.63	0.599	0.96	4.61
Households without access to any toilet facility (per cent)	3.88	0.915	-2.81	4.54
Households with access to shared (public) toilet facility (per cent)	0.32	1.099	-3.51	3.94
Households with non-natural source of water (per cent)	4.54	0.211	1.27	4.61
Children fully vaccinated in age 12-23 months (per cent)	3.63	0.756	-0.36	4.59
Prevalence of childhood (under 3 years) diarrhoea (per cent)	2.39	0.776	-1.24	3.74
Interaction between diarrhoea and oral rehydration salts use	5.81	0.894	2.75	7.88
Percentage of rural population with access to any one of the 7 health facilities	3.78	0.466	1.61	4.61
State's offtake from public distributions system to its total allocation(per cent)	44.12	19.234	5.88	96.15

Table A4 Correlation between child undernourishment rates and its covariates

	1	2	3	4	5	6	7	8	9	10	11
Child nourishment rate (per cent)	1										
Women with secondary education and above (per cent)	0.363*	1									
Prevalence of anaemia among pregnant women (per cent)	-0.254*	-0.115*	1								
Households without access to any toilet facility (per cent)	-0.355*	-0.337*	0.331*	1							
Households with access to shared (public) toilet facility (per cent)	0.135*	0.139*	-0.152*	-0.308*	1						
Households with non-natural water (per cent)	-0.103*	-0.084	0.296*	0.264*	-0.008	1					
Children fully vaccinated (per cent)	0.199*	0.423*	0.126*	0.199*	-0.041	0.214*	1				
Prevalence of childhood (under 3 years) diarrhoea (per cent)	-0.205*	-0.208*	0.198*	0.073	-0.153*	0.095	-0.0818	1			
Interaction between ORS and diarrhoea	0.093	-0.02	0.021	-0.142*	-0.066	0.016	0.1138*	0.670*	1		
Prevalence rate for access to any type of health care (per cent)	0.224*	0.153*	-0.060	-0.252*	0.157*	0.089	0.1134*	-0.068	0.154*	1	
PDS offtake of the state as per cent of state's allocation (per cent)	0.258*	0.031	-0.354*	-0.207*	0.248*	-0.170*	0.017	-0.326*	0.049	-0.002	1

APPENDIX B

Description of Variables

Estimates of Land Productivity

Three-year average value of District Gross Domestic Product from crops and livestock sources at constant prices per hectare of cultivable land: This includes net areas sown, current fallows and permanent fallows, and area under miscellaneous crops not included in the net area sown.. The district GDP data is from *Indicus Analytics*. The data pertains to 2002, 2003 and 2004, to correspond to the DLHS-2 reference years of 2002-2004.
Land productivity has been estimated as a function of six variables in addition to 13 agro-climatic dummy variables. Fourteen major agro-climatic zones have been taken into consideration. The Trans-Gangetic Plain with fairly high land productivity has been used as the base and 13 dummy variables have been created. The other six variables included in the equation are as follows:

1. **Three-year average (2002, 2003 and 2004) of annual rainfall in millimetres at the district level:** This is an important variable for any study-related agriculture. High rainfall regions have a better potential of land productivity in general. Further, the level of rainfall determines the crop pattern. Some of the low rainfall regions achieve agricultural growth by growing high value crops such as cotton and oilseeds. Rainfall levels also influence groundwater recharge and surface water collected in ponds and tanks.

   The data have been taken from the India Meteorology Department and expressed in millimetres for all the months in the year for 2002, 2003 and 2004. The annual rainfall figures have been averaged to arrive at the annual average for three years, using the 2001 district list. Unfortunately, 2003 rainfall data was not complete for all the districts and hence only 2002 and 2004 data had to be averaged. In any case, averaging the annual rainfall data gives a better idea of rainfall received for the reference period.

2. **Three-year average (2002, 2003 and 2004) of gross irrigated area as a percentage of three-year average of total cropped area in the district**: Irrigation influences land productivity, in conjunction with rainfall. Canal irrigation can help even when rainfall is deficient. Canal irrigation can also recharge groundwater to some extent in the winter season and summer season, when canal water is not available.

   The data on area irrigated as well as the total cropped area for each year have been taken from the Ministry of Agriculture and Co-operation.

3. **Land operational inequality at the district level represented by Gini ratio:** Unequal distribution of operated land in agriculture seems to reduce overall agricultural land productivity. One standard deviation reduction in land operational inequality seems to bring about an increase of 8.5 per cent in land productivity (Vollrath 2007). Hence, it has been considered as an important variable for the determination of land productivity.
   The distribution of operated land in various size classes for the year 2004-5 for each district is given by the Agricultural Census Data collected by the Ministry of Agriculture and Co-operation. Gini ratio has been calculated from the data for each district.

4. **Three-year average of area under non-food crops as a percentage of total cropped area in 2004-05:** Non-food crops are important as some of them are high value crops and help the prosperity of low rainfall regions. Reliable data on all crops and total cropped area was available from census at the district level and hence a single year data for 2004-05 has been used. Non-food crops' contribution to land productivity also captures the spillover effects of agricultural prosperity to non-agricultural employment in the district. Higher land productivity from non-food crops may mean more jobs in the non-crop sector and more incomes and higher prosperity.

5. **Per capita foodgrain production in the district in tonnes per person per annum:** This variable basically captures the foodgrain abundance in the district. Though the low percentage of non-food crops means high percentage of food crops, it may not amount to high land productivity from food-grains. Food-grain abundance means higher yields and more land productivity. Further, food-abundance districts in contrast to food-deficit districts also have spillover effects of non-farm employment in trade, transport and processing. The contribution to land productivity from abundance of food-grain production would mean cheaper local grain to the population and better calorie consumption.

   Three-year average (2002, 2003 and 2004) of food-grain production at the district level has been taken from the Ministry of Agriculture and Co-operation and divided by the projected district population for the year 2004, to get the per capita annual food-grain production in the district as tonnes/ per capita.

6. **Women's education** is a control variable in the land productivity equation to capture awareness and adoption of technology, capability of acquiring skills relevant for crop and animal production, awareness of bank credit and the ability to take advantage of a number of schemes that the government offers. It is a proxy for all education, including that of men (as men's education is closely correlated with women's education), in the land productivity equation. Higher levels of education help skill acquisition and improve technology adoption in agriculture and result in higher land productivity. (Chaudhri 1968; Panda et al. 2013).

   Reliable district data on the percentage of women who received education above secondary level was available in the DLHS data.

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