More details/abstract: A recent global hunger index indicated a 12 percent decline in child underweight rates. This study attempts an empirical explanation of the factors that influence child underweight rates at the district level. Agricultural land productivity, share of women educated above the secondary level and participating in work, maternal, and child health seem to contribute to the reduction in child underweight. However government health and water supply facilities turn out to be ineffective.

Child Under-weight and Agricultural Productivity in India: Implications to Public Provisioning and Women's Agency

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Acknowledgement:

This study is part of the ongoing research program on Leveraging Agriculture for Nutrition in South Asia (LANSA) funded by UK Aid from the Department for International Development, UK. The authors are consultants or regular staff of M.S. Swaminathan Research Foundation, India, one of the six partner institutions of LANSA.

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1. Introduction:

Literature on the subject documented the following stylized facts about child nutrition - agriculture links. Agricultural shocks lead to child mortality and child undernutrition in the developing countries as the coping mechanisms include reduction in calorie intake. The well-known pathways that link agriculture to child nutrition are food, quality of food and care of feeding. Further, agricultural productivity growth contributes significantly to poverty reduction and contributes to reduction in child undernutrition. Care of children and feeding practices depend upon women's knowledge and hence women's education and their freedom to act are closely related child nutrition. Further, repeated morbidity such as diarrheal and respiratory infections and lack of timely health care advice and medical help, reduce food absorption capacity leading to underweight and stunting in children. Hence, sanitation, safe water and health provisioning are the enabling factors crucial for reducing child underweight.

The enigma is that south Asia and especially India has fairly low child mortality rates as low as 5.6%, but higher child undernutrition rates, despite abundant food supply and higher growth rates of GDP. Widespread attention to Asian Enigma (Ramalingaswami, et.al 1996) and Indian enigma (Headey et.al, 2011), gave way to some skepticism about India's ability to reduce child malnourishment. However, recent Global Hunger Index (International Food Policy Research Institute 2014) reported a reduction in child underweight rates in India. The child underweight rates fell by about 12% between 2006 and 2013. Limited data released by the Ministry of women and child development pertains to 21 out of the 36 states and union territories in India in 2012-13 (GOI 2014). Latest survey excludes states such as Bihar and Madhya Pradesh that record higher rates of child malnourishment in 2002-04. Recent data shows deterioration in 6 states and union territories, and substantial reduction of more than 10% in child underweight rates in 9 states and moderate improvement in the rest. Complete data sets are not yet available for analysis and hence nothing much can be said.

Now the relevant question to ask is 1.What has changed in India? 2. What are the likely factors that contributed to the improvement or deterioration in child underweight rates in India?" It is not possible to satisfactorily answer the questions without the help of the latest data. However, we may look at some relevant macro aspect that may have influenced the micro outcomes.

Factors influencing child underweight rates could be captured with earlier data of the Ministry of women and child development at the district level pertaining to 2002-04 (GOI 06). Analysis of district level data enables us to combine the data sets from different sources. District is a single administrative unit and influenced by similar governance. It also falls under the same agro-climatic zone with similar production patterns and agricultural prosperity.

The aim of the paper is to look at the association of the proportion of underweight children, with the overall agricultural productivity, women's agency, child and maternal health status and the available public services, across 430 districts with the help of linear regressions and quantile regressions. The paper is different from the others that have been looking at the child undernutrition agricultural linkages in India. Most of the studies relied on household level data. The spillover effects of agricultural prosperity and its importance for child underweight can be captured better at the district level. The present study has excluded the 100% urban districts from the study to capture the agriculture linkage to child nutrition better. This is one of the few studies that tries to explicitly link agricultural prosperity to child under weights. Section II briefly discusses the macro issues that may have helped better nutritional outcomes. Section III presents the past evidence. Section IV discusses the data, and the methodology and section V interprets the results and concludes the study.

II. Macro level changes in the Indian economy

Nothing dramatic has happened in India in agricultural sector or health sector or education sector. Improvement in public provisioning has not occurred in a significant manner. All the same, there are subtle changes that may have contributed to the improvement in child underweight.

Affordability and food consumption patterns have changed in India .Consumption patterns underwent changes commensurate with the changes in the agricultural production. More vegetables, fruits, eggs and milk were produced in the country increasing their share in the agricultural GDP compared to that of food grains (GOI (2012). Real per capita average monthly expenditure increased by 22.2% in the rural areas and by 26.5% in urban areas between 2004-05 and 2011-12 (NSSO 2013). While calorie consumption declined in all expenditure classes,

dietary diversity increased even in the lower deciles. More milk, eggs, vegetables and fruits as well as processed foods from formal and informal sector were consumed at the average level, both in urban and rural areas (NSSO 2014).

Another important aspect is that the number of children below the age of five has been falling rapidly in India. Birth rate is around 22.2 per thousand in 2014. Many households are without young children. Fewer children coupled with improved affordability higher literacy of women may have improved the care given to the children at least in not so poor families and in urban areas, where women's literacy rates are improving.

Further as pointed out by Sen, A. K (1992) in the context of public provisioning and targeting, a gap exists between the availability of public services and their actual use by deprived groups. Lack of education according to him is the main constraint. Education helps to close the information gap. Basic literacy improvement resulting in 65% female literacy, may have played an important role in easily imbibing the health education and nutrition education spread by the public machinery of community health workers (Accredited Social Health Activist) and workers for Integrated Child Development Services. Once people are convinced about the importance of health and nutrition, they may obtain paid services from private sector, subject to affordability, Utilization of available public services also improves with literacy and higher levels of education result in demanding the public services due to them reducing diversion to non- target group. There is some evidence of improvement in this aspect

III. **Past evidence on factors influencing child nutrition.**

Four set of factors expected to influence child underweight are related to 1) agricultural prosperity, 2) women's agency, 3) maternal and child health, and 4) public provisioning of health, sanitation and water.

Agriculture child nutrition linkage is mainly through food consumption and affordability. . Calorie deprivation along with other social indicators could explain about 26% of the child underweight between 1975 and 1995 (Smith et.al. 2000) A number of studies that tried to link food production through interventions at the household level on 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 agricultural productivity growth has been the single most significant factor in poverty reduction and better nutrition (DFID 2004).

Women's agency aspect has been stressed time and again on child nutrition in the literature. The "Agency" which brings about desirable change, shapes the social structures. The agent may or may not be aware of the role played by her/him (Herda 1999). The preference to emphasizing women's agency as against women's empowerment is that, there is less clarity on empowerment than that of agency aspect. For example women's work participation may have positive impact on child nutrition through income effect, but it may not be considered as empowerment as it may increase women's work burden. Some studies have shown that women's employment improves child nutrition (Thampi 2007, Bhalotra 2010, Shukla 2011). However there are other studies that doubt the positive impact of women's work on child nutrition. Additional female wages were found to be too small to change the spending allocation to health (Berman et al. 1997). Rural infant mortality risk seems to be fifty percent higher if the mother works in agriculture (Bhalotra 2010). Female literacy has been widely recognized as having positive impact in reducing underweight and stunting in children (Mishra et.al. 2000; Subramanyam et al., 2011). Authors have also shown that the status of women in the society and violence against women within the households are associated with higher levels of child under-nutrition (Bhagowalia et al 2012).

Much of the under-nutrition currently prevalent in the children of developing countries is attributable to conditioned malnutrition, arising from infections (Gopalan, 2013). Sanitation and safe drinking water have been identified as key factors in reducing stunting and underweight by researchers (Bhagowalia et. al. 2012, Spears2013). Hammer et.al (2013), have shown that approximately 1.3 centimeters height gain is possible in a four-year-old child, with the provision of safe sanitation to children's immediate environment. Improvement in water and sanitation lowers the incidence of diarrhea by 7-17 percent and reduce the risk of under-five, child mortality by about 50% (Gunther F. G., et.al, 2010). As per the Diarrhea report, of UNCEF (2009), food absorption capacity of the child declines with diarrheal infections. This may result in under nourishment and underweight. Remedial measures such as administration of oral rehydration salts can substantially prevent survival risks (UNICEF 2009).

IV. **Data and methodology.**

Proportion of not underweight children is the dependent variable both in OLS and quantile regressions. Four sets of variable representing agricultural prosperity (Agricultural Land productivity averaged over three years to remove the weather effect), women's agency (Interaction of the proportion of women with education above secondary level and women's work participation rates in the district), Maternal and child health (proportion of pregnant women with anemia, and proportion of three year olds reporting diarrhea, proportion of children administered with oral rehydration salts) and public provisioning (proportion of households with access to any government health facility, proportion of households with access to public toilets and proportion of household with access to piped water or well water, mostly from public sources) are the variables included in the study. Most of the data are taken from District health survey-2 conducted by the government of India. Other sources are the department of agriculture and GDP data from Central statistical organization.

Immunization data was available but due to the strong correlation with women's education, it was not included in the model. Alternative model gives significant association of proportion of immunized children with underweight. Further women's work participation as well as women's education above secondary level show significant association with child underweight even when considered independently.

While own toilets are better than public toilet shared, public toilet facility represents the public provisioning to the deprived sections. Normally toilet ownership captures, literacy and income levels.

Linear regression models and the quantile regression models test the association of four sets of independent variables with the proportion of children who are healthy and not underweight at the district level. Quantile regression helps us to understand the influence of the variables at various levels of severity of the problem of underweight. The quantile method estimates several regression models, each based on various quantiles or percentage point of the distribution of child underweight rates (Koenker, 2005). This approach helps us in understanding the differences in the causal relationship across the entire distribution (spread of the distribution) of

the child underweight rates. Since lower quantiles would encompass districts with high levels of underweight rates and they are of interest from a public policy perspective for intervening, such an analytical tool is of relevance in the current context. .To ensure that one would not miss-out on the lowest deciles, the under-weight percentage is reversed to non-underweight percentage.

V. Results and interpretation:

Table 1 presents the descriptive statistics for the variables used in the analysis and Table 2 presents the results for OLS estimates while the interpretation of results is mainly based on quantile regression estimates given in Table 3.

Agricultural land productivity has a significant positive impact on the percentage of normal children, indicating underweight rates could come down with agricultural prosperity. The quantile regression estimates (Table 3) show the impact of land productivity is higher around the mid quantiles (0.4 and 0.6) and that a higher impact is observed for a lower quantile of 0.20 (5.55) than for the top quantile of 0.80 (5.17).

Women's agency aspect through work, education and health has an impact of improving child nutrition. The interaction of women's work participation and above secondary level education has significant positive association with proportion of normal children at the overall context and also in all the quantiles, in the district context. The non-linear effect of education and women's participation is what appeared to be significant perhaps highlighting the fact that income effect that comes through the woman's participation in the labour market and the awareness effect of child care that comes through better education status has to be combined to see the impact on reducing undernourishment among very young children.

Anemia among pregnant women reflecting mother's health status has a significant negative influence on proportion of normal children with the largest impact (-0.13) for the lowest quantile 0.20 compared to the other quantiles. This provides scope to focus on this aspect of women's health.

Child's own health status and timely medical advice has positive impact on underweight rates as expected. The lower the incidence of diarrhoea among three year olds in a given district, and

higher the possibility of administering a simple remedy like oral rehydration salt when affected by diarrhea, higher the added effect in improving the rates of better nourished children. The quantile regression estimates however show that impact of these two variables is most prominent in the top quantile of 0.80. This probably due their sensitivity to level of undernourishment.

We choose percentage of households with access to any government facility as a measure to capture public provisioning of health services and find that the impact is visible only for the lowest quantile (0.20) reported here.

Basic amenities like access to toilets and piped water have been shown to have an impact on undernutrition in most studies. Most studies tend to use open defecation as a measure of lack of basic sanitation facility and its impact on undernourishment prevalence rates. However we find that instead of that variable, access to at least shared toilets has a positive impact but it has a significant impact only for the top quantiles (0.60 and 0.80). Given that in most parts of rural areas, open defecation is still highly prevalent it perhaps indicates that in more urbanized areas, with lower rates of underweight children, the public toilets as in the slums may prove effective. Piped water in particular is an indicator of affluence as well as provisioning of water by the state as some infrastructure has to be provided by the state for supply of water through pipes. However, it is observed that this variable is either insignificant or has a negative association with the percentage of normal children in the higher quantile. Irregular supply of water is one possibility and it has also been observed from other studies that instead of source of water the variable whether the household purifies water or not has a stronger impact on undernourishment which we were unable to source from this database. There is also a possibility of contaminated pathogen infested groundwater being pumped by shallow pump sets installed in urban slums. Such instances may lead to higher incidence of diarrhea. Unless public provisioning of sanitation, water and health improve, substantial reduction in child underweight may not be possible.

Table 1: Descriptive Statistics

Variable	Mean	Std. Dev.	Coef. of Variation
Normal Weight Children (%)	54.2	15.2	28.0
Ln of Land productivity in agriculture	3.0	0.7	24.8
Female work participation (%) * female education above secondary level (%)	920.5	537.7	58.4
Women with anaemia (%)	43.2	19.2	44.5
Children below age 3 with prevalence of diarrhea (%)	15.1	7.6	50.4
Children Administered with Oral Rehydration Salt (%)	34.6	18.4	53.4
Households with access to any Govt. Facility (%)	48.3	19.2	39.7
Households with access to Shared Toilets (%)	2.4	4.3	181.6
Households using Non-natural water (Piped water + Well water) (%)	94.2	11.3	12.0

Table 2: Impact of agricultural land productivity, women's agency, health and sanitation on percentage of normal children: OLS Estimates

Normal Children (%) (100 – proportion of underweight children)	Coefft.	*p-value*
Ln of Land productivity in agriculture	4.66***	0.000
Female work participation (%) * female education above secondary level (%) (interaction term)	0.01***	0.000
Women with anemia (%)	-0.09*	0.014
Children under age 3 with prevalence of diarrhea (%)	-0.24**	0.007
Children Administered with Oral Rehydration Salt (%)	0.20***	0.000
Households with access to any Govt. Facility (%)	0.06	0.101
Households with access to Shared Toilets (%)	0.56*	0.015
Households using Non-natural water (Piped water + Well water) (%)	-0.12	0.102
Constant	43.53***	0.000
R-sq=0.3512; Prob>F=0.000; No. of Obs: 427		

Source: DLHS-2 (2002-04), Indicus Analytics & Department of Agriculture

Note: #p-value< 0.10; *p-value<0.05; ** p-value <0.01; *** p-value <0.001

Table 3: Impact of agricultural land productivity, women's agency, health and sanitation on percentage of normal children: Estimates from Quantile Regression Model

Normal Weight Children (%)	Quantile (0.20)		Quantile (0.40)		Quantile (0.60)		Quantile (0.80)	
	Coefft.	*p-value*	Coefft.	*p-value*	Coefft.	*p-value*	Coefft.	*p-value*
Ln of Land productivity in agriculture	5.55**	0.002	6.87***	0.000	6.20***	0.000	5.17***	0.000
Female work participation (%) * female education above secondary level (%)	0.005*	0.054	0.01***	0.000	0.01***	0.001	0.005*	0.016
Women with anaemia (%)	-0.13*	0.022	-0.10*	0.015	-0.09*	0.014	-0.10*	0.041
Children under age 3 with prevalence of diarrhea (%)	-0.03	0.816	-0.08	0.408	-0.21#	0.070	-0.29**	0.004
Children Administered with Oral Rehydration Salt (%)	0.13*	0.036	0.13**	0.001	0.13*	0.024	0.29***	0.000
Households with access to any Govt. Facility (%)	0.13*	0.038	0.06	0.135	0.04	0.331	-0.01	0.763
Households with access to Shared Toilets (%)	0.34	0.473	0.72#	0.095	0.73*	0.013	0.82**	0.010
Households using Non-natural water (Piped water + Well water) (%)	0.13	0.426	-0.17	0.231	-0.22*	0.024	-0.30**	0.002
Constant	6.13	0.690	37.93***	0.004	52.27***	0.000	69.99***	0.000
R- Sq	**0.1576**		**0.2073**		**0.2363**		**0.2681**	
No. of Obs	**427**							

Source: DLHS-2 (2002-04), Indicus Analytics & Department of Agriculture; Note: #p-value< 0.10; *p-value<0.05; ** p-value <0.01; *** p-value <0.001

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