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Dietary Diversity and Women's BMI among Farm Households in Rural India

Brinda Viswanathan, Getsie David, Swarna Vepa and R V Bhavani
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About this paper

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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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Abstract

Undernutrition is more widespread and persistent in South Asia, including India, with higher numbers of undernourished people living in rural areas. Indian evidence often shows a weak linkage between agriculture and nutrition, though there is ample scope for agriculture to contribute towards reducing undernutrition. This study probes further to understand the linkage between agriculture, dietary diversity and women's Body Mass Index (BMI) in rural areas of India, as few studies have looked at household nutritional intake and adult nutrition outcome in this context.

In the first part of the analysis, we find that in Indian rural areas, women in cultivator households or those who have a higher share of agricultural incomes have lower rates of undernutrition and it is the women in non-agricultural wage labour households who are worse off. To capture the specific features of agriculture, the second part of the analysis focuses on farm households, wherein dietary diversity reflecting nutrition intake is modelled at the household level, while women's BMI-capturing nutrition outcome is modelled at the individual level. Instrumental variable quantile regression model is used to estimate the women's nutritional status with potential endogeneity of dietary diversity. Our findings validate once again that dietary diversity improves with (a) affordability coming from higher income, better wealth status, larger area under cultivation; (b) access to better diets in a sustained manner, in the form of crop and income diversification, ownership of cows and buffaloes as well as market access to sell the crops; (c) better awareness among households because of the presence of an educated adult member. For improvement in an adult woman's BMI, dietary diversity matters, and equal importance must be given to environmental conditions like better quality of drinking water, good sanitation, smoke-free cooking area and better access to healthcare facilities. Religion, caste and regional variables also play significant roles in enhancing both intakes and outcomes, while there is evidence for a limited role played by education and empowerment in an individual's nutrition status once all these variables are controlled for.

1. Introduction

The evidence on the link between agriculture and nutrition has so far been tenuous. On the one hand, undernutrition rates are severe and more widespread among those involved in agriculture. This evidence is more pronounced when the households or regions with agricultural predominance are compared with non-agricultural regions (Dahiya and Viswanathan, 2015). Countries and regions that have faster economic growth caused by structural transformation from agricultural to non-agricultural activities, with an accompanied shift in the pattern of employment, have reduced undernutrition at a faster rate. On the other hand, studies show that wherever there are policies which favour agriculture or regions which have sustained a high growth rate in value from agriculture, poverty and undernutrition are both lower (De Janvry and Sadoulat, 2001 and Webb and Block, 2011).

On its own, agriculture would influence nutrition primarily through increased food intake from own production and also through the channel of increased incomes from diversification into higher value crops, including horticulture, or livestock rearing (Kadiyala *et al.*, 2012). Improvement in productivity of food crops could reduce food prices, thereby having an economy-wide impact on undernutrition. Reducing inequities in resource ownership like land or improved access to irrigation and/or credit across socially disadvantaged groups, including women, would, in turn, feed back into increasing agricultural growth and productivity. Pinstrup-Andersen (2013) argues that the link between agriculture and nutrition is not just due to the quantum of food produced. These pathways are behavioural in nature, as in the case of women's time allocation that would influence feeding and care practices. Hence undernutrition could also be policy induced, as in the case of agricultural trade policies, which could affect the net consumers and net producers differently, or investment policies that affect rural infrastructure and basic amenities and hence impact agricultural growth.

It is well known that agriculture continues to enjoy state support all over the world in order to sustain itself. In a country like India, it is not just about support to agriculture but also preserving agricultural diversity, addressing market imperfections and removing certain malaise associated with deep-rooted socio-cultural practices that need to be addressed simultaneously, to have a more widespread impact on nutritional outcomes. With greater emphasis being laid on evidence-based policy making (Malhotra, 2014), more empirical evidence to understand the linkage between nutrition and agriculture becomes essential. This study is a contribution in this direction and focuses only on rural India. It attempts to connect agricultural production diversity to dietary diversity at the household level, and then links dietary diversity to women's Body Mass Index (BMI), as well as several non-food components that could, for instance, affect nutrition absorption. By studying women's BMI, we focus on the individual as the final unit of analysis rather than a household. This further enables us to look into the impact of woman's empowerment in influencing her own nutritional status, an area of immense importance in the South Asian context.

Section 2 is a brief summary of the empirical evidence that relates agricultural features to nutritional outcomes assessed by child and adult anthropometric variables emerging from recent studies. Section 3 presents a summary of the observed variations in women's BMI in India and the factors that explain the variations. Section 4 discusses the data and variables used for the analysis. Section 5 discusses the methodology followed by Section 6 on results and findings of the study with Section 7 concluding the study.

2. Agriculture and Nutrition Outcomes in India: Recent Empirical Evidence

Singh *et al*. (2011) find that the probability of low BMI among women is highest in cases where the husband's occupation is in the primary sector. While trying to connect trends in agricultural growth to changes in undernutrition rates among children and women, Headey *et al*. (2011) find that the patterns are mixed. The study finds agricultural GDP per worker to have a negative significant association with stunting but not with underweight (among children) at the state level. Compared to child undernutrition rates, prevalence rates of low BMI among women responded the most to changes in indicators like wealth and per capita GDP growth. From the agricultural perspective, women's BMI improved due to changes in agricultural GDP per worker. The study further shows that, after controlling for other covariates including economic status, women and men involved in agricultural work had lower average BMI. Further, in the case of women, the gap was not (statistically) significant when compared to unskilled non-agricultural employment.

Gulati *et al*. (2012) show that the level of agricultural performance or income has a strong and significant negative relationship with indices of undernutrition among adults and children; suggesting association between improvement in agricultural productivity and reduction in undernutrition. The differences in the results of these two studies on the impact of agriculture on undernutrition is due to the nature of data and the measures used and hence the type of analysis. Headey *et al*. (2011) use a two-period data while Gulati *et al*. (2012) use a single cross-section so the former is a medium-run effect while the latter is a long run effect since a single cross-section is being compared. In the former study, agricultural growth and other forms of agricultural performance indicators, including agricultural GDP per worker, are used, while in the latter study the agricultural GDP is taken as a proportion of rural population. There is also a difference in the measure of undernutrition: Heady *et al*. consider proportion of women with low BMI while Gulati *et al*. consider a normalised index of adult undernutrition that comprises of only thin women and (also) men.

Most of the studies in India are based on micro-level data; regional-level analysis can provide a different insight into the nature of variations in undernutrition. Vepa *et al*. (2015a) find that child underweight rates are lower for districts with higher agricultural land productivity. However, it also matters how agricultural component is measured and what other factors are also included in explaining the variations in child underweight rates in the analysis using regional data. For instance, when per worker agricultural GDP is the only explanatory variable, it has a significant and negative impact on underweight rates but food grain production per capita does not have a significant impact on child underweight rates (Vepa *et al*., 2015b). In the same study, with the addition of variables related to women's empowerment and health and sanitation, agriculture does not retain its significance.

Dahiya and Viswanathan (2015) find that women who participate in agricultural work have lower average BMI compared to those who do not work. However, between agricultural and non-agricultural labour, the average BMI is lower among the latter than the former. Between those who are in farming and agricultural labour, the latter are worse off. There are also variations across BMI quintiles; the average BMI is lowest across the quintiles for those who are both self-employed in agriculture and also work as farm labourers. These results, perhaps, reflect the nature of physical activity carried out by these women in the labour market and not so much whether women in agriculture have a lower BMI than those who are not in agriculture.

3. Variations in Women's BMI: Evidence from India

According to NFHS-3, 50 per cent of women from the poorest quintile have chronic energy deficiency (CED) i.e. having a BMI below 18.5, and so do women belonging to disadvantaged social groups. About one-half of women below 20 years of age have CED, while CED rates decline to one-fourth for women of 40 to 49 years of age. Clearly, there is improvement in CED rates with age but older women also show a higher rate of overweight and more so in urban areas and in States like Tamil Nadu and Kerala (Seshadri, 2009).

Navaneetham and Jose (2008) show that around 40 per cent women in rural India have CED, which is 15 percentage points higher than the incidence among urban women.[1] The highest incidence of CED is found in the eastern States, such as Bihar (45.1 per cent), Jharkhand (43.4 per cent), Orissa (41.7per cent) and West Bengal (39.1 per cent), and the southern States have the lowest incidence of CED (Deaton, 2008). Ackerson *et al.* (2008) show from an earlier round of NFHS at a more granular level of districts and villages, that there are clear regional patterns. Contiguity of low BMI regions and high BMI regions and its association with regional development is an important finding of that study. Undernutrition was most prevalent among women belonging to the lowest quintile of standard of living and over-nutrition was observed among top-most quintile of standard of living. People from higher income groups consume a diet containing 32 per cent of energy from fat while people from lower income group consumed only 17 per cent of their energy from fat. This according to them partially explained the positive relationship between socio-economic standards and BMI of women. Dahiya and Viswanathan (2015) find that economic status captured by three different variables: per capita income, per capita total consumption and wealth status have an influence on the women's BMI after controlling for several other variables. It is noted that magnitude of the per capita consumption variable decreases and then increases with the BMI quintile, while the magnitude of the per capita income variable is very similar across the BMI quintiles and there is a dissimilar effect of higher wealth status across all the BMI quintiles.

The gender gap in BMI between male and female rural CED rates is marginally higher than that of urban but is not significant when compared to the huge gender gap in anaemia at the all-India level (Jose, 2012). This gap is relatively higher among the lower wealth categories and among scheduled tribes when compared to other caste groups, and only very few States like Bihar exhibit huge gender gaps in CED rates. There is significant evidence that the mother's educational status directly influences her own as well as her children's nutritional and health status. Many women in developing countries cultivate, purchase and prepare much of the food eaten by their families, but they often have limited access to information about nutrition. An educated woman has better abilities for the control of physical and financial assets and is motivated to eat a healthy diet and feed her babies and children foods that meet their special nutritional requirements. Since women's status is a latent variable and is multi-dimensional in nature, most studies use proxy measures consisting of several indicators that depict sources of power such as education or age at marriage as measures of women's autonomy. Bhagowalia *et al.* (2012b) find that women's empowerment, which includes her mobility, decision-making power, and attitudes toward verbal and physical abuse, is positively associated with her nutritional outcome as well as that of her children. Women's education and paid work have been shown to be associated with the overall well-being of a household or a region, perhaps due to the autonomy and agency effects (Dreze and Sen, 1995; Agarwal, 1997 and Sen, 1999). Jose (2012) finds that CED rate among women who have some autonomy in decision-making related to daily purchases, major purchases, healthcare, or mobility (visits to relatives and friends) is lower than those who do not have this 'luxury'. There appeared a 10 per cent point difference in CED rates between women who have no decision-making power and those who have decision-making power in all the four components mentioned above. It is very likely that women with less autonomy could also be less educated or belong to more backward regions and hence constrained in other ways, so that to assess the magnitude of the impact of women's autonomy on BMI, one needs

[1]As for adult heights, Viswanathan and Sharma (2009) using the same data show that the agriculturally prosperous Indian States of Punjab and Haryana are the only exceptions, wherein the average heights of women in rural areas are higher than that in urban areas for all cohorts of women born between 1955 and 1990.

to control for these other factors. Dahiya and Viswanathan (2015) estimate an index of autonomy which captures aspects of mobility, financial freedom, and the woman's involvement in decision making. This index value is then converted into quintiles to capture increasing levels of autonomy. The results show that one observes the impact only at the highest level of autonomy, though its magnitude is nearly similar across the BMI quintiles.

Better and safer access to basic infrastructure like water, electricity, sanitation and cooking fuel has a direct impact on the individual's health status by preventing frequent (infectious) illnesses. For instance, Rao *et al*., (2008) show that the collection of drinking water and fuels, which is primarily carried out by women, has considerable adverse impact on women's nutritional reserves. Use of fuels like firewood, crop residue or dung etc. exposes women to harmful smoke while cooking, leading to a higher incidence of respiratory illnesses among women and children (Parikh, *et al*., 1999 and Duflo *et al*., 2008).

Government plays a major role in providing basic amenities to people and hence these variables also reflect regional effectiveness of the provisioning and maintenance of essential public goods. Even if these amenities are available, their irregular use could be a matter of preference or the lack of awareness of households towards leading a hygienic life. For instance, there may be a preference for cooking with firewood in spite of LPG being available and use of open area for defecation despite having a toilet inside the house.[2]Jose and Navaneetham (2010) show that CED rates for women in India in 2005-06 was higher by about 15-20 percentage points when there was no access to toilets; or when water was not available on premises and had to be fetched from outside; or there was use of cooking fuel that creates indoor air pollution. This same study further reports that even after wealth effects, rural/urban residence and other socio-demographic variables were controlled for, each of these variables were individually relevant in explaining the presence or absence of CED among women in India.

Dahiya and Viswanathan (2015) also explore the impact of infrastructure on women's BMI in rural and urban areas across the BMI quintiles. If drinking water is purified then it has a significant impact, while covering it with a lid does not make a significant difference. The impact of water purification is higher for the lowest BMI quintile than for the higher BMI quintiles. Having access to regular piped water compared to those who have to fetch water from a longer distance, which takes time (the reference category), has a significant positive impact with the effect more visible for the higher BMI quintiles. On the other hand those who do not have access to water within the premises but take less time to fetch it are also better off than the reference category mentioned above. The use of clean cooking fuel has an impact for higher BMI quintiles and is not significant for the lower BMI quintiles. Thus, one observes that there is limited evidence to understand how different aspects of agriculture affect an adult anthropometric indicator like BMI. The aim of this study is to fill this gap and also to contribute to the empirical evidence by trying to explore several dimensions of agriculture that could possibly give a better assessment of the linkage between agriculture and undernutrition. The primary objective of this study is to understand what role agriculture and allied activities play in improving women's BMI. It is an anthropometric indicator defined as the ratio of body weight (in kilogram) to the square of height (in metres). For adults, BMI is strongly correlated with body weight rather than with height, but as body weights are also related to stature, weight is

[2]Studies have documented that cooking in firewood provides a different taste to the preparation and the use of toilets within the house is not considered clean enough.

normalised by (squared) height. Any adverse shock in consumption or disease environment could result in reduction of body weight and hence BMI, so it is considered as a short-term indicator of nutritional status. Prior studies in India have analysed the impact of agriculture on undernutrition, focussing mainly on children aged 0-3 years or 0-5 years as determined by the data availability. However, in a given socio-economic setting, it is the adults who are mainly involved in the decisions of production, consumption and health-seeking behaviour at the household level. Hence, it would be more appropriate to study the nature and intensity of linkage between agriculture and adult nutrition. A second objective of this study is to understand the importance of several other factors mentioned in Section 2 above along with features of agriculture, in determining women's BMI within farming households.

4. Data[3]

The empirical analysis has been carried out using data from the 2005 India Human Development Survey (IHDS) (Desai, *et al*. 2007) conducted jointly by University of Maryland and National Council of Applied Economic Research (NCAER). It contains information from 41,554 households in 1,503 villages and 971 urban neighbourhoods across all the States and Union Territories of India.

The data set provides information on variables related to consumption, income, asset ownership, some details on agricultural activities, health, education, employment, anthropometry and social capital. The data provides regional information on some aspects of institutions and gender centric data relating to women's empowerment. The survey included two questionnaires, one for the household head and the other for the eligible woman, who is typically the wife of the household head. The questions related to household wealth, income and expenditure were asked from the household head, while the questions related to health, education and some social indicators were administered to women.

4.1 Farm Households

Since the focus is on rural farm households, adult women among farm households in rural India are considered for this study. A household which has reported cultivation of at least one crop is referred to as a farm household. Among the 26,734 households in the rural sample, 12,143 grew at least one crop. Around 98 per cent of these farm households own and cultivate land while the remaining do not own land but cultivate on somebody else's land. This analysis excludes pure agricultural labour households but includes households that cultivated small parcels of land, say 0.1 hectares, but report that their major source of income is not from farming and related activities. The purpose of the study is to understand the variations in women's BMI among farm households. However, we do carry out a preliminary analysis of women's BMI across all households to provide a comparative perspective of farm households with non-farm households.

4.2.1 Nutritional Indicator: Dietary Diversity Index of the household

For a particular household, Dietary Diversity Index (DDI)=$1-\sum_{i=1}^{k} d_i^2$ where d_i is the share of expenditure from the i^{th} food item in the total household food expenditure. The data set has collected information on expenditure for 13 broad groups of food items. The value of the above

[3] A detailed description of the variables used in this analysis can be found in Viswanathan (2015)

expression lies between 0 and 1 and higher the value of this index, the higher is the diversity in food items consumed by the household. Consumption of certain food items like cereals is available in quantities but for many other food items either the quantity information is not available or the food group is too broad. For instance, different types of pulses (or meat, egg and fish) are reported as single food group. Consequently, the conversion of such broad groups of food intakes into their macro and micro-nutrient content is not possible as each of these food items have varied amount and frequency of consumption and also their nutrient content varies substantially across sub-components of the food types. Hence, expenditure on various food items is used to calculate dietary diversity. Kennedy *et al*. (2007) show that dietary diversity is correlated with calorie adequacy.

4.2.2 Nutritional Indicator: BMI of Adult Women

The anthropometric data on heights and weights have been gathered for children aged 0-5 years and 11-13 years and for adult women aged 15-49 years. For this study BMI of women between 20 and 45 years of age is taken as an indicator of nutrition outcome variable. For women, height is stable between 20 and 45 years (large part of linear growth is attained by menarche) and studies usually consider 20 years as the starting age to analyse adult women's heights and the ending age is taken as 45 years, after which stooping may set in. Given that height is not expected to vary in this age group, the changes in BMI are effectively changes in body weight, affected mainly due to various social, economic and environmental factors. In the sample, 19,220 women are in this age group, and 10,559 women among them belong to households that grow at least one crop. After excluding missing and outlier values for income, consumption and production, the final sample size is 9,771 women.

4.3 Factors Influencing Dietary Diversity

We estimate an equation for dietary diversity which captures the factors that influence the variations in quality of current food consumption in farm households of rural India. This equation is at the household level and hence the variables are all features of the household. The variables directly relevant to agriculture are production diversity, which would influence food consumption directly from own production, and the sale of agricultural produce that would influence consumption indirectly via income effect.

Own production is expected to have positive spill over on consumption of milk, poultry products, fruits and vegetables in terms of improving the quantity and quality of diets and the frequency of consumption. Ecker *et al*. (2012) find that among rural Ghanaian households, farm households have a slightly higher dietary diversity attributing it to direct access to food due to farming. Similarly, Bhagowalia *et al*. (2012a) find that cow or buffalo ownership improved milk consumption among children in rural Indian households. In Bangladesh, the introduction of Homestead Food Production that supported home gardening, aquaculture and small-scale livestock rearing in the early 1990s seems to have improved micronutrient deficiency. Iannotti *et al*. (2009) show that the impact could be attributed to both improved production leading to enhanced consumption of qualitative diets as well as other positive externalities from increased incomes, better awareness from community participation and women's empowerment. Zezza and Tascotti (2010) find that though the role of urban agriculture could be very limited, among African households, those involved with some agricultural activity in urban areas have better quality diets, thereby reducing the food insecurity among the urban poor. De Janvry *et al*. (1991) and Hoddinot *et al*. (2014) observe that in the absence of well-functioning markets for selling the own produce, consumption from home-grown produce improves the quality of diets. Ruiz-Arranz *et al*. (2006), while evaluating the PROGRESA and

PROCAMPO programmes in rural Mexico, find that the former programme improves quantity and quality of diets by improving the purchase and access to retail markets and the latter by investment in home production.

In this study, production diversity index is defined as $1-\sum_{i=1}^{k} p_i^2$ where p_i is the share of cultivated area for the i^{th} crop in the total cultivated area. The larger the value of this index, the larger is the diversity in crop production. The influence of awareness on diversified diet is captured through the educational qualification of the head of the household. Presence of cows and buffaloes, small ruminants and poultry captures the effect of diversity in livestock ownership. Proportion of sale in market in total crop production captures the access to markets for own produce.

In other words, diversity in agricultural production and its allied activities influences dietary diversity so that accessibility (both in terms of proximity and periodicity) to diverse diet improves. With access to well-functioning markets, household's affordability improves either from production diversity by reducing seasonal vagaries and improving the flow of income or by the sale of high-value crop, possibly cash crop. However, improving affordability may not be sufficient to improve dietary diversity, as access to and awareness of diversified diet is also necessary. Awareness is captured by the education level of the highest educated member in the household.

Further, under the assumption that consumption decisions are based both on current income and long-term wealth, the dietary diversity equation is estimated by including per capita income and household's wealth status. The income variable, as reported by the household, is taken as a proportion of the household size, while the wealth status is captured by a categorical variable formed by estimating a wealth index on the basis of the possession of consumer goods by the household. In order to capture smooth flow of income, we also include a variable for income diversity of the household contributed either by different members of the household or possibly by a few members having the option of multiple ways of earning income. Income diversification in rural areas has been discussed more extensively in the context of Africa. Barrett *et al*. (2001) highlight that the need for households to pursue multiple economic activities arises mainly from push factors that reduce both risk and the effect of diminishing returns from a factor of production, either due to population pressure or land fragmentation. Similarly, agricultural policy-induced shocks could suddenly push households into poverty, and interventions through food for work programmes in non-farm activities can reduce the impact. Based on Indian data, Himanshu *et al*. (2013) finds that non-farm diversification reduces poverty at the margin while at a localised (village) level this could also increase inequality if the social protection policies are not effectively administered.

We have not included any variable on credit though it is also a relevant one for influencing consumption by reduction in liquidity constraint. Similarly, irrigation has also been excluded as we found that once wealth index was accounted for, it becomes insignificant. Other household-level variables are household size and composition and caste and religion of the household, reflecting socio-cultural influences on dietary diversity. These variables are also included in the BMI equation and are discussed in some detail in Section 4.5, after discussing variables specific to the equation.

4.4 Factors Influencing BMI

The dietary diversity index is one of the explanatory variables in the regression model for women's BMI. The fact that this is a household-level variable and not what the individual woman consumes limits us from capturing the appropriate impact of diversity in food intake on women's BMI. Women's status within the household influences her health and nutrition outcomes. In this study we have used three different binary variables to capture women's status in a household: whether women have permission to go to the grocery store; whether women in the household follow the practice of wearing *purdah* and whether the women eat along with men or after them. These variables are a reflection of both societal and familial practices that could indicate a woman's ability to influence her own well-being as well as those of her family members.

Water, sanitation, electricity and cooking fuel signify some basic amenities of civilised life. More importantly, they have strong influences on health in terms of causing short-term illnesses like diarrhoea and fever or long-term impacts on respiratory and immune systems which, in turn, affect the absorption of the nutrient intakes and hence the overall nutrition status, that is BMI. Categorical (dummy) variables that indicate use of consumption of purified water for drinking, use of different types of sanitation facility,[4] access to electricity, and use of LPG/kerosene as primary (clean) cooking fuel are included in the econometric estimations.

Age, education, type of employment including for those not involved in labour market, short-term morbidity status, pregnancy status, access and use of healthcare facilities during short-term illness and antenatal care during pregnancy are the individual variables considered for the analysis. Though the database had information on other long-term morbidity like diabetes, hypertension and respiratory illnesses, these had lot of missing observations for women in rural areas. Education is a categorical variable represented by five groups who are (i) either not literate, or (ii) have finished primary, or (iii) secondary, or (iv) higher secondary or (v) college-level education. The reference category in the model is chosen as 'not literate' and the mean BMI is expected to improve with education (controlling for other factors), since an educated woman is more likely to be conscious and aware about her health and well-being.

There are five dummy variables referring to the employment status and occupation of women:

- Self-employed *only* in agriculture comprising of farm work and animal rearing
- Self-employed in agriculture and sometimes engaged as agricultural wage labour
- Only as agricultural wage labour
- Non-agricultural wage labour
- Salaried work or in business
- Not actively engaged in any economic activity in the labour market.

The reference category chosen in the econometric model is the last one consisting of women who do not actively participate in the labour market and are mainly involved in domestic work.

A pregnant woman should, on an average, have a higher BMI compared to others and hence this has been used as a control variable.Though one could have dropped the group of women who are

[4]Geruso and Spears (2014) recommend the use of open defecation prevalence at the village level as having an impact on child's undernutrition rather than whether the practice is at the household level. This is because, according to them, it is other people's germs that are harmful and hence children in villages that show a higher prevalence of open defecation show a higher level of stunting. In our study, we could not find the village-level variable to be significant in the econometric estimations, while the household level variable shows significant coefficient estimates.

pregnant, the intention is to also assess how access to antenatal care impacts their BMI after controlling for other variables. So the focus is more on the possible effect of access to healthcare and its impact on BMI and how the magnitude of this coefficient varies across quintiles of BMI. To capture the variations in access to different sources of healthcare, the women who report pregnant have been classified into: (i) pregnant but no access to antenatal care; (ii) pregnant with access to antenatal care and visiting doctor or nurse; (iii) pregnant with access to antenatal care and visiting *dai* or others.

We use short-term morbidity status captured by the number of days ill with fever etc. a month prior to the survey so that we expect that this could have resulted in loss of body weight and hence a lower average BMI even after controlling for other variables. Further, this variable is interacted with the type of medical care facility used, if at all used, when reported sick. The medical care sought is classified as: (i) ill but did not seek treatment; (ii) ill and visits public doctor; (iii) ill and visits private doctor; (iv) ill and seeks help of traditional healer.

4.5 Factors Influencing Dietary Diversity and BMI

Religion, caste, household size, household composition and regional variation in terms of dummy variables for States are the common factors in both dietary diversity and BMI equations.

There are four religion dummy variables – Hindu, Muslim, Christian and Other Religions, with 'Hindu' taken as the reference category in the econometric estimations. This variable is included to capture another aspect of dietary diversity that is the consumption of plant-based food in comparison to animal-based food products. The dietary diversity variable does not capture this feature adequately in our data set and we feature this indirectly through the religion variable. It is well known that vegetarianism is prevalent more among the Hindus while Muslims and Christian in India consume non-vegetarian food. Animal-based protein intake is known to have a better impact on nutritional status and therefore, one could expect better nutrition status among Muslim and Christian women than their Hindu counterparts.[5] In the BMI equation, religion is included to capture gendered aspects of theological practices that influence women's status.

Indian society has been divided, since ancient times, into various castes (*varna* system of the Hindus) on the basis of their occupation. Relegation of menial jobs to some social groups with limited or no access to productive resources and the subsequent persistent discrimination in several other domains of social and economic status has created high socio-economic disparity among these groups in the Indian society. Five major castes: upper caste Hindus, Other Backward Caste, Scheduled Castes, Scheduled Tribes (reference category) and Other Castes are included as dummy variables both in the dietary diversity and BMI equations to assess the impact of social discrimination on consumption and nutritional outcomes.

Household composition is expected to capture two aspects relating to nutrition. One feature would be the impact of dietary composition arising out of differences in sharing of resources, particularly food items, so that we expect a household with a higher proportion of children compared to adults would perhaps have a higher share of, say, milk and milk products. The second feature is to capture the impact on the effort of women due to childcare so that women in households with a higher

[5]Note that apart from dietary explanation, there could be other reasons of BMI difference across religious groups. For instance Geruso and Spears (2014) argue that sanitation is worse among Hindus than among Muslims.

proportion of children than adults would expend more energy and hence have a lower BMI on average after controlling for other factors. The household composition variables relate to the proportion of people in the following age groups in a household: zero to four years of age, five to 14 years of age 15 to 60 years of age, and above 60 years of age. Since these proportions add up to one, the first group is excluded and is taken as equivalent to the reference category as would be in the case of categorical variables. When the effect of household composition is analysed, it is important to control for household size, as a four-member household can have three adults and one child or two adults and two children, causing a difference in the food composition as well as women's BMI status.

State-level policies or the quality of service delivery of the Central (welfare) schemes as well as other economic, social and cultural features that could systematically differ across States in India can have differential impacts on the dietary intake and its composition, as well as average BMI across States. In order to account for this, dummy variables for each State, with Punjab as the reference, are included in the analysis. Punjab is chosen as the reference State, since it has the highest mean value of total land area cultivated, large share of households engaged in agriculture in rural areas and also has one of the lowest rates of CED among women as observed from the data set.

5. Methodology

The first component of the empirical analysis makes comparisons between agricultural and non-agricultural aspects using an econometric model for the likelihood of CED. This is followed by a more detailed analysis of women's BMI in farm households to understand what factors within agriculture are more relevant for explaining variations in BMI. The main intention is to understand how different determinants affect the distribution of BMI. The focus of this paper is on features of agriculture, dietary diversity of the households and aspects of women's empowerment. However, other variables that are also likely to influence the nutrition status like economic status, access to basic amenities like water, sanitation, health and clean cooking fuel are also included in the econometric model while explaining the variations in BMI. This model is estimated using the quantile regression model where dietary diversity could possibly be endogenous. So an instrumental variable quantile regression model is estimated. Before we discuss this model specification, we also estimate two other specifications. The following sub-sections discuss them in more detail.

5.1 Modelling the Likelihood of CED

Different ranges of BMI refer to different states of nourishment: CED or undernutrition is when BMI is less than 18.5; normal when BMI is between 18.5 and 25; overweight when BMI is between 25 and 30; and obese when BMI is 30 or above. For a developing country like India, a concern for policy intervention is the issue of undernutrition more than malnutrition due to high levels of BMI, though latter is also a becoming a concern for public health in urban areas. So we begin with an analysis that indicates the determinants of CED among women in rural areas. The model is estimated using a probit model where the dependent variable takes a value 1 if the woman has BMI below 18.5 and 0 otherwise.

This model is estimated for all the households and is used to find out if the likelihood of CED is lower or higher among women in a farm household compared to a non-farm household. Three different variants of this model are estimated to capture different aspects of agriculture as explanatory variables in the model.

(i) In the first variant, categorical variables representing the major source of household income is used. Cultivation or managing the livestock or agricultural wage labour as the major source of income represents an agricultural household. A statistically significant coefficient with a negative sign for a particular source of income would imply that women in such a household are less likely to have CED when compared to a reference household say, whose major income source is 'other source'. More details on the types of income sources as available in the data are discussed in the section on data and subsequently in the section on results.

(ii) In the second variant, share of income from farming, livestock rearing, agricultural property and agricultural wages and also share of non-agricultural wages are included as separate variables. The significance of any or all of the first three variables in the model would capture the differences in BMI between farm and non-farm household. The negative coefficient would then indicate agricultural households less likely to have CED and vice-versa for a positive coefficient.

(iii) In the third variant, a dummy variable for whether the household cultivates land or not is used along with share of income from agriculture and allied activities. If these coefficients are statistically significant with a positive coefficient then farm households are less likely to have women with CED.

5.2 Instrumental Variable Quantile Regression Model

Recent studies on the analysis of nutritional status using anthropometric data or using nutritional intake data have preferred quantile regression method (QRM) over the regression model that estimates the mean equation (Koenker, 2005). Such a method provides estimates of the impact of the determinants across the distribution of the nutritional variable say, BMI, or z-scores of child underweight or child stunting instead of a single estimate that captures the average effect of the determinants, as would be the case in a classical least squares model. QRM is also less sensitive to outliers and has better properties in the presence of heteroscedasticity.[6]

Most studies that have used quantile regression in the nutrition literature ignore the possibility of potential endogeneity of some of the regressors as endogenous regressors lead to inconsistent estimates. The imminent question is which of the variables are potentially endogenous and which ones are exogenous. Evidence from literature shows that income or consumption is usually considered endogenous.[7]Burchi (2010) considers the endogeneity is due to possible measurement error in these variables while others like Chen and Tseng (2010) consider nutrient intake, health

[6]Several of the recent studies have preferred to use this method: Burchi (2010) for child's nutrition in Mozambique; Borooah (2005) for child-height-for age in India; Aturupane *et al.* (2008) for stunting and underweight among Sri Lankan children; Kandpal and McNamara (2009), Mazumdar (2010) for inequality in nutritional outcome of children in India; Block *et.al.* (2012) for undernutrition among children in developing countries; Seshadri (2009) for BMI and heights of women in India; Chen and Tseng (2010) for BMI of women in Taiwan; Sinha (2005) for calorie intake among rural Indians; Vepa *et al*. (2015a and 2015b) for child underweight rates across districts of India). The results from these studies substantiate the fact that such a statistical methodology helps in assessing the variation in impact across different levels of nutritional indicator rather than its mean and provides useful insights both from a behavioural perspective as well as for policy inputs.

[7]There are also studies that allow for endogenous regressors for a single (average) model as in Venkataramani (2010). In this study, instrumental variable approach is used to isolate non-genetic from genetic mechanisms behind intergenerational associations in height with parental height being the endogenous variable in the model for child's height-for-age z-scores. Conditions faced by the parents during their year of birth and early childhood serve as instruments, as early-life conditions influence later life outcome and that height determining genes do not change within a short term, say within a generation. A more recent study by Mukhopadhyay and Crouse (2014) considers BMI as potentially endogenous in a wage equation and estimates the model using instrumental variable quantile regression model.

behaviour and nutrition knowledge to be potentially endogenous as individuals make a choice about these and hence they are determined by other exogenous factors. Bassole (2007), on the other hand, does not provide any reason to consider income to be potentially endogenous while estimating the instrumental variable QRM for the determinants of child health in Senegal.[8]

In this study, we consider dietary diversity (for a farm household in our context) to be potentially endogenous as the decision to consume a variety of food items is determined by its direct intake from home production (represents availability and access) and/or indirectly from the market purchase (involves affordability due to income effect and availability if markets sell more variety of food items). The exogenous variables in the dietary diversity equation are income, wealth index, ownership of land, crop production diversity, ownership of different types of livestock, caste, religion, education of the head of household and household size and composition. These were discussed in the previous section.

We follow the steps as in Chen and Tseng (2010) for estimating the instrumental variable QRM. The first stage equation is the household-level dietary diversity equation taken as a function of household-level characteristics and regional features. In the second-stage QRM, the BMI for women in the age of 20-45 years is estimated using several individual and household-level characteristics including the (endogenous) dietary diversity variable predicted from the first stage.[9] In the QRM, the results are reported for four quantiles of BMI i.e., 20th, 40th, 60th, and 80th quantile. The lower quantiles would encompass those who are CED, the middle quantile would represent the normal levels and the top quantiles would include those who are overweight and obese.

6. Results from Econometric Estimations

6.1 CED rates and Mean BMI: Comparing Non-farm and Farm households

We observe that most rural households in India depend on agriculture as a main source of income and that many agricultural households have diversified sources of income. Among the rural women aged 20-45 years in the data set, 36 per cent of them belong to households that report cultivation as the major source of income while about 21 per cent of these women belong to households that report agricultural wages as the main source of income (Table 1). The average share of net farm income which includes income from cultivation, livestock and agricultural property in total income is 63 per cent among women in cultivator households. For women in several other types of household, share of farm income in total household income is not negligible either.

[8] Chernozhukov and C. Hansen (2013) provide detailed overview of the theoretical discussion on this method.

[9] If both the equations were to be estimated for an individual, then this instrumental variable quantile regression model could be supported by the conceptual framework of health production function provided by Becker (1965) and used in Chen and Tseng (2010). Under those conditions, an individual's health is determined by her nutrient intakes, health behaviour (physical activity, health seeking and care), nutrition awareness and other exogenous factors (environmental conditions, socio-demographic and cultural features, economic condition and genetics). Simultaneously, an individual's nutrition intake is influenced by her health behaviour, nutrition awareness and some exogenous factors. Extending this to a regression model, an individual's health is captured by BMI as determined by a set of factors including nutrient intake which is endogenous and hence an instrumental variable approach is used.

Table 1: Distribution of women aged 20-45 years across Major Source of Income in rural areas.

Major Source of Income	Distribution (%)	Average Share of Farm Income1 (%)	Grow at least one crop (%)	CED2 (%)	Mean BMI3	Standard Deviation of BMI3
Cultivation	36.0	62.8	94.5#	27.6	20.5	3.21
Agricultural Wage Labour	20.7	12.7	28.5	30.6	20.1	2.98
Non-agricultural Wage Labour	17.6	11.0	30.4	34.7	19.9	3.00
Artisan	4.9	8.8	22.7	22.7	21.3	3.67
Trade & Business	6.7	9.1	30.4	22.9	21.3	3.61
Salaried & Professionals	11.0	13.8	40.7	20.7	21.4	3.30
Others	3.2	18.1	39.4	24.3	21.3	3.44
Total	100.0	30.2	54.1	28.1	20.5	3.24

Note: (1) Share of farm income is in total income; (2) CED is BMI below 18.5; (3) The unit for mean and standard deviation of BMI is kg/m2. #This number is expected to be 100 per cent, but about 5 per cent of women from households with cultivation as major source of income either report no land cultivated or have nil crops grown. Such data are eventually excluded from the sample in the analysis of farm households.

As for undernourished (or CED) women, we observe that those in wage labour households are the worse off with non-agricultural labour being worse off than all others, and women in households reporting salaried and professionals are the better off; women in cultivator households are somewhere in the middle. It is, however, observed that the mean BMI of women in these households is also well above 18.5 for all these categories with lower standard deviation among wage labour households, indicating a narrower distribution around the mean compared to women in other types of households.

In order to assess if mean BMI and CED rates are statistically different across women in households with different sources of income, a regression model is estimated with dummy variables representing the different sources of income.

$Y_i=\beta_1 M_{1i}+\beta_2 M_{2i}+\beta_3 M_{3i}+\beta_4 M_{4i}+\beta_5 M_{5i}+\beta_6 M_{6i}+\beta_7 M_{7i}+u_i$

Y_i is the woman's BMI.

M_{1i}=1 if the i^{th} woman belongs to a household with cultivation as a major source of income.

=0 otherwise

M_{2i}=1 if the i^{th} woman belongs to a household with agricultural wage labour as the major source of income.

=0 otherwise

M_{3i}=1 if the i^{th} woman belongs to a household with non-agricultural wage labour as the major source of income.

=0 otherwise

M_{4i}=1 if the i^{th} woman belongs to a household with artisanal work as the major source of income.

=0 otherwise

M_{5i}=1 if the i^{th} woman belongs to a household with trade and business as the major source of income.

=0 otherwise

M_{6i}=1 if the i^{th} woman belongs to a household with regular salary or profession as the major source of income.

=0 otherwise

M_{7i}=1 if the i^{th} woman belongs to a household with others sources like rents, pensions etc. as the major source of income.

=0 otherwise

In this model, $E(Y_i|M_{1i}=1, M_{ji}=0, \forall\ j\neq 1) = \beta_1$. This implies that the estimated coefficient $\hat{\beta}_1$ from the data is the mean BMI of the women who are from households with cultivation (M_{1i}=1) as the major source of income. Similarly, each of the estimated coefficients is the mean BMI of the women from those households with another major source of income. The null hypothesis of testing for equality of some or all the coefficients in the estimated model above is equivalent to testing for the mean BMI to be same for women from households with different sources of income.

We also estimate another model, where the dependent variable Y_i takes the value 1 if the woman is CED and 0 otherwise, then the expression: $E(Y_i|M_{1i}=1, M_{ji}=0, \forall\ j\neq 1) = \beta_1$ implies that the estimated coefficient $\hat{\beta}_1$ from the data is the mean CED rate of the women who are from households with cultivation (M_{1i}=1) as the major source of income. In this model, the estimated coefficient values are multiplied by 100 to show the rates in percentages in Table 2.

Table 2: Mean Differences in BMI and CED rates across Major Sources of Income.

	BMI		CED	
Estimated Coefficients				
Major Source of Income	Coefficients	p-value	Coefficients	p-value
Cultivation (β_1)	20.5***	0.000	27.7***	0.000
Agricultural Wage Labour (β_2)	20.1***	0.000	30.7***	0.000
Non-agricultural Wage Labour (β_3)	19.9***	0.000	34.7***	0.000
Artisan(β_4)	21.3***	0.000	22.7***	0.000
Trade & Business(β_5)	21.3***	0.000	22.9***	0.000
Salaried & Professionals(β_6)	21.4***	0.000	20.7***	0.000
Others(β_7)	21.3***	0.000	24.3***	0.000
Tests of hypothesis	F-statistic	p-value	F-statistic	p-value
H_0: $\beta_1=\beta_2$, H_1: $\beta_1\neq\beta_2$	29.39***	0.000	11.82***	0.000
H_0: $\beta_2=\beta_3$, H_1: $\beta_2\neq\beta_3$	8.31***	0.000	14.33***	0.000
H_0: $\beta_1=\beta_2=\beta_3$, H_1: At least one is different	38.47***	0.000	28.35***	0.000
H_0: $\beta_4=\beta_5=\beta_7$, H_1: At least one is different	0.03	0.973	0.26	0.768
H_0: $\beta_1=\beta_6$, H_1: $\beta_1\neq\beta_6$	127.54***	0.000	38.66***	0.000

Note: (1) The above are coefficients estimates obtained by regressing BMI and CED respectively on the dummy variables for major source of income. (2) *p-value<0.10; ** p-value <0.05; *** p-value <0.01

The lower part of Table 2 below also presents the results of the test of hypothesis: H_0: $\beta_i=\beta_j$, H_1: $\beta_i \neq \beta_j$; i and j here refer to different category of major source of income. The results based on the F-tests show that the mean BMI of women in cultivator households is higher than those in agricultural wage labour followed by those in non-agricultural wage labour. Further, women in households with either 'trade and business' or 'salaried and professionals' or 'others' as major source of income have same mean BMI and CED rates as the nulls of equality of those coefficients cannot be rejected based on the p-value of the test statistic.

Table 3: Percentage of Women with CED across Asset Quintile: Comparing Non-farm and Farm Households in Rural Areas.

Asset Quintile Class@	**Distribution of Women**		**CED Rates (%)**		**Mean$ BMI (kg/m²)**	
	Non-Farm Household	**Farm# Household**	**Non-Farm Household**	**Farm Household**	**Non-Farm Household**	**Farm Household**
Bottom 20% (Q_1)	20.9	15.5 (46.4)	38.1	40.5	19.5 (2.60)	19.3 (2.55)
20-40% (Q_2)	16.9	22.0 (60.6)	31.6	34.9	20.0 (2.80)	19.8 (2.74)
40-60% (Q_3)	19.8	20.5 (55.1)	28.5	29.1	20.6 (3.20)	20.4 (3.14)
60-80% (Q_4)	22.3	20.0 (51.0)	24.0	24.7	20.9 (3.42)	20.6 (3.19)
Top 20% (Q_5)	20.0	22.0 (56.6)	13.5	18.6	22.5 (3.61)	21.5 (3.53)
All	100	100 (54.0)	27.0	28.9	20.7 (3.32)	20.4 (3.16)

Note: @The five asset quintile groups are obtained by ranking the households based on their asset ownership index; #Values in brackets are share of women within the asset quintile group; $Values in brackets are standard deviation of BMI.

We estimate a regression model to compare the differences in mean BMI and mean CED rates for farm and non-farm households for each quintile. For each of the five asset quintiles separately, the following two equations are estimated:

(1) BMI Equation-

$Y_i = \beta_1^{NF} + \delta_1 D_i + u_i$;

Y_i= BMI of the i^{th} woman

D_i= 1 if the woman is from a farm household or

=0 otherwise.

(2) CED Equation

$Y_i = \beta_2^{NF} + \delta_2 D_i + u_i$;

In this case D_i remains the same as in (1) but the independent variable is:

Y_i=1 if BMI<18.5 for the i^{th} woman or

=0 otherwise.

In the BMI equation for a particular quintile, if the δi coefficient is statistically significant and negative, then the women in farm households have lower average mean BMI than those in non-farm households belonging to the same asset quintile. Further, we could expect women in farm households to have lower BMI on account of more physical activity as farm households in general are known to use household labour for farming and related activities. The results in Table 4 show that mean BMI is lower for women in farm households compared to non-farm for all the quintiles as the δi coefficient is statistically significant and negative. The magnitude of this coefficient is not low so that the average BMI in farm households (β_3^F) ranges between 19.27 and 21.55 which is within the normal range.

What may be more relevant to compare is if the CED rates which capture undernutrition is higher on an average among farm than non-farm households. Similar to the BMI regression equation, in the CED equation, if the δi coefficient is statistically significant and positive for a given quintile, then the women in farm households have higher average CED rates for that quintile and hence lower nutritional status than those in non-farm household. From Table 4, we observe that δi coefficient is statistically significant and positive for the second and fifth asset quintile and for 'all' the households. Overall, the CED rate is higher by two percentage points among women in farm households (29 per cent) compared to non-farm households (27 per cent).

Table 4: Comparing Non-Farm and Farm households for differences in mean BMI and mean CED rates

	Asset Quintile					
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**All**
BMI equation						
Non-Farm (β_1^{NF})	19.51***	20.05***	20.59***	20.91***	22.46***	20.72***
p-values	0.000	0.000	0.000	0.000	0.000	0.000
Gap between Non-Farm and Farm (δ_1)	-0.23**	-0.21**	-0.23**	-0.29***	-0.91***	-0.32***
p-values	0.012	0.032	0.030	0.005	0.000	0.000
Farm ($\beta_1^F = \beta_1^{NF} + \delta_1$)	19.27	19.84	20.36	20.62	21.55	21.02
CED equation						
Non-Farm (β_2^{NF})	0.381***	0.316***	0.285***	0.239***	0.135***	0.2703***
p-values	0.000	0.000	0.000	0.000	0.000	0.000
Gap between Non-Farm and Farm (δ_2)	0.024	0.0342***	0.0072	0.007	0.0507***	0.0196***
p-values	0.169	0.042	0.632	0.608	0.000	0.000
Farm ($\beta_2^F = \beta_2^{NF} + \delta_2$)	0.4052	0.3504	0.2924	0.2468	0.1857	0.2899

Note: (1) The coefficients are estimated for each of the quintiles; (2) Q1-Q5 are the five quintiles by ranking the households based on their asset ownership index as shown in Table 3; (3) *p-value<0.10; ** p-value <0.05; *** p-value <0.01; (4) The estimated coefficients in the CED equation are ratio and are to be multiplied by 100 to get the CED rates.

6.2 Likelihood of CED: Comparing Women in Non-farm and Farm Households

The results from Tables 3 and 4 indicate that though women in farm households are somewhat wealthier with more of them belonging to higher asset quintiles, they have higher levels of CED rates with lower average BMI. We supplement these results with some additional preliminary analysis, using a regression framework so that women in households involved with agriculture activities are compared with those households in non-agricultural activities after controlling for other factors that could potentially be different between these households. In other words, omission of these other variables could bias the estimates in the results in Table 4. We focus only on CED and estimate a probit model with the dependent variable taking a value 1 when the woman has BMI below 18.5 and zero otherwise. Before, the results of this regression model is presented we provide the descriptive statistics of the variables used in different regression models in Table 5 below.

Table 5: Descriptive Statistics

Variable	**Mean**	**Standard deviation**	**Variable**	**Mean**	**Standard deviation**
BMI	20.4	3.17	Household Head: Not literate	0.21	0.408
Dietary Diversity Index	0.82	0.085	Household Head: Primary or Middle	0.35	0.476
Production Diversity Index	0.45	0.273	Household Head: Secondary	0.22	0.414
Log of total land area cultivated (acres)	3.24	1.118	Household Head: Higher Secondary	0.12	0.319
Log of total Agricultural Income (Rs.)	9.56	1.190	Household Head: graduate and above	0.11	0.311
Share of Sale of Own Produce	0.35	0.366	Allowed to purchase groceries	0.34	0.473
Number of Crops Grown	2.8	1.698	Eat with family members	0.40	0.489
Log of Household Income per person (Rs.)	8.42	0.938	Do not practice purdah	0.34	0.473
Share of total agricultural income	0.66	0.359	Has access to electricity	0.61	0.488
Share of non-agricultural wage income	0.12	0.247	Use clean cooking fuel	0.08	0.269
Share of members in age group 4-14 years	0.24	0.193	Use clean cooking fuel	0.13	0.333
Share of members in age group 15-60 years	0.60	0.204	Open defecation	0.75	0.433
Share of members above the age of 60 years	0.06	0.098	Traditional latrine	0.10	0.300
Household Size	6.5	3.028	VIP latrine	0.04	0.203
Age	32.2	7.297	Flush toilet	0.11	0.308
Ownership of draft animals	0.53	0.499	Not literate	0.54	0.498
Ownership of cows and buffaloes	0.59	0.491	Primary or Middle	0.31	0.462
Ownership of small ruminants	0.34	0.474	Secondary	0.10	0.306
Ownership of poultry and others	0.56	0.496	Higher Secondary	0.03	0.180

Table 5: Descriptive Statistics (contd.)

Asset Quintile 1 or 'Poorest'	0.15	0.362	Graduate and above	0.02	0.122
Asset Quintile 2 or 'Poor'	0.22	0.414	Self-employed in agriculture	0.57	0.495
Asset Quintile 3 or 'Middle'	0.21	0.404	Self-employed in agriculture and agricultural labour	0.16	0.363
Asset Quintile 4 or 'Rich'	0.20	0.400	Agricultural labour	0.02	0.134
Asset Quintile 5 or 'Richest'	0.22	0.414	Non-agricultural labour	0.01	0.071
			Not in labour force	0.24	0.425
Hindus	0.86	0.346	Not pregnant	0.95	0.209
Islam	0.09	0.287	Pregnant but no antenatal access	0.02	0.126
Christianity	0.01	0.113	Pregnant with antenatal access and going to doctor or nurse	0.03	0.159
Others	0.04	0.186	Pregnant with antenatal access and going to dai or others	0.00	0.059
Upper Caste Hindus	0.05	0.217	No illness (short-term morbidity) reported in the last 30 days	0.89	0.308
Other Backward Classes	0.44	0.497	Ill but did not seek treatment	0.009	0.094
Scheduled Caste	0.17	0.377	Ill and goes to public doctor	0.021	0.143
Scheduled Tribes	0.10	0.306	ill and goes to private doctor	0.073	0.261
Other Castes	0.23	0.423	Ill and seeks traditional help	0.003	0.057

The magnitude of the estimated coefficients in the probit regression model cannot be interpreted directly and we infer the direction of relationship. A negative (positive) sign on the estimated coefficient, when statistically significant, would imply that the likelihood (or probability) of CED is lower due to that variable after controlling for other variables (factors) that would potentially influence CED. The results in Table 6 show that in all instances, the likelihood of CED is less among households that depend primarily on cultivation or agriculture in general, when compared to households with 'other sources' of major income. We observe that dietary diversity index reduces the likelihood of CED (Variant 1) while the expenditure share of cereals in total food expenditure, which is a measure of low diversity in food consumption, increases the likelihood of CED (Variants 2 and 3).

The model also includes other control variables pertaining to economic status, household amenities, and individual characteristics of these women. These estimates show that women from higher asset quintiles, with lesser restrictions in terms of mobility or *purdah* practice, non-Hindus or non-Muslims, non-SC/ST, larger households with lower proportion of children, and households with some form of water purification, some form of toilets usage are all less likely to be CED. As for the individual characteristics, older women, women who are not self-employed in agriculture, those having access to better antenatal care among pregnant women are also less likely to be CED. The model also includes State dummy variables, which is not reported here, and show substantial variations across the States.

Table 6: Estimates from probit model for CED comparing agricultural household with non-agricultural households in rural India

	Variant 1		Variant 2		Variant 3	
Variable	**Coefficient**	**p-value**	**Coefficient**	**p-value**	**Coefficient**	**p-value**
Household's Major Source of Income [Other sources=reference]						
Agriculture and allied activities	-0.197**	0.027				
Agricultural labour	-0.237**	0.011				
Non-agricultural labour	-0.004	0.964				
Artisans	-0.174	0.119				
Petty trade and business	-0.180*	0.071				
Salaried and professionals	-0.144	0.133				
Share of income from cultivation			-0.143**	0.016		
Share of income from livestock rearing			-0.254**	0.015		
Share of agricultural property income			-0.175	0.254		
Share of agricultural wage income			-0.114*	0.079		
Share of non-agricultural wage income			0.13*	0.063	0.127*	0.070
Share of total agricultural income					-0.146***	0.003
Cultivates land					0.059	0.265
Income Diversity Index	0.119	0.108				
Dietary Diversity Index	-.557**	0.036				
Expenditure share of cereals in total food expenditure			0.451**	0.016	0.464**	0.013
Logarithm of per capita income	-0.028	0.205	-0.030	0.174	-0.028	0.201
Logarithm of monthly per capita consumption expenditure	0.035	0.318	0.065*	0.067	0.0615*	0.081
Asset Quintile Groups [Quintile 1 or 'Poorest'=reference]						
Quintile 2 or 'Poor'	-0.028	0.562	-0.031	0.519	-0.031	0.516
Quintile 3 or 'Middle'	-0.146***	0.006	-0.145***	0.006	-0.147***	0.006
Quintile 4 or 'Rich'	-0.216***	0.002	-0.213***	0.002	-0.217***	0.002
Quintile 5 or 'Richest'	-0.365***	0.000	-0.359***	0.000	-0.361***	0.000
Allowed to purchase groceries (Yes=1, No=1)	-0.086***	0.014	-0.081**	0.018	-0.082**	0.016
Eat with family members (Yes=1, No=0)	-0.029	0.377	-0.032	0.339	-0.031	0.356
Do not practice *purdah* (Yes=1, No=0)	-0.14***	0.000	-0.135***	0.001	-0.137***	0.001
Religion [Hindus=reference]						
Islam	-0.042	0.459	-0.062	0.279	-0.057	0.313
Christianity	-0.278**	0.017	-0.259**	0.026	-0.256**	0.028
Other religions	-0.256***	0.002	-0.255***	0.002	-0.255***	0.002

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

Table 6: Estimates from probit model for CED comparing agricultural household with non-agricultural in rural India (contd.)

	Variant 1		Variant 2		Variant 3	
Variable	**Coefficient**	**p-value**	**Coefficient**	**Variable**	**Coefficient**	**p-value**
Caste [Scheduled Tribe =reference]						
Upper Caste Hindus	-0.283***	0.003	-0.286***	0.003	-0.284***	0.003
Other Backward Classes	-0.176***	0.002	-0.179***	0.001	-0.181***	0.001
Scheduled Caste	-0.043	0.470	-0.065	0.269	-0.062	0.295
Other castes	-0.15**	0.015	-0.142**	0.021	-0.144**	0.019
Household Composition, share of members in different age group [children in age group 0-4 years= excluded group]						
Share of members in age group 4-14 years	-0.211	0.102	-0.22*	0.085	-0.23*	0.082
Share of members in age group 15-60 years	-0.399***	0.007	-0.42***	0.004	-0.42***	0.004
Share of members above the age of 60 years	-0.58***	0.004	-0.54***	0.007	-0.54***	0.006
Household size	-0.015**	0.027	-0.01**	0.039	-0.01**	0.034
Drinking water is treated in some form (Yes=1, No=0)	-0.22***	0.000	-0.23***	0.000	-0.226***	0.000
Sanitation Facility [None, open fields= reference]						
Traditional latrine	-.198***	0.000	-.201***	0.000	-0.202***	0.000
VIP latrine	-.197**	0.020	-.194**	0.021	-0.192**	0.022
Flush toilet	-.181***	0.001	-.181***	0.001	-0.182***	0.001
House has access to electricity (Yes=1, No=0)	-0.016	0.691	-0.022	0.593	-0.021	0.608
Use clean cooking Fuel (Yes=1, No=0)	0.0138	0.809	0.002	0.963	0.003	0.951
Age	-0.012***	0.000	-0.012***	0.000	-0.012***	0.000
Primary or Middle	-0.047	0.216	-0.047	0.219	-0.04	0.201
Secondary	-0.017	0.758	-0.013	0.810	-0.02	0.778
Higher Secondary	0.028	0.783	0.025	0.810	0.022	0.834
Completed Education level of the woman [Not literate=reference]						
Graduate and above	0.006	0.961	0.011	0.938	0.006	0.965
Employment Status [Not in the labour force =1]						
Self-employed in agriculture	0.131***	0.007	0.17***	0.000	0.158***	0.001
Self-employed in agriculture and agricultural labour	0.11*	0.052	0.165***	0.004	0.166***	0.003
Agricultural labour	0.033	0.572	0.055	0.372	0.071	0.226
Non-agricultural labour	-0.014	0.885	-0.056	0.573	-0.058	0.562

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

Table 6: Estimates from probit model for CED comparing agricultural household with non-agricultural in rural India (contd.)

	Variant 1		Variant 2		Variant 3	
Variable	**Coefficient**	**p-value**	**Coefficient**	**p-value**	**Coefficient**	**p-value**
[Not Pregnant=Reference]						
Pregnant but no antenatal access	-0.455***	0.004	-0.468***	0.003	-0.466***	0.003
Pregnant with antenatal access and going to doctor or nurse	-0.348***	0.001	-0.336***	0.002	-0.341***	0.001
Pregnant with antenatal access and going to *dai* or others	-1.13***	0.001	-1.16***	0.001	-1.16***	0.001
Shorter term morbidity or illness reported in the last 30 days [Not Ill =Reference]						
Ill but did not seek treatment	0.167	0.295	0.159	0.321	0.158	0.327
Ill and goes to public doctor	0.0419	0.668	0.040	0.682	0.040	0.683
Ill and goes to private doctor	0.225***	0.000	0.22***	0.000	0.221***	0.000
Ill and seeks traditional help	-0.035	0.873	0.010	0.964	0.009	0.968
Intercept	0.881**	0.016	-0.007	0.983	-0.021	0.949

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

6.3 Variations in Women's BMI within Farm Households

We now focus more on the nature of variations within farm households to understand how features of agriculture are beneficial to women's BMI. It may perhaps be less relevant to understand what causes the differences between farm and non-farm households in rural areas, as farming is an important activity and moving people out of it is not a way out. As discussed in the introduction, agricultural activities do have a lot of potential for improving undernutrition and within the setting of farming activities what causes variations in CED rates or BMI among such households is more important in the context of the present focus of this study. It is observed from the above results that many women are better off among farming households: 71 per cent (29 per cent) of them have BMI above (below) 18.5 and the average BMI of 20.7 is above this threshold value with a standard deviation of 3.2 (Table 3).

Estimates for Household's Dietary Diversity:

Estimates in Table 7 for the dietary diversity equation show that agricultural variables matter significantly. The production diversity index (for area shares) and total area under cultivation are positively significant at 10 per cent and 1 per cent levels of significance respectively. We observe that the presence of cows and buffaloes in the home has a positive and significant impact on dietary diversity, a finding similar to Bhagowalia *et al.* (2012a). Alongside this result we also observe that the value-share of crops sold in the market has a positive influence on dietary diversity as in Galab and Reddy (2011).

The economic status variables captured by asset quintile coefficients as well as total per capita household income are positive and significant with the expected signs. One observes that among farm households dietary diversity is lower among households with higher share of agricultural income or non-agricultural wage income compared to those having other income sources, implying that income diversity matters for farming households.

Muslim households have higher dietary diversity compared to Hindu households; all other caste households have a higher dietary diversity than the scheduled tribe households. Similarly, if the education level of (highest educated) adult in the household is high then it significantly influences dietary diversity. Larger households after controlling for other factors have less diversified diet but household composition does not have any impact on the dietary diversity.

Table 7: Estimates from the dietary diversity equation (first stage)

Variables	**Coefficient**	**p-values**
Production diversity index	0.0074**	0.073
Log of total land area cultivated (acres)	0.0048***	0.000
Log of total agricultural income (Rs.)	-0.0057***	0.002
Share of sale of own produce	0.0068**	0.011
Ownership of livestock [draft animals is the reference category]		
cows/buffaloes (Yes=1, No=0)	0.0082***	0.000
Small ruminants (Yes=1, No=0)	-0.0016	0.424
Poultry and others (Yes=1, No=0)	0.0019	0.276
Log of household income per person (Rs.)	0.0076***	0.000
Asset Quintile Groups [Quintile 1 or 'Poorest'=reference]		
Quintile 2 or 'Poor'	0.0157***	0.000
Quintile 3 or 'Middle'	0.0248***	0.000
Quintile 4 or 'Rich'	0.0333***	0.000
Quintile 5 or 'Richest'	0.0359***	0.000
Share of agricultural income in total income	-0.0109**	0.047
Share of non-agricultural wage income	-0.0182***	0.000
Religion of the household head [Hindus=reference]		
Islam	0.0094***	0.001
Christianity	-0.0037	0.628
Others	-0.0104*	0.070
Caste of the household head [Scheduled Tribe =reference]		
Upper Caste Hindus	0.0309***	0.000
Other Backward Classes	0.0205***	0.000
Scheduled Caste	0.0168***	0.000
Other	0.0222***	0.000
Education of the household head [not literate=reference]		
Primary or Middle	0.0039*	0.099
Secondary	0.0079***	0.003
Higher secondary	0.0097***	0.001

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

Table 7: Estimates from the dietary diversity equation (first stage) (contd.)

Variables	Coefficient	p-values
Graduate and above	0.0100***	0.004
Household composition, share of members in different age group [children in age group 0-4 years= excluded group]		
Share of members in age group 4-14 years	-0.0080	0.223
Share of members in age group 15-60 years	-0.0072	0.312
Share of members above the age of 60 years	-0.0073	0.445
Household size	-0.0015***	0.000
Intercept	0.7597***	0.000

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

Quantile Regression Estimates

The estimates from the quantile regression model for four quantiles: 20 per cent, 40 per cent, 60 per cent and 80 per cent are given in Table 8. The results show that dietary diversity influences BMI significantly for all the quantiles and the magnitude increases with the quantile. No clear pattern emerges on the influence of women's status within the household captured by practices that are usually considered to improve mobility and decision making and thereby influences one's own nutritional status. Religion and caste affiliations seem to influence BMI lesser than in the dietary diversity equation. Household composition has a larger influence for the upper quintiles with higher share of adult members having a larger positive effect on women's BMI.

The results from this study shows that basic amenities like use of treated water for drinking, better sanitation facilities and cleaner cooking fuels have a significant and large influence on BMI, which holds true for all the quintiles. These results are similar to what is observed for child undernutrition. Among individual variables, education did not matter so much for BMI and, instead, the nature of employment carried out by the women matters significantly. We observed that once types of occupation are controlled for, education becomes insignificant. Compared to women in other types of occupation including not in employment, women in agricultural employment - whether on the farm or as wage labour as well as those in non-agricultural wage employment - have a lower average BMI, and this gap is large for the uppermost quantile. The differences are perhaps occurring due to higher physical activity of women across these different types of occupation.

Average BMI for pregnant woman is naturally expected to be higher than others. As mentioned earlier, pregnant women were further classified into groups based on the type of antenatal care they were seeking. The coefficients are positive and significant in most quantiles, although the magnitude of this coefficient is lower for women who are accessing trained practitioners and professionals compared to those who do not seek any care or go to the *dai* or others. This may appear counter-intuitive but is a reflection of the care-seeking behaviour among pregnant women. Those who are worse off are perhaps seeking antenatal care with professionals as they perceive themselves to need more attention and care which in turn is reflected in their lower average BMI.

Similar to pregnant women, the average BMI of women who consulted a doctor is lower than those who have been ill and not consulted a doctor. Furthermore, the average BMI after controlling for other explanatory variables is no different for those who are ill but do not seek any medical advice, as the illness may not have been severe and hence there is no perceptible decline in BMI (or weight). The topmost quintile shows no difference in BMI across care behaviour perhaps because their chances of falling ill could be less frequent due to better ex-ante nutritional status.

Both these results on accessing healthcare imply that when needed many women in rural areas are able to access the right type of attention.

Thus, summarising the results on BMI, we observe that in rural areas cultivation and livestock rearing has significant influence in reducing women's likelihood of low BMI. Empowerment variables noticeably influence the likelihood of low BMI than quantiles of BMI. The features of agriculture impact household's dietary diversity and most of the amenities-related variables are more prominent in influencing BMI. All the models estimated include State dummy variables, the results of which are not reported here. The regional variations across the States capture institutional and cultural features that could not be accounted for in these models. We find that most of the coefficients are negative and statistically significant compared to the reference State of Punjab (as mentioned earlier), indicating that these other features are important in explaining inter-State variations in either nutrition intake or nutrition outcome.

Table 8: Estimates quantile regression model for women's BMI

Quantiles→	20%		40%		60%		80%	
Variables ↓	**Coeff**	**p-value**	**Coeff**	**p-value**	**Coeff**	**p-value**	**Coeff**	**p-value**
(Predicted value of) Dietary Diversity Index	7.89***	0.000	6.22***	0.003	12.8***	0.000	18.8***	0.000
Allowed to purchase groceries (Yes=1, No=1)	0.137*	0.066	-0.017	0.809	-0.070	0.370	-0.039	0.702
Eat with family members (Yes=1, No=0)	0.12	0.130	0.112	0.144	0.175**	0.036	0.196*	0.072
Do not practice Purdah (Yes=1, No=0)	0.146	0.113	0.397***	0.000	0.318***	0.001	0.179	0.156
Religion [Hindus=reference]								
Islam	0.117	0.398	0.131	0.327	0.0608	0.677	0.305	0.107
Christianity	1.37***	0.000	1.2***	0.000	1.53***	0.000	0.665	0.164
Others	0.546**	0.018	0.46**	0.039	0.491**	0.043	0.517	0.101
Caste [Scheduled Tribe =reference]								
Upper Caste Hindus	0.405*	0.067	0.563***	0.008	0.445*	0.056	0.054	0.857
Other Backward Classes	0.124	0.392	0.165	0.240	0.196	0.201	-0.087	0.662
Scheduled Caste	-0.385**	0.011	-0.188	0.199	-0.068	0.670	-0.34	0.102
Other	-0.111	0.493	0.379**	0.015	0.291*	0.087	0.0013	0.995
Household Composition, share of members in different age group [children in age group 0-4 years= excluded group]								
Share of members in age group 4-14 years	-0.127	0.696	0.47	0.134	0.643*	0.061	1.00**	0.024
Share of members in age group 15-60 years	0.184	0.584	0.794**	0.014	.985***	0.005	1.11**	0.016
Share of members above the age of 60 years	0.532	0.249	0.719	0.107	1.54***	0.002	2.02***	0.001
Household size	0.039***	0.001	.0469***	0.000	0.041***	0.002	0.037**	0.029
Drinking water is treated in some form (Yes=1, No=0)	0.718***	0.000	0.586***	0.000	0.449***	0.000	0.371**	0.019
Sanitation Facility [None, open fields= reference]	0.671***	0.000	0.851***	0.000	0.53***	0.000	0.92***	0.000
Traditional latrine	0.895***	0.000	0.868***	0.000	0.645***	0.001	0.754**	0.002
VIP latrine	0.582***	0.000	0.951***	0.000	0.773***	0.000	0.824***	0.000
Flush toilet	0.235**	0.008	0.199*	0.020	0.288**	0.002	0.3*	0.013

Note: *p-value< 0.10; **p-value<0.05; *** p-value <0.01(Contd.)

Table 8: Estimates quantile regression model for women's BMI

Quantiles→	**20%**		**40%**		**60%**		**80%**	
Variables ↓	**Coeff**	**p-value**	**Coeff**	**p-value**	**Coeff**	**p-value**	**Coeff**	**p-value**
House has access to electricity (Yes=1, No=0)	-0.058	0.671	-0.20	0.129	-0.078	0.587	0.502***	0.007
Use clean cooking fuel (Yes=1, No=0)	0.015**	0.010	0.035***	0.000	0.052***	0.000	.082***	0.000
Age	0.671***	0.000	0.851***	0.000	0.53***	0.000	0.92***	0.000
Completed education level of the woman [Not literate=reference]								
Primary or Middle	0.133	0.121	0.232***	0.005	0.095	0.293	0.251**	0.032
Secondary	0.006	0.967	0.008	0.949	0.029	0.834	0.257	0.160
Higher Secondary	-0.004	0.984	-0.275	0.192	-0.55**	0.017	-0.22	0.460
Graduate and above	-0.061	0.845	0.362	0.225	-0.002	0.994	-0.13	0.760
Employment Status [Not in labour force and other employment=reference]								
Self-employed in agriculture	-0.085	0.345	-0.226***	0.009	-0.282***	0.003	-0.511***	0.000
Self-employed in agriculture and agricultural labour	-0.226*	0.082	-0.53***	0.000	-0.414***	0.003	-0.538**	0.003
Agricultural labour	-0.223	0.411	-0.197	0.452	-0.257	0.368	-0.221	0.551
Non-agricultural labour	-1.18**	0.016	-0.443	0.350	-0.751	0.147	-1.41**	0.036
[Not Pregnant=Reference]								
Pregnant but no antenatal access	1.66***	0.000	1.72***	0.000	1.93***	0.000	3.03***	0.000
Pregnant with antenatal access and going to doctor or nurse	0.59***	0.005	0.646***	0.001	0.55**	0.013	0.492*	0.086
Pregnant with antenatal access and going to dai or others	2.09***	0.000	2.01***	0.000	1.57***	0.009	0.623	0.423
Shorter term morbidity or illness reported in the last 30 days [Not Ill =Reference]								
Ill but did not seek treatment	0.115	0.750	0.15	0.668	0.153	0.687	-0.500	0.311
Ill and goes to public doctor	-0.619**	0.012	-0.492**	0.040	-0.523**	0.045	-0.218	0.520
Ill and goes to private doctor	-0.642***	0.000	-0.432***	0.001	-0.366***	0.008	-0.226	0.208
Ill and seeks traditional help	-0.715	0.205	-0.833	0.126	-1.56***	0.009	-0.959	0.214
Intercept	11.1***	0.000	12.3***	0.000	8.48***	0.000	5.66**	0.020
Pseudo R^2	0.0759		0.0906		0.0999		0.1096	

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

7. Conclusions

Nutrition forms the basis of the overall well-being of a person. It is even more important in the case of women, since an undernourished woman gives birth to an undernourished child, contributing to a vicious circle. Therefore, arresting the problem of undernourishment at different stages of the lifecycle is essential to reduce the huge burden of under nutrition observed in the Indian sub continent. In this context, India stands out in terms of several puzzles. There has been faster economic growth in last two decades but the undernourished population, particularly children, is still very large in number. With modest decline in poverty rates, the undernourishment rates have shown even slower rates of decline with rural areas showing the largest concentration of undernourished children and adults. During this period of rapid overall growth, agricultural growth has been rather tame and more varied across regions of India and over time. The share of agriculture in value addition has been declining at a continuous pace but the share of agriculture in employment still remains large. All this has resulted in the focus shifting to reviving the possible pathways that agriculture would play in reducing undernutrition.

This paper has attempted to explore the nature of relationship between agriculture and nutrition based on two components: nutrition intake (dietary diversity) and nutrition outcome (BMI). The nature of the data set is such that by using a large-scale survey for the first time, we have been able to explore the linkages between dietary diversity, features of agricultural production and women's BMI among farm households in rural India. However, the nature of the data set is also such that the nutrition intake is at the household level while the nutrition outcome is measured at the individual level. The methodological framework envisaged here resulted in establishing a relationship between agricultural components and dietary diversity which in turn influences women's BMI. Given that adults are more in control of the resources at the household level and women in particular are the main actors of change for children, a study of this nature gains significance.

This study finds that the likelihood of poor nutrition status for women as captured by BMI levels below 18.5 is the highest among non-agricultural wage labour households which face the largest brunt in the rural areas. If one were to understand what components within agriculture influence variations in the nutritional status, then the focus is to be on households involved in farming and allied activities. From such an analysis we find that agriculture variables influence dietary diversity, that is nutrition intakes, which in turn influence nutrition outcomes, that is BMI. Diversification either in terms of crop production or in terms of income improves dietary diversity and so does a higher of sale of crops and ownership of cows and buffaloes after controlling for per capita income and wealth status, both of which also have significant positive influence on dietary diversity. All of these variables improve affordability and access to diverse diets while higher the education of the household head, better is the dietary diversity due to improved awareness. BMI which pertains to an individual's nutrition status while influenced by dietary diversity, it is the access to basic amenities like good quality water, better sanitation facilities, a smoke-free cooking environment, an employment status that is less strenuous seem to have better consequences. After controlling for these variables, education and empowerment variables seem to have a less pronounced effect on the women's BMI, while there is an indication that women are able to seek better health care facilities when they feel the need to do so. Overall, we find that our results corroborate the findings from other studies that the components of agriculture that are expected to improve nutrition intake do so with an equally important role for household's prosperity and environmental conditions that assist in maintaining a good health for the individual.

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