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### Food insecurity in Nepal : a cross-sectional analysis from 75 districts

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*Food Insecurity in Nepal: A Cross-Sectional Analysis from 75 Districts*

*By*

*Aarti Reddy*

*Honors Thesis*

*In*

*Department of Economics  
University of Richmond  
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## **Abstract**

There are a number of studies regarding food insecurity, but not many that investigate the simultaneous relationships between food insecurity and the measures of well-being (health, education and gender equality). This paper conducts a district-level cross-sectional analysis of the relationship between food insecurity and the measures of well-being in Nepal using an ordered probit model. Instrument variables are used in a two-stage analysis to address the problem of endogeneity. The study finds that health deprivation levels significantly affect levels of food insecurity in a district but education and gender literacy disparity are less significant. Addressing issues of endogeneity and multicollinearity more effectively will allow for more reliable results. A better understanding of these relationships is essential to decrease food insecurity as well as to improve broader socio-economic outcomes.

## **I. Introduction**

### Food Insecurity

One in eight people in the world are estimated to be suffering from chronic hunger, regularly not getting enough food to conduct an active life (FAO et al., 2013). In the year 2000, all 189 United Nations (U.N.) member countries and at least 23 international organizations committed to improve the lives of billions of people around the world. They set eight Millennium Development Goals (MDGs)<sup>1</sup> to be met by 2015. The MDGs are used widely as targets and measures for development efforts around the world. MDG Goal 1 is “to eradicate extreme poverty and hunger with a sub-goal of halving the proportion of people who suffer from hunger between 1990 and 2015”. By 2014, 63 developing countries had met the MDG target (FAO, 2014). Despite general progress, significant differences are observed between regions of the world with slow progress in South Asia.

Food security is defined as the condition when all people, at all times, have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996). The understanding of this concept has evolved from the Malthusian idea that food insecurity was caused by the inability of food production to keep up with increasing population. It is now a multifaceted concept widely categorized into four dimensions: 1) availability; 2) access; 3) utilization; and 4) stability.

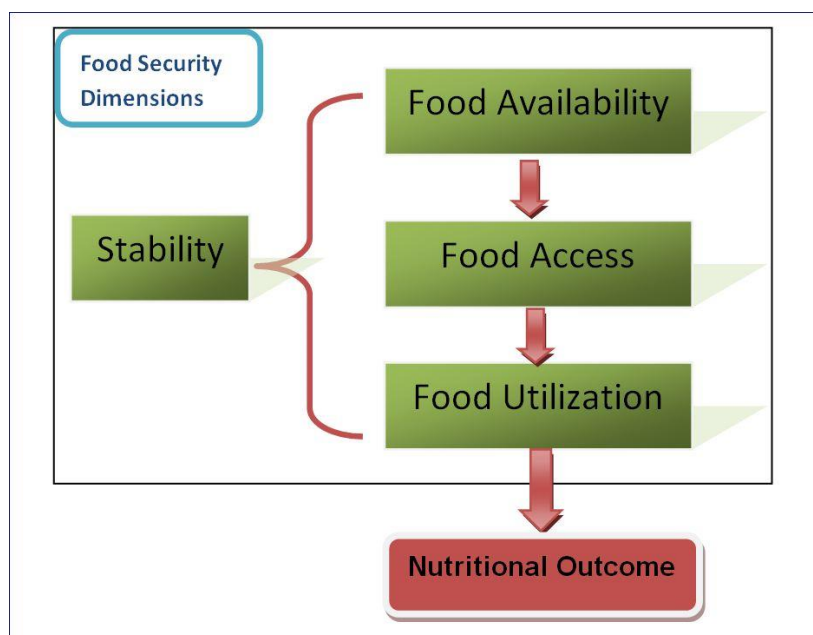
*Availability* refers to whether food is actually or potentially physically present. It includes production, wild foods, food reserves, markets, and transportation. *Access* refers to whether

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<sup>1</sup> The Millennium Development Goals were designed to promote and measure progress towards meeting the needs of the world’s poorest for the target date of 2015. They include halving extreme poverty, halting the spread of HIV/AIDS, and providing universal primary education. Goal 1 of the MDGs, to eradicate extreme poverty and hunger, includes the following sub-goals: 1) Halve, between 1990 and 2015, the proportion of people whose income is less than \$1 a day; 2) Achieve full and productive employment and decent work for all, including women and young people; 3) Halve, between 1990 and 2015, the proportion of people who suffer from hunger.

households have sufficient access to the food that is available. It includes physical aspects such as distance and infrastructure; financial aspects such as purchasing power; and social aspects such as ethnicity, religion and political affiliation. *Utilization* refers to whether households sufficiently utilize the food available and accessible to them. It included aspects such as food preferences, preparation, feeding practices, storage, and access to better water sources. Some measures include individuals' biological utilization of food. *Stability* refers to whether the whole system is stable and if households are food-secure over time. It includes aspects such as variations in food prices, supplies and access due to adverse weather, pests, pathogens, or political and economic instability.

These dimensions together contribute to the nutritional outcomes for a population, as depicted in the following diagram:



Source: Basic Concepts of Food Security: Definition, Dimensions and Integrated Phase Classification  
Yadav Sharma Bajagai, 2013

The factors that contribute to food security can be categorized into three broad areas (Khadka, 2010): 1) overall socio-economic, political and natural environment; 2) performance of

the food economy; 3) household level factors such as assets, livelihood, care practices, health and sanitation conditions. This paper focuses on factors within the first and third categories.

### Characteristics of Nepal:

Nepal is a developing country located in Asia between China to the north and India to the south, east and west. Nepal has the second lowest per capita income<sup>2</sup> (\$2260) in Asia. It has a population of more than 27 million people (CBS, 2011) with 31% living below the poverty line (UNDP, 2008). Despite recent progress in poverty reduction, Nepal is one of the poorest countries in the world and has a Human Development Index ranking of 157<sup>3</sup> among 187 countries (UNDP, 2013).

Nepal's economy is highly dependent on agriculture with more than 70% of the population working and accounting for 38% of GDP (USAID, 2014). Yet Nepal does not meet its citizens' food demand. Limited access to technology and market opportunities for farmers combined with declining agricultural production due to urban migration has depressed rural economies and increased rates of hunger.

Almost half of Nepal's population is undernourished and roughly 50% of under-five children are chronically malnourished. Chronic under-nutrition has debilitating effects on health, educational attainment, and income earning ability. Nepal is ranked amongst the lowest countries for food security status according to the Global Food Security Index 2012.<sup>4</sup> The population is estimated to reach 40.5 million by 2025, posing further challenges to fulfilling the food requirements (Khadka, 2010).

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<sup>2</sup> Per capita income measured in: GNI PPP current \$ (World Bank Data)

<sup>3</sup> Nepal has a HDI value of 0.463. The HDI ranges from 0 as the lowest level of human development and 1 as the highest. The Human Development Index (HDI) is a composite measure of life expectancy, education, and per capita income indicators, used to rank countries in terms of human development.

<sup>4</sup> 79<sup>th</sup> rank out of 105 countries

There is strong interdependence between food security and the broader sustainable development agenda including economic growth, population dynamics, employment, health, education, clean water access, energy, health, sanitation, natural resource management, and the protection of ecosystems. Addressing gender and urban-rural inequalities are as critical to fighting hunger and ensuring food security as they are to universal sustainable development. Empirical analysis of these interdependencies can facilitate better policy decisions that address multiple aspects of development challenges simultaneously.

Nepal's unique geographical characteristics<sup>5</sup> often make it more challenging to improve food security and substantive measures of well-being. While the national poverty rate is 31%, it is much higher in the Mid-Western and Far-Western regions at about 45% (UNDP, 2008). These hilly and mountainous regions have rugged terrain, low rainfall, and poor-quality soil which make farming, economic activity, and service delivery difficult in these areas. These areas are physically isolated, with insufficient infrastructure and poor communication capabilities. Understanding the regional differences in the relationship between food insecurity and measures of well-being is important to address food insecurity on a national level.

The rural-urban divide is significant. About 80% of the population live in rural areas and depend on subsistence farming for their livelihoods. Household food insecurity and poor nutritional outcomes are a serious concern in these areas and most rural households have little to no access to primary health care, education, safe drinking water, sanitation, and other basic necessities.

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<sup>5</sup>Nepal can be categorized into three main geographical regions: Mountain, Hill and Terai. The mountainous North has 8 of the world's ten tallest mountains and more than 240 peaks, while the southern Terai region is fertile and humid. Population density in the country varies according to altitude with an average of more than 1,000 persons/ km<sup>2</sup> in the Terai region to about 300 persons/ km<sup>2</sup> in the hilly areas to as few as 30 persons/ km<sup>2</sup> in the mountainous areas. For administrative purposes it is divided into 5 development regions: Eastern, Central, Western, Mid-Western, and Far-Western, which are further divided into 75 districts.

Diversity within the country as described above implies that country-specific and sub-national analysis is necessary to inform policy and resource allocation for any national effort in Nepal, particularly the effort to reduce food insecurity.

In addition to its inherent importance, higher levels of food insecurity can lead to higher levels of conflict. Therefore, reducing food insecurity is important for a nation's peace and national security. This is probably even more pertinent to Nepal, a nation that has recently emerged from a time of political instability and turmoil following a civil war in 1996-2006. Not only does the government have an obligation to reduce levels of food insecurity on the basis of universal human rights<sup>6</sup>, it is also in the interest of the political parties and officials in power to do so in order to maintain peace and power.

In recent years, the Government of Nepal (GoN) has been directing more attention to food security as a development issue, demonstrated through a series of documents and plans.<sup>7</sup> There are also a number of projects<sup>8</sup> by and in collaboration with development partners and local organizations.<sup>9</sup> Nepal relies heavily on foreign aid.<sup>10</sup> Foreign aid represents 26% of the national budget from over 40 donors (GoN MoF, 2011). Donors include governments of other countries, multilateral organizations, and non-profit organizations. However, the political climate, corruption and inability to utilize aid effectively, are decreasing donor confidence which may

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<sup>6</sup> Food sovereignty is recognized as a fundamental citizens' right in the Interim Constitution of 2007. According to Article 18.3 "every citizen shall have the right to food sovereignty as provided for in the law". Food sovereignty is defined as "the true right to food and to produce food, which means that all people have the right to safe, nutritious and culturally appropriate food and to food-producing resources and the ability to sustain themselves and their societies."

<sup>7</sup> Including: the second Three Year Plan (2010/11-12/13), the National Agriculture Sector Development Priority plan (NASDP 2011-2015), and the associated Country Investment Plan (CIP) and the Multi-Sectoral Nutrition Plan. Through this plan, The National Planning Commission (NPC) aims to collaborate with the Ministry of Agriculture Development to create the basis for a national "nutritional architecture".

<sup>8</sup> Some examples include local seed production and storage, livestock productivity enhancement, crop diversification, off-farm livelihood development (including micro-enterprises), training and capacity building, and creation of self-help groups.

<sup>9</sup> For more information please see: (World Bank, Report No: 69117-NP, 2013).

<sup>10</sup> Four% of its gross GNI was Official Development Assistance (ODA) in 2012.



reduce future aid flows. The mismatch of priorities between donors and government of Nepal creates gaps and overlaps leaving development needs inadequately addressed. In order to increase the effectiveness of both government and donor organizations, there is need for thorough country-specific analysis before, during and after the implementation of any socio-economic development intervention.

This paper will examine the endogenous relationships between food insecurity and three aspects of well-being (health, education and gender equality) amongst districts in Nepal, in an effort to facilitate better evidence-based policy making and resource allocation for socio-economic development.

## **II. Literature Review**

A number of indicators have been used to gauge food insecurity levels. Calorie adequacy is one basic measure that has been used in studies by Payne (1990), Haddad et al. (1994), Chung et al. (1997) and Jabo et al. (2014). Anthropometric<sup>11</sup> measures of food deprivation as used by Barrett (2002) are also common. Some studies use income-based measures. For example, Amarasinghe et al. (2005) use purchasing power parity (PPP). They map poverty using a nutrition-based poverty line to analyze its spatial clustering in Sri Lanka. They found that rural areas with low poverty cluster around urban areas with better road access. Also, availability of and access to land resources are important factors that affect levels of poverty and food insecurity. Farrow et al. (2005) use poverty and food consumption measures to examine the district-level geographic distribution of food consumption and food poverty in Ecuador. The spatial analysis also showed that the processes underlying food poverty in Ecuador are spatially

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<sup>11</sup> Anthropometric measures are measures of the human body in terms of the sizes and proportions of bone, muscle and fat tissue. They are measures of nutritional outcomes that can be used as an indicator of food insecurity.

variable. Improvements in transportation and infrastructure would decrease levels of food poverty country-wide.

These studies focus on quantitative measures that often tend to represent only one dimension of the multi-faceted issue of food insecurity. Maxwell et al. (1999) and Mason (2003) recommend using multiple measures. Gittelsohn et al. (1997) uses a qualitative measure of dietary diversity to investigate food utilization in rural Nepali households. He finds gender differences in dietary diversity, which are not reflected in the simpler measure of calorie consumption.

Naylor (2014) asserts that, “Any society that fails to build on the potential of all its members will always be at a disadvantage. Food and nutrition insecurity reflects and contributes to this unmet potential. It affects everything from the health of an unborn child, to the educational attainment of a given society, to the political stability and economic progress of the world.” There has been plenty of literature recognizing the role of securing food security in improving measures of well-being, but not much that explores the reverse relationships as Naylor does. He emphasizes that decreasing food insecurity is not only a matter of addressing its direct casual factors, but that “It also depends on us putting in place the right policies to address poverty and inequality, promote gender equality, strengthen and rights, and accelerate wider economic and social development.” There is still a dearth of empirical studies that investigate the interdependencies between socio-economics factors and their reciprocal relationships with food insecurity.

Many parts of the world have observed a paradox of widespread food insecurity and malnutrition despite net food surpluses. Iram et al.’s (2004) study of households in Pakistan uses an OLS model to regress the log of per capita calorie intake on the determinants of food

insecurity. They conclude that food programs are likely to have a significant impact only when public or donor investment in health, particularly reducing illnesses, is prioritized. Further, they find that efforts to decrease food insecurity may have a limited effect on the nutritional well-being of individuals unless the links between food insecurity, disease, poor sanitation, and inadequate education are addressed. They emphasize that effective food security programs need multi-sectorial approaches and should consider social, economic, cultural, and ecological constraints. Finally they stress that, in planning these investment programs, the synergistic effects of food and non-food interventions should be harnessed.

Maitra et al. (2014) conducted household-level multivariate analyses of the impact of poverty and other socio-economic factors on food security in India. They use experiential measures of food security that capture both quantitative and qualitative dimensions. They account for endogeneity in their analysis through a simultaneous ordered probit model. This study also uses cross-sectional data due to poor availability of panel data, and takes into account urban-rural dynamics in South Asia. This study is the most relevant paper to mine. Since my paper takes a more holistic approach to food insecurity, a relatively new and multi-dimensional measure of food insecurity will be used. The discrete nature of my dependent variable for food insecurity will require an ordered probit model.

Gundersen et al. (2007) used probit and ordered probit models to investigate gender differences in food insecurity using data from a 2004 household-based survey of children in Zimbabwe. They found no significant gender differences in food insecurity but that other household characteristics including age and household wealth did matter. These results are supported by research showing that allocation of food resources in Sub-Saharan African households is generally gender egalitarian as opposed to South Asia.

There are relatively fewer studies on food insecurity in Nepal. Aside from the previously discussed study of gender differences, Gittelsohn et al. (1998) analyze the relationship between quality of food consumption and food insecurity in the past, present and future. This study is limited to a relatively small area within a district in the Far West region of Nepal.

Maharjan et al. (2006) investigated the relationship between socio-economic characteristics and food insecurity status on a household level using ANOVA. They find that land distribution amongst households affects their food insecurity levels alongside other socio-economic household characteristics.

Most of the studies specific to Nepal have examined areas on a household level. However, allocation of development funding and decisions for development interventions are often made on a district level. There are quite a few reports on the relationship between food insecurity and specific factors such as road density, poverty levels, and access to water and sanitation, but few empirical studies that examine the relationship between food insecurity and the measures of well-being (health, education and gender equality). Further, there is a dearth of research that accounts for endogeneity between food insecurity and these measures of well-being.

### **III. Data and Model**

The model is a cross-sectional regression using 75 districts of Nepal. Factors that affect food insecurity were identified and the best indicators to represent these aspects were chosen from the district-level data available. The basic structure of the model is:

Food Insecurity = f (Health deprivation, Education, Gender Literacy Disparity, Poverty Severity, Population Density, Population to Arable land ratio, Road Density, Political Participation, Central Region).

## **Dependent Variable:**

The dependent variable, a measure of food insecurity, is the Integrated Chronic Food Security Phase Classification (IPC). The classification is based on criteria of severity and prevalence of food insecurity. A standardized set of tools is used to classify the level of food insecurity in each district on a scale of 1 to 4<sup>12</sup>. Phase 1 is the least insecure and Phase 4 is the most. These intervals are based on the percentage of households that meet the reference cut-off levels for bivariate indicators. With an assumption that percentage of households equals percentage of population, higher IPC levels indicate higher prevalence of chronic food insecurity in a given area. The classification is based on indicators including food consumption, safe water availability, livelihoods changes, nutritional status, and mortality. These indicators are analyzed within local contexts, alongside the contributing factors of food availability, access, utilization, and stability.<sup>13</sup> According to Headey and Ecker (2013), a good measure for food security allows for cross-sectional and inter-temporal validity and maintains nutritional relevance. This new classification approach will allow for comparability across countries and over time as it becomes more commonly used. The framework also provides decision makers with objectives corresponding to each phase to facilitate better response in socio-economic development and emergency contexts.

The IPC distinguishes between acute and chronic food insecurity. This study uses chronic food insecurity which is defined as “the prevalence of persistent food insecurity – i.e. levels of food insecurity that continue even in the absence of hazards/shocks or high frequency of years

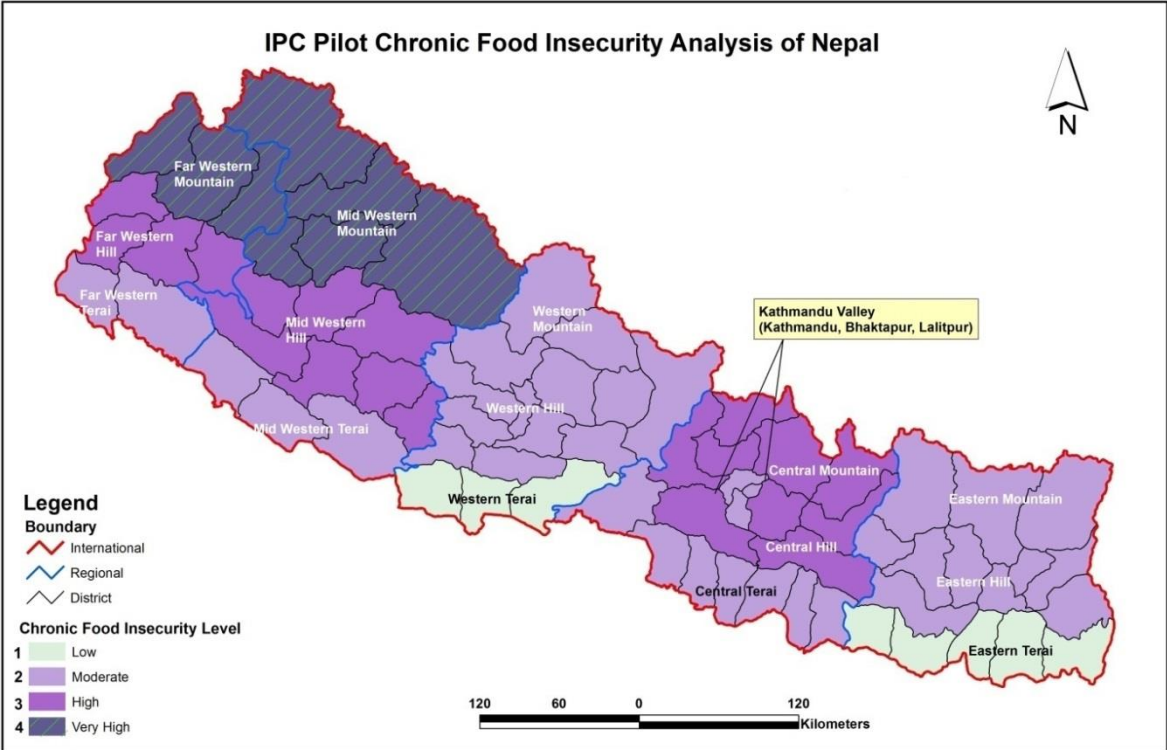
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<sup>12</sup> The original IPC method has five classifications: 1= generally food secure, 2= moderately/borderline food insecure, 3= acute food and livelihood crisis, 4= humanitarian emergency, 5 = famine/humanitarian catastrophe. (Integrated Food Security Phase Classification, User Guide, Version 1.0). The IPC classification method adapted for use in Nepal however has 4 classifications of chronic food insecurity: 1= Low, 2= Moderate, 3=High, 4 = Very high. (Nepal Integrated Food Security Phase Classification (IPC) Chronic Food Insecurity Situation Overview, 2012)

<sup>13</sup> See Appendix 1 for more information.

with acute food insecurity”. The acute classification system is designed to inform crisis mitigation and prevention, while the chronic classification to inform structural and developmental policies and programs. The long term applicability and consideration of underlying causes make the chronic measure more appropriate for assessing the relationship between levels of food insecurity and substantive measures of well-being.

Map of chronic food insecurity in Nepal:



Source: Nepal Integrated Food Security Phase Classification (IPC) Chronic Food Insecurity Situation Overview

**Focal Independent Variables:**

The three focal independent variables are health deprivation, education and gender literacy disparity. Along with poverty, these three are the most widely targeted measures of well-being in socio-economic development agendas around the world.

*Health Deprivation:* Health deprivation is be measured by the percentage of people not expected to survive age 40. It is the best substitute that could be found for the commonly used

measure of life expectancy as a proxy for overall health in socio-economic development contexts. However, this measure does not fully capture the general health level of the population but more so the level of fatalities, some of which may be caused by poor health. One would expect higher food insecurity in districts that have higher health deprivation due to lower productivity. Not only does productivity affect the income earning capacity of individuals which they use to buy food (access) but it also affects the population's ability to work and produce the food (availability). Further, since over 70% of Nepal's population works in the agriculture sector, which constitutes about 38% of the GDP (USAID, 2015), this relationship of health, productivity, food supply, and food insecurity is probably important.

*Education:* The basic education level is measured by the percentage of population between 15 and 24 that is literate, the closest indicator available to the commonly used measure of overall literacy rate. Higher levels of education are expected to be associated with lower levels of food insecurity. An educated person is not only expected to have better income earning capacity but also more control over their lives and better bargaining power in their daily interactions (access). He/she is more likely to make better spending decisions on food and its utilization. They will probably be better prepared to cope with uncertainties and be better off on the stability aspect of food insecurity.<sup>14</sup>

*Gender Literacy Disparity:* Gender equality can make a substantial contribution to a country's economic growth and is an important determinant of food security (ADB, 2013). A cross-country study of developing countries study by Smith & Haddad found that 43% of hunger reduction was attributable to improvement in women and girls' education. Women and girls play an important role in various dimensions of food insecurity within availability, access, utilization,

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<sup>14</sup> This is not to say that illiterate homemakers do not understand some of these best practices learned from traditional approaches and from family members without formal education, but that formal education generally would build further upon these capacities.

and stability. Educated women generally have better access to employment opportunities. Employment and education both increase their economic autonomy and bargaining position within the family. This affects their voice in household decisions and the likelihood of changing traditional feeding and caregiving practices that favor males. It also affects the general household level food insecurity, health and nutrition outcomes. Additionally, the material deprivation faced by women resulting from gender inequality affects their ability to fulfill their significant role in food production, preparation and processing. Inability to adequately fulfill their role in ensuring proper nutrition for their children has long term impacts.

Gender equality can be measured through a number of dimensions including gaps in health, education, income, positions of power, political participation, and their general reproductive health. Data by gender at the district level was readily available only for education. This is used in the variable, gender literacy disparity, which is the ratio of male to female percentage of literate population age 15-24. This measure serves as a reasonable proxy for gender equality in education. Perfect gender literacy parity is a value of 1 and the further away the ratio is from 1 the greater is the gender literacy disparity. All the values for this variable are above 1 demonstrating a bias towards males. Therefore, in this analysis we associate a higher ratio with greater gender literacy disparity. It is expected that higher gender literacy disparity ratios will be associated with higher levels of food insecurity.

### **Control Independent Variables:**

The control variables are included in the model because they are important factors that affect food insecurity. However, they are not the focus of the paper due the following reasons. Population density and population to arable land ratio cannot realistically be changed intentionally without making people relocate and essentially infringing on their rights. The other



three control variables, poverty severity, road density, and political participation are already being incorporated into efforts to decrease food insecurity. Whereas, the three focal variables (health deprivations, education and gender literacy disparity) can realistically be changed, have more ambiguous relationships with food insecurity, and are not sufficiently incorporated into efforts to decrease food insecurity. This makes them suitable to be the focus of this paper.

*Poverty Severity:* Poverty Severity measures the inequality among the poor in terms of the depth of poverty relative to the national poverty line. It is a fraction between 0 and 1, with a score of 0 implying that no individual is below the poverty line and a score of 1 implying that the entire population has no income.<sup>15</sup> Higher levels of poverty severity are expected to be associated with a higher probability of food insecurity.

*Population Density:* Population density is the number of people per km squared. It is included in the regression in order to capture urbanization. It does not fully capture urbanization since it is aggregating population density at a district level which consists of a number of smaller clusters of cities, towns and villages of varying size and density. Despite this limitation, it is still the best readily available proxy for urbanization.<sup>16</sup> The relationship of population density to food insecurity levels is uncertain.

*Population to arable land ratio:* Population to arable land ratio serves as a measure of food supply (availability) and income generation ability (access). Arable land is one measure of natural resource endowment which varies greatly across districts in Nepal.<sup>17</sup> Higher population to arable land ratios are expected to be associated with higher levels of food insecurity.

*Political Participation:* Sen, a reputed economist and philosopher, finds that “no famine has ever taken place in the history of the world in a functioning democracy”. He explains that,

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<sup>15</sup> See Appendix 2 for more details.

<sup>16</sup> See Appendix 2 for more details.

<sup>17</sup> See Appendix 2 for more details.

“Famines are easy to prevent if there is a serious effort to do so, and a democratic government, facing elections and criticisms from opposition parties and independent newspapers, cannot help but make such an effort.” Political participation, measured here as the percentage of population that is voting, serves as an indicator of accountability, ability to attract government funding and attention, and peoples’ ability to voice their opinions. Higher percentage of population voting is likely to be associated with lower food insecurity.

*Road Density:* Road density is measured as the km of road per 100 km squared. Supplies to and produce from districts are primarily transported by road. Roads are the main form of transportation in Nepal. The greater the road density in a district, the more readily available and affordable food is likely to be. The more connected a district is, the lower are the transaction costs of having access to supplies. Greater connectivity with other parts of the country also improves dietary diversity (in the utilization aspect of food security) by allowing populations to consume other than what they themselves produce in the area. With a large proportion of the population dependent on agriculture, access to deeper markets also affects the earnings capabilities of rural farming households, which in turn affects levels of food insecurity. Roads also provide access to facilities that improve other measures of well-being such as health and education, which in turn determine levels of food insecurity. Further, people who have had the opportunity to travel and understand the larger national context better, are likely to be informed and empowered to drive the necessary changes to decrease food insecurity.

*Region Dummy:* Nepal is divided into five development regions - east, west, central, mid-west and far west. Of these, the latter two are considered the least developed due to their difficult terrain and remoteness. The ideal would be to have a dummy variable for each of the five regions to explore any regional effects that may be present. But due to lack of variation in the dependent

variable, food insecurity levels, the model could not accommodate dummies variables to account for each of the five regions. A dummy for whether the district is part of the central region or not, which the model can handle, has been included to control for any factors unique to this region holding the other factors constant. Districts in the central region are expected to display lower food insecurity levels due to their proximity to the capital city Kathmandu.<sup>18</sup>

Table 1: Summary of variables and Descriptives

| Variable Name    | Description  | N  | Min    | Max    | Mean    | Std. Dev |
|------------------|--|----|--------|--------|---------|----------|
| IPC              | Food insecurity  | 75 | 1      | 4      | 2.35    | .814     |
| Pop_den          | Population/km <sup>2</sup> land area   | 75 | 3      | 4416   | 312     | 590      |
| Pov_Sev          |  | 75 | .003   | .082   | .024    | .017     |
| Pop_arable       | Population/ha arable land  | 75 | 1.5704 | 477    | 15      | 55       |
| Road_den         | Km road/ km <sup>2</sup> land area   | 75 | 0      | 94     | 10.81   | 12.45    |
| Poli_part        | % population voted   | 75 | 0.3420 | 1.1329 | 0.7220  | 0.1424   |
| Health_depr      | % population not expected to survive age 40  | 75 | 3.31   | 14.48  | 8.2773  | 2.17502  |
| Pred_health_depr | From OLS of health on independent variables and IVs  | 75 | 2.68   | 14.42  | 8.2773  | 1.7086   |
| Education        | % population of age 15-24 that is literate   | 75 | 53.55  | 97.43  | 84.8595 | 11.4177  |
| Pred_edu         | From OLS of education on independent variables and IVs   | 75 | 65.05  | 104.08 | 84.8595 | 8.9139   |
| Gender_disp      | % female population of age 15-24 that is literate<br>% male population of age 15-24 that is literate | 75 | 1.0026 | 1.9785 | 1.1888  | 0.2193   |
| Pred_gender_disp | From OLS of Gender on independent variables and IVs  | 75 | 0.8610 | 1.6940 | 1.1888  | 0.1760   |
| Disb_pc          | Foreign aid disbursement per capita (\$)   | 75 | 7      | 665    | 46.16   | 82.62    |
| Projects         | No. of aid projects  | 75 | 6      | 65     | 24.51   | 10.86    |
| Sex_ratio        | No. of males/100 females   | 75 | 76     | 127    | 92.75   | 8.96     |
| Dummy_central    | Central region =1, Other regions=0   | 75 | 0      | 1      | .25     | .44      |
| Valid N          |  | 75 |        |        |         |          |

The sources of data are listed in Appendix 3.

The basic model is:

$$IPC_i = \beta_0 + \beta_1(Health\_depr_i) + \beta_2(Education_i) + \beta_3(Gender\_disp_i) + \beta_4(Pov\_sev_i) + \beta_5(Pop\_den_i) + \beta_6(Pop\_arable_i) + \beta_7(Road\_den_i) + \beta_8(Poli\_part_i) + \beta_9(Dummy\_central_i) + \mu_i$$

where the subscript i indicates observations for each variable from 75 districts of Nepal and  $\mu_i$  is the error term. This model however, does not correct for the endogeneous relationships that exist

<sup>18</sup> See Appendix 2 for more details.

between food insecurity and health deprivation, education, gender disparity, and poverty severity.<sup>19</sup> As discussed before, the measures of well-being affect food insecurity, but food insecurity also affects levels of health, education and gender equality. Adequate nutrition is a major determinant of health. According to Children’s Health Watch, “Food insecurity can damage children’s health and brain development years before they enter a classroom. By kindergarten, food-insecure children often are cognitively, emotionally and physically behind their food-secure peers”. Further, in a country with relatively high incidence of child labor, children in households with high poverty and food insecurity are likely to be made to work rather than go to school. Food insecurity affects the achievement of gender equality in a number of ways. For example, when food insecurity translate to fewer meals, the women and girls are usually the bearing the burden of the cut. Girls are also less likely to attend school than boys when a household faces food insecurity. Similarly, outcomes of other dimensions of gender equality are likely to suffer in situations of food insecurity since females are generally affected by its negative consequences disproportionately.

### **Instruments:**

Instrument Variables (IVs) were chosen to address the problem of endogeneity for Health deprivation, Education and Gender literacy disparity variables. Although poverty severity also has a reciprocal relationship with food insecurity, an appropriate IV could not be found. The resulting magnitude and significance of the effect of a change in poverty severity is therefore likely to be overestimated.

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<sup>19</sup> See Appendix two for further discussion regarding the endogenous relationship between food insecurity and poverty severity.

*Health Deprivation:* Foreign aid plays an important role in Nepal's socioeconomic development, representing 26% of the national budget, measured in amount of disbursement<sup>20</sup>. Aid disbursement for a district is often calculated based on the standard of living of people in that area. According to the Nepal Human Development Report 2014, the Human Development Index (HDI) is an important element of in the allocation of development aid at the district level. Life expectancy is a major component of the HDI, making the per capita disbursement amount a good IV for the health deprivation variable. A good IV is one that affects the independent variable being instrumented for, but is not affected by the dependent variable. Per capita disbursement is significantly and positively correlated with health deprivation, however per capita disbursement would not be affected by food insecurity levels. Food insecurity has not yet been incorporated much into the larger development agenda, partly due to its complexity and obscurity about its relationship with other measures of well-being. Further, measuring the level of food insecurity is a relatively new concept and although data on components of food insecurity such as child mortality and rates of malnourishment, stunting and wasting are available, data for a more holistic assessment of food insecurity at a district level has only recently been available.

*Education:* The education sector has been identified to have a relatively large rate of aid fragmentation. This means that the aid is scattered in many places with small projects implemented by different organizations. The decision of where to implement projects and how many of them to implement, is based on indicators including the literacy rate. Therefore the number of projects per district is negatively correlated with the level of education. The higher the

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<sup>20</sup> Foreign aid is disbursed in two ways in Nepal: On-budget or Off-budget. On budget disbursement is through government projects and is reflected as part of the government budget for the year. Off budget disbursement is through independent projects implemented by the donors themselves or through local partners apart from the government.

literacy rate, the higher the number of aid projects per district. The level of food insecurity (the dependent variable) does not affect the number of aid projects (the instrument) for the same reasons that food insecurity does not affect per capita aid disbursement levels – food insecurity has not yet been used in district-level allocation of aid related resources.

*Gender Literacy Disparity:* The sex ratio is an indicator of gender perceptions in society. The same reasons that would affect the gender literacy disparity - perceptions of traditional gender roles and lower value to a female life - also result in female feticide and female infanticide, which would be reflected in the sex ratio.<sup>21</sup> The sex ratio therefore is positively correlated with the gender literacy disparity. Assuming that sex ratio is not significantly affected by food insecurity levels<sup>22</sup>, it makes a good IV for gender disparity in education. So, although food insecurity affects gender literacy disparity, it does not affect the sex ratio which makes it a good IV.

### **Model:**

The First stage consists of an OLS regression for each of the three measures of well-being on the chosen Instrument Variables (IVs) and control variables:

$$Health_i = \beta_0 + \beta_1(Disb\_PC_i) + \beta_2(Projects_i) + \beta_3(Sex\_ratio_i) + \beta_4(Pop\_den_i) + \beta_5(Pov\_sev_i) + \beta_6(Pop\_arable_i) + \beta_7(Road\_den_i) + \beta_8(Pol\_part_i) + \beta_9(Dummy\_central_i) + \mu_i$$

$$Education_i = \beta_0 + \beta_1(Disb\_PC_i) + \beta_2(Projects_i) + \beta_3(Sex\_ratio_i) + \beta_4(Pop\_den_i) + \beta_5(Pov\_sev_i) + \beta_6(Pop\_arable_i) + \beta_7(Road\_den_i) + \beta_8(Pol\_part_i) + \beta_9(Dummy\_central_i) + \mu_i$$

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<sup>21</sup> A better IV might be sex ratio at birth which is less likely to be affected by food insecurity than the overall sex ratio of the population. This indicator was not readily available.

<sup>22</sup> This assumption is based on the following reasoning. The burden of food insecurity is borne by females and results in poorer health. However, the extent of gender discrimination attributable to food insecurity is not serious enough to result in significantly higher rates of fatality, and lower ratio of females to males in the population.

$$Gender_i = \beta_0 + \beta_1(Disb\_PC_i) + \beta_2(Projects_i) + \beta_3(Sex\_ratio_i) + \beta_4(Pop\_den_i) + \beta_5(Pov\_sev_i) + \beta_6(Pop\_arable_i) + \beta_7(Road\_den_i) + \beta_8(Pol\_part_i) + \beta_9(Dummy\_central_i) + \mu_i$$

where the subscript i indicates observations for each variable from 75 districts of Nepal and  $\mu_i$  is the error term.

The first stage regressions generally displayed good fit with R-square values between .61 and .65. The F-statistic was significant for all three regressions. The predicted y values from the first stage regressions were saved as Pred\_health, Pred\_edu and Pred\_gender<sup>23</sup> and used in the second stage probit regression:

$$IPC_i = \beta_0 + \beta_1(Pred\_health_i) + \beta_2(Pred\_edu_i) + \beta_3(Pred\_gender_i) + \beta_4(Pov\_sev_i) + \beta_5(Pop\_den_i) + \beta_6(Pop\_arable_i) + \beta_7(Road\_den_i) + \beta_8(Poli\_part_i) + \beta_9(Dummy\_central_i) + \mu_i$$

#### IV. Results and Analysis

Table 2: Results

| Variables               | Basic Model: No IV  |            | Final Model: With IV |            |
|-------------------------|---------------------|------------|----------------------|------------|
|                         | Coefficient         | Std. Error | Coefficient          | Std. Error |
| (Predicted) Health_depr | .175                | .110       | -1.533** (.670)      | .670       |
| (Predicted) Education   | .201 <sup>†</sup>   | .049       | -1.222 (.846)        | .846       |
| (Predicted) Gender_disp | 10.163 <sup>†</sup> | 3.157      | -98.469 (64.10)      | 64.098     |
| Pov_sev                 | 40.137**            | 17.108     | 544.254*             | 283.337    |
| Pop_arable              | .002                | .005       | .060*                | .033       |
| Poli_part               | -1.861              | 1.378      | -9.358*              | 4.872      |
| Road_den                | -.038**             | .016       | -.079**              | .035       |
| Pop_den                 | -4.596E-5           | -4.596E-5  | -.001**              | .001       |
| [Dummy_Central=0]       | -2.227 <sup>†</sup> | .496       | 3.676                | 3.077      |
| Observations            | 75                  |            | 75                   |            |

\*90% confidence \*\*95% confidence <sup>†</sup>99% confidence

<sup>23</sup> Descriptives for the predicted values are in Table 1.

The Pseudo R-squared values for both models indicated that they were generally a good fit.<sup>24</sup> The above results cannot be interpreted directly for magnitude since it is a probit model, however the signs on the coefficients indicate the general direction of the relationship between the dependent and independent variable. A positive coefficient indicates that an increase in the level of that independent variables, holding other things constant, is associated with an increased probability food insecurity level being high ( $y = 4$ ) and decreased probability of food insecurity levels being low ( $y = 1$ ). The opposite holds for a negative sign. The direction of change for the levels in between ( $y = 3$  and  $y = 2$ ) are determined by calculating the marginal effects which is presented later in this paper.

### **Basic model**

In the basic model, Education and Gender\_disp are significant at the 1% level. Pov\_Sev and Road\_den are significant at the 5% level and Health\_depr is significant at the 10% level. Higher rates of health deprivation and gender literacy disparity are associated with increased probabilities of food insecurity, supporting common knowledge. A population with better health levels and gender literacy disparity, should be more productive and make better food-related decisions, and therefore, have lower probability of being food insecure. However, the endogeneity of these relationships, i.e. the reverse relationships could be contributing to this result. The results also suggest that higher literacy rates are associated with increased probability greater food insecurity which is contrary to common knowledge. One possible explanation for this could be that since the literacy rates are of age 15-24, the impact of increased literacy on reducing food insecurity may not have taken effect yet. Another less likely possibility is that the more literate youth are choosing occupations other than in agricultural, resulting in lower food

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<sup>24</sup> Cox and Snell Pseudo R-Squared values for Basic model = 0.602 and for Final model = 0.506



production per capita and therefore higher food insecurity. This would follow from the underlying assumption that districts are generally not well-connected and therefore the food available in each district is largely that which is produced in that district, with the exception of the larger urban centers, particularly in the central region. However, the counter-intuitive relationship could be due to the effects of endogeneity and multicollinearity.

### **Final Model: Correcting for endogeneity**

It is interesting to note that after accounting for endogeneity using instruments, the signs on the coefficients change for the three focal variables (Health\_depr, Education and Gender\_disp). In the final model, the coefficient on Health\_depr becomes more significant from 10% to the 5%, but the sign changes to negative, contrary to what was expected. Perhaps the fact that more people are dying before they are 40 means that they are not there to be counted as suffering from food insecurity. Although the chosen measure, percentage of population not surviving to age 40, is supposed to be a good proxy for general level of health, it may in reality only account for people facing fatal incidents rather than the population's general level of health. Further, a longer life expectancy may in fact result in a larger food burden, assuming older people are less productive, particularly in an agriculture dependent economy.

Education and Gender\_disp are not significant at the 10% level as they were in the basic model. If the instrument is effective in correcting this problem of endogeneity, the regression would more accurately estimate the relationship in one direction as opposed to estimating the reciprocal relationship. Since the standard errors on these two variables are relatively low, interpreting the coefficient estimates can still be meaningful. Education now has a negative sign on the coefficient, indicating that higher level of youth literacy are associated with decreased probability of food insecurity, in line with common knowledge. The relationship between

Gender\_disp and food insecurity requires further investigation. The positive coefficient on Gender\_disp indicates that higher levels of gender literacy disparity are associated with lower probability of food insecurity which is inconsistent to common knowledge and general development findings. It is likely that this result inconsistent due to the endogeneity issue being addressed inadequately. Further, a number of studies investigating the relationship between gender inequality and other measures of well-being have found conflicting results which they often attribute it to high levels of colinearity present in regression analyses involving gender inequality.

Road\_den, Pop\_den are significant at the 5%. Pov\_Sev, Pop\_arable and Poli\_part are significant at the 10% level. The signs on these control variables are as expected. Districts with higher road density and with higher population density are associated with lower probability of food insecurity. The relationship of road density and food insecurity is quite intuitive and is discussed in the Data section. The results of population density supports the hypothesis that more urbanized districts are likely to have lower levels of food insecurity since they have more access to resources as discussed in the Data section. Higher poverty severity and population to arable land ratio are associated with increased probabilities of food insecurity, as expected. Higher levels of political participation are associated with decreased probability of food insecurity, in line with Sen's assertions. Finally, the positive sign on the region dummy indicates that a change from districts that are in the central region to those that are not in the central region, holding other factors constant, increases probability of being food insecure, as expected. The region dummy however is not significant. Before correcting for endogeneity it is significant at the 1% level, but with a negative sign. There is need for further investigation into the how differences between development regions affect food insecurity. These regional differences have important

practical implications since development interventions, budget distributions and allocation of resources are done by development regions as well as by districts.

## Marginal Effects

Table 3: Marginal Effects

|                   | y=1       | y=2      | y=3     | y=4     |
|-------------------|-----------|----------|---------|---------|
| Health_depr** (-) | 0.6030    | -0.5543  | -0.0498 | -0.0007 |
| Road_den** (-)    | 0.0311    | -0.0286  | -0.0024 | -0.0000 |
| Pop_den** (-)     | 0.0004    | -0.0003  | -0.0000 | -0.0000 |
| Pov_sev* (+)      | -214.0909 | 196.8246 | 17.0266 | 0.2397  |
| Poli_part* (-)    | 3.6811    | -3.3842  | -0.2928 | -0.0041 |
| Pop_arable* (+)   | -0.0236   | 0.0217   | 0.0019  | 0.0000  |
| Education (-)     | 0.4807    | -0.4419  | -0.0382 | -0.0006 |
| Gender_disp (-)   | 38.7343   | -35.6104 | -3.0805 | -0.0433 |

The coefficient estimates of an ordered probit cannot be interpreted directly as marginal changes in food insecurity like in the case of an OLS regression. The coefficients are used to calculate the marginal effects, which are the change in probabilities of each category of the dependent variable, for a change in the independent variable, holding all other things constant. For example, for a one unit *increase* in road density, on average, the probability of the food insecurity level being 1 *increases* by 3.11%, the probability of the food insecurity level being 2 *decreases* by 2.86%, the probability of food insecurity level being 3 *decreases* by 0.24% and so on. This is consistent with the general interpretation of the negative sign on the coefficient indicating that an increase in road density decreases food insecurity.

For a one unit *increase* in literacy rate (i.e. a one percent *increase* in percentage of population of age 15-24 that is literate), on average, the probability of the food insecurity level being 1 *increases* by 48.07%, the probability of the food insecurity level being 2 *decreases* by 44.19%, the probability of food insecurity level being 3 *decreases* by 3.82% and the probability

of food insecurity level being 4 *decreases* by 0.06%. In general, as indicated by the negative sign on the coefficient for Education, an increase in level of education decreases food insecurity.

Appendix 4 discusses details of how the marginal effects were calculated and alternate methods.

### **Multicollinearity**

The substantive measures of well-being are interrelated. Health deprivation, education, gender literacy disparity, and poverty severity are highly correlated, which causes a problem of multicollinearity. This can lead to insignificant results and coefficients not being robust. I explore this issue by dropping three of the four variables and re-estimating the model with only one of these four main variables and all the same control variables as the previous models. Table 4 shows the main variable that was kept in the model, with the corresponding results.

Table 4:

|             | <b>Final model</b> | <b>After dropping</b> | <b>Expected</b> |
|-------------|--------------------|-----------------------|-----------------|
| Health_depr | ._**               | +                     | +               |
| Education   | -                  | -                     | -               |
| Gender_disp | -                  | -                     | +               |
| Pov_sev     | +*                 | +*                    | +               |

The first row compares the sign and significance of Health\_depr coefficient estimate in the Final model with the sign and significance of the coefficient estimate after dropping the three other measures of well-being (Education, Gender\_disp and Pov\_sev). This abridged model in the second column shows a positive insignificant coefficient on Health\_depr. The positive sign in this model is more in line with the expectations. The especially high significance (5%) of the negative sign on the final model solicits for further investigation on the effect of health on food insecurity. The same procedure was applied to Education, and it was still not significant. The negative sign is consistent with the expected relationship between education and food insincerity.

The sign and significance of Gender\_disp remain the same which is contrary to the expected positive sign. This variable also warrants further investigation due to the uncertainty around the direction of its relationship with food insecurity. Although it is not significant, the standard error is relatively low, making it still relevant. Pov\_sev is significant and positive in both versions of the model as expected.

### **Other caveats and limitations**

In addition to some of the problems discussed above, this study is limited the availability of data. The accuracy of the results are dependent on the quality of the data compiled, as well as the ability of these indicators to represent the concepts that are being examined. The relatively small sample size may weaken the statistical strength of the analysis. The probit model assumes normal distribution of the data which may not necessarily hold. Further, the standard errors are likely to be underestimated due to the two-stage regression.

Other aspects that affect food insecurity levels but for which data could not be found include population growth rate, conflict levels, labour productivity, age distribution, and measures of social structure such as how egalitarian the population is, ethno-linguistic fractionalization, and the composition of population in terms of caste and religion<sup>25</sup>. The omission of these variables may result in over or underestimation of the effect of the independent variables.

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<sup>25</sup>Ethno-linguistic fractionalization is an index measure of heterogeneity in the form of ethnic or cultural diversity that may explain socio-economic outcomes.

## V. Conclusion

This is the first district-level cross-sectional analysis of the relationship between food insecurity and the measures of well-being in Nepal that uses the chronic IPC, a newer and more holistic measure of food insecurity. The study finds that health deprivation levels significantly affects levels of food insecurity in a district. However, the direction of this relationship is uncertain due to issues of endogeneity and multicollinearity, warranting further investigation using different measures of health, better instruments, and an improved over all model. Education and gender literacy disparity are less significant in affecting levels of food insecurity, but addressing issues of endogeneity and multicollinearity more effectively may provide better insights. The significant effect of control variables on food insecurity support common knowledge. Higher levels of poverty severity and population to arable land ratio are associated with increased probability of food insecurity. Higher levels of road density, population density, and political participation are associated with decreased probability of food insecurity.

Policy implications for the control variables are straightforward. Decreasing poverty, improving connectivity of districts through better roads, increasing methods of accountability, and empowering citizens to demand for their rights should be incorporated into initiatives to reduce food insecurity. The implications for the focal variables are less clear. The interdependencies between the measures of well-being: health, education and gender equality, as well as their reciprocal relationships with food insecurity need to be studied and better understood. There is need for sub-national analysis of food insecurity with a model that can address endogeneity and multicollinearity. The lack of clarity in these relationships, as demonstrated by this study makes investigating them even more necessary, in order to develop effective interventions that make best use of government and development aid resources.

## **VI. Further Scope**

Investigating this relationship over time would allow for more reliable results. The model can be improved with better indicators and better instruments for the three focal measures of well-being. Instruments could be used for other variables whose endogeneity was not accounted, such as poverty severity. Other methods to correct for the problem of reverse causality would help get a deeper understanding of these reciprocal relationships. Further, the model could be extended to investigate the interaction between variables.

As discussed before, there is need for research at sub-national levels but at a scale that is larger than households, since clusters of food insecurity may require collective or structural interventions targeting communities rather than individuals, such as investment in transport infrastructure or formation of special development zones. Most governments of developing countries have interventions to reduce poverty and food insecurity. However, gaps in identifying and locating those who really need these interventions limit their impact. National assessments are often compiled using household surveys that are then separated into larger classifications such as administrative districts. These aggregated statistics are not compatible to identify spatial patterns within and across districts. The spatial analyses discussed in the literature review are the kind of studies best suited to help inform food insecurity interventions, particularly for a geographically diverse country like Nepal.

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## **Appendices**

### ***Appendix 1***

**Dependent Variable:** Integrated Chronic Food Security Phase Classification (IPC)

The classification was conducted by: The National Technical Working Group (NTWG), which comprised of experts from the Government of Nepal (GoN), UN agencies, NGOs, INGOs, donors, the private sector and academia. This group included both local and international experts.

The basic /core indicators identified and used by the NTWG during the analysis were:

- Livelihood - Ownership of production assets (Assets refers to land, water, finance, extension service, equipment, forest, with specific focus on women)
- Access/ Market - Prices (staple food, price trend)
- Disaster and climate change – Drought, Flood / Landslide
- Nutrition, Health and WASH - Type of water source, Access to improved sanitation facilities, Percentage of population under the national poverty level, Underweight, Stunting, BMI, Anemia, IMR (infant mortality rate) , Under 5 Mortality Rate
- Agriculture and Food Security - Food Consumption Score (FCS), Household Dietary Diversity Score (HDDS), Copying Strategy Index (CSI), Food balance sheet, Production Figures, Proportion of population unable to access a basic consumption basket during the analysis period (Poverty or food poverty line), Percentage of income spent on food (for the poorest quintile), Household food stocks , Access to agriculture /input seeds/fertilizer and irrigation

### ***Appendix 2***

#### **More information on the control variables**

##### **Poverty Severity:**

The Poverty Severity Index is the squared value of the Poverty Gap Index (PGI). The PGI is the average of the poverty gap (the difference between the poverty line and the income of each individual below the poverty line) as a fraction of the income at the poverty line.

Poverty Severity =  $\frac{1}{N} \sum_{i=1}^N \left[ \frac{G_i}{z} \right]^2$ , where N is the size of the sample z is income at the poverty line, G<sub>i</sub> is the poverty gap. The Poverty Severity index takes into account the depth of poverty relative to the poverty line. A higher poverty severity index means that poverty is more severe in that area as opposed to a higher Poverty Headcount, which simply indicates more people under the poverty line. The poverty line used is the one defined for the country. The poverty gap index can be multiplied by the poverty line and the total number of individuals to get the total amount needed to bring the poor out of poverty i.e. up to the defined poverty line. Income levels which has been considered in the classification of districts by the IPC method, directly affect food insecurity levels. However, the severity of poverty and the level of inequality amongst the poor also affect the level of food insecurity apart from simply the income.

Higher levels of poverty severity are likely to be associated with higher levels of food insecurity. Many households below the poverty line can usually afford basic food requirements, although

probably not the most nourishing. Even if a district has sufficient or increased supply of food, high levels of inequality in society and especially among the poor can result in persistence of food insecurity levels because the poorest of the poor cannot afford food. The uncertainty levels of extreme poverty deteriorate the stability dimension of food security. The more severe the level of poverty, the more sensitive they probably are to decreased availability and price fluctuations (affecting affordability), the more likely are any sort of changes that affect other measures of well-being which then affect food insecurity levels. Without the luxury of the most nutritious range of foods and adequate dietary diversity, their already chronically malnourished bodies are less likely to be able to absorb nutrients from the food accessible to them. Further, the correlation between poverty severity and health may suggest that the stress and physiological toll of extreme poverty could affect people's ability to be productive members of society and cognitive abilities to make prudent decisions regarding their well-being, including food security. The reverse relationship is more apparently understandable. As Smith said "A plentiful subsistence [e.g., food security] increases the bodily strength of the labourer, and the comfortable hope of bettering his condition, and of ending his days perhaps in ease and plenty, animates him to exert that strength to the utmost. Where wages are high, accordingly, we shall always find the workmen more active, diligent, and expeditious than where they are low".<sup>26</sup> The effect of food insecurity on individuals' health and productivity push them further into poverty. Further, the poorest of the poor, sometimes referred to as the ultra-poor are most directly affected by fluctuations in the dimensions of food insecurity. They are also more likely to bear the brunt of increase in food insecurity levels. Higher levels of food insecurity act as catalysts for those in poverty to enter downward spirals into further poverty, increasing the level of poverty severity.

#### Population Density:

It does not fully capture urbanization since it is aggregating population density at a district level which consists of a number of smaller clusters of cities, towns and villages of varying sizes and densities. For example, there may be a district with a high population density, but people could be spread out evenly and not clustered together in urbanized settlements. Despite this limitation, it is still the best readily available proxy for urbanization. Due to the diverse geographic terrain and poor transport system in Nepal, it is likely that the more urbanized areas have lower levels of food security due to availability. Also, incomes are generally higher in urbanized areas leading to better access. However, higher prices may result in higher food insecurity despite higher incomes. Higher levels of urbanization could mean less production of food. Rapid increase in rural-urban migration leaves many people in urban poverty and higher food insecurity than in rural areas.

#### Population Arable land ratio:

Natural resources including arable land, rivers, rainfall, climate, foliage, (what else?) not only affect the ability to produce food, but also generally affects people's well-being, which in turn has an effect on levels of food insecurity as demonstrated in this model.

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<sup>26</sup> (1776, p. 99). Smith, Adam. (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations*, 2 vols. (Indianapolis: Liberty Press, 1981).

### Political Participation:

Sen finds that “no famine has ever taken place in the history of the world in a functioning democracy”. Democracy as it is today, is new to Nepal and the political system may not be functioning most efficiently in order to translate voter’s voice into perceivable action. However, political participation, measured here as the percentage of population that is voting is still a measure of accountability, a major feature linking democracy to prevention of famines. Infrastructure, funding and other resources, even when allocated by NGOs or donors, almost always have to be in consultation with government officials. Districts with more % of population voting is likely to receive more attention from government officials in order to influence future election outcomes. Political participation is also measure of people’s self -perception as citizens of the Nepal with basic human rights, their ability to voice their opinions. The higher the percentage of population voting, the more active that district’s people are likely to be and more likely to express their views to their local leaders and drive action to lower food insecurity.

### Region dummy:

Migration from all over Nepal to the central region in search for jobs and better livelihoods has resulted in this area being more population dense and more urbanized. The cities in this area are more developed, have more resources, transportation, infrastructure, better quality facilities and services, and are more connected to the rest of the world. The proximity to the capital probably also provides these districts more attention from government projects and funding. Development projects and interventions are more likely to be set up in this region due to the convenience for people such as development practitioners or government officials implementing these projects. Since other measures of well-being also affect food insecurity levels, the greater focus of development efforts in the central region may be decreasing food insecurity levels. Apart from these, there may be other phenomena such as the way resources are allocated to these development regions which may need further exploration with a dummy for each of the five regions.

## ***Appendix 3***

### **Data Sources:**

- IPC (2011): Nepal Food Security Monitoring System (NeKSAP)
- Health\_depr (2011): *Nepal Human Development Report, UNDP*
- Education, Gender\_disp (2013): *UNESCO*
- Pov\_sev (2011): *World Bank and Central Bureau of Statistics Nepal*
- Pop\_den, Pop\_arable, Road\_den, Regions (2011): *Environment Statistics of Nepal*
- Poli\_part (2006-7): *Election.gov.np*

Most of the data is from OpenNepal, a data portal to promote more effective development through the increased use of data and information. The life expectancy data for the year 2011 was extracted from the Nepal Human Development Report (2014) by UNDP. The literacy rates are from the report ‘Literacy Status in Nepal’ in collaboration with UNESCO. The gender literacy parity was calculated using the same data. The poverty severity measure for 2011 was

extracted from the Nepal Poverty map by the World Bank and Central Bureau of Statistics, Nepal. The number of voters for the year 2006-2007 compiled from the government election website was used to calculate the political participation measure. Although the year for this measure is further apart from the rest of the data, the using political participation from 2006-7 allows for the time lag in political activity translating into lower food insecurity. Further, the level of political activity across the nation was generally high during that time period and can represent current political activity reasonably. Data on this indicator for the year 201-11 would be ideal. Two of the IVs: Disbursement Per Capita and Number of Projects for the year 2012-2013 were reported through the Aid Management Platform in the ‘Development Cooperation report, Ministry of finance, Government of Nepal 2012-13’. The one year time lag for these two variables is intentional in order to better fulfill the assumption for it to be a good IV, that the level of health affects the per capita disbursement for the following year and that the level of education affects the number of projects for the following year. The rest of the data is for the year 2011, extracted from the Environment Statistics of Nepal, 2013.

#### Appendix 4

The marginal effects presented in the results section of this paper were calculated by using the average of the independent variables across all y values (i.e. all four levels of food insecurity).

|                   | y=1       | y=2      | y=3     | y=4     |
|-------------------|-----------|----------|---------|---------|
| Health_depr** (-) | 0.6030    | -0.5543  | -0.0498 | -0.0007 |
| Road_den** (-)    | 0.0311    | -0.0286  | -0.0024 | -0.0000 |
| Pop_den** (-)     | 0.0004    | -0.0003  | -0.0000 | -0.0000 |
| Pov_sev* (+)      | -214.0909 | 196.8246 | 17.0266 | 0.2397  |
| Poli_part* (-)    | 3.6811    | -3.3842  | -0.2928 | -0.0041 |
| Pop_arable* (+)   | -0.0236   | 0.0217   | 0.0019  | 0.0000  |
| Education (-)     | 0.4807    | -0.4419  | -0.0382 | -0.0006 |
| Gender_disp (-)   | 38.7343   | -35.6104 | -3.0805 | -0.0433 |

An alternate method is to calculate the average of the independent variables at each y value (i.e. at each of the four levels of food insecurity) and then using these averages to calculate the marginal effects each of the four levels. This method provides more nuanced results, presented below. So for example, one can see the change in probability that a district *will be* in each level of food insecurity, for one unit increase in road density in a district that *is* at each of the four levels of food insecurity.

| Health_depr | using mean of x values at y=1 | using mean of x values at y=2 | using mean of x values at y=3 | using mean of x values at y=4 |
|-------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| y=1         | .4611                         | .1931                         | .0245                         | .0001                         |
| y=2         | -.3085                        | .2149                         | .5828                         | .1008                         |
| y=3         | -.1477                        | -.3684                        | -.3519                        | .4497                         |
| y=4         | -.0049                        | -.0396                        | -.2554                        | -.5505                        |

| Road_den | using mean of x values at y=1 | using mean of x values at y=2 | using mean of x values at y=3 | using mean of x values at y=4 |
|----------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| y=1      | .0238                         | .0100                         | .0013                         | .0000                         |
| y=2      | -.0159                        | .0111                         | .0300                         | .0052                         |
| y=3      | -.0076                        | -.0190                        | -.0181                        | .0232                         |
| y=4      | -.0003                        | -.0020                        | -.0132                        | -.0284                        |

| Pop_den | using mean of x values at y=1 | using mean of x values at y=2 | using mean of x values at y=3 | using mean of x values at y=4 |
|---------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| y=1     | 0.00030                       | 0.00013                       | 0.00002                       | 0.00000                       |
| y=2     | -0.00030                      | 0.00014                       | 0.00038                       | 0.00007                       |
| y=3     | -0.00020                      | -0.00024                      | -0.00023                      | 0.00029                       |
| y=4     | 0.00000                       | -0.00003                      | -0.00017                      | -0.00036                      |

| Pov_sev | using mean of x values at y=1 | using mean of x values at y=2 | using mean of x values at y=3 | using mean of x values at y=4 |
|---------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| y=1     | -166.7054                     | -69.8313                      | -8.8622                       | -.0199                        |
| y=2     | 111.5446                      | -77.6861                      | -210.7064                     | -36.4435                      |
| y=3     | 53.3857                       | 133.1987                      | 127.2274                      | -162.5793                     |
| y=4     | 1.7751                        | 14.3187                       | 92.3412                       | 199.0427                      |

| Poli_part | using mean of x values at y=1 | using mean of x values at y=2 | using mean of x values at y=3 | using mean of x values at y=4 |
|-----------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| y=1       | 2.8146                        | 1.1790                        | .1496                         | .0003                         |
| y=2       | -1.8833                       | 1.3116                        | 3.5576                        | .6153                         |
| y=3       | -.9014                        | -2.2489                       | -2.1481                       | 2.7450                        |
| y=4       | -.0300                        | -.2418                        | -1.5591                       | -3.3606                       |

| Pop_arable | using mean of x values at y=1 | using mean of x values at y=2 | using mean of x values at y=3 | using mean of x values at y=4 |
|------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| y=1        | -.0180                        | -.0076                        | -.0010                        | .0000                         |
| y=2        | .0121                         | -.0084                        | -.0228                        | -.0039                        |
| y=3        | .0058                         | .0144                         | .0138                         | -.0176                        |
| y=4        | .0002                         | .0016                         | .0100                         | .0215                         |