

# REGIONAL HETEROGENEITY IN FOOD SECURITY: THE CASE OF NEPAL

By

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(Under the Direction of **Gopinath Munisamy**)

## ABSTRACT

Ensuring adequate access to food to all has remained a major challenge of the 21<sup>st</sup> century. Many studies have quantified populations vulnerable to food insecurity, mostly at the national level. This study tracks the substantial regional heterogeneity in the food security status within Nepal. Employing FAO's methodology and National Living Standards Survey data from 1995, 2003 and 2011, this study found that Nepal's prevalence of undernourishment declined between 1995 and 2003, but increased between 2003 and 2011. The *Terai* domain - provinces 2 and 5 - and rural regions of all provinces are found to be most vulnerable to food availability and access concerns. Household characteristics such as education, land holdings and occupation are associated with food access. By examining where, how many and who are food-insecure within Nepal, this study has provided a more accurate picture of the prevalence of undernourishment for better targeting assistance to improve the livelihood of its citizens.

INDEX WORDS: regional food insecurity, energy consumption, minimum energy requirements, prevalence of undernourishment, provinces of Nepal

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This document is dedicated to  
*food insecure communities around the world*

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## CHAPTER 1

### INTRODUCTION

Global food security (GFS) remains elusive after decades of economic growth and technological advances in agriculture and the broader economy. Food is a major component of basic services needed to sustain life. World Food Summit (WFS) conceptualized that “food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (WFS, 1996).

Since the WFS declaration, lowering both the absolute number as well as the share of food insecure population has been a major goal of individual governments and international non-governmental and private agencies (WFS, 1996; USDA, 2020a; ADBI, 2017; Ayanlade and Radeny, 2020). To aid in this effort, several national and international agencies have attempted to quantify the food-insecure population by relying on four pillars: food availability, access, utilization, and stability. Chief among them is the Food and Agriculture Organization’s (FAO) prevalence of undernourishment (PoU), a count of the number of people by country who consume dietary energy (i.e., food) below the requirements for a normal life including physical activities. Nearly 700 million people on the planet faced food insecurity, according to FAO’s State of Food Security and Nutrition (SOFI, 2019). Other indicators – from the International Food Policy Research Institute (IFPRI), United Nations Development Program (UNDP) in cooperation with Oxford Poverty and Human Development Initiative (OPHI), the United States Department of Agriculture (USDA), The Economist’s Intelligence Unit (EIU) – also provide

global or national estimates of the share of the population experiencing food insecurity (OPHI and UNDP, 2019; GFSI, 2016; von Grebmer *et al.*, 2017; Thome *et al.*, 2019).<sup>1</sup>

Haen *et al.* (2011) provided a comprehensive review of the methods underlying major PoU indicators, and their advantages and disadvantages. One set of indicators – FAO, IFPRI, USDA – rely on national data, complemented by survey data to compute PoU. These so-called first-generation estimates identify the gap between food availability and consumption needs for the whole population of a country or its income deciles. The former is derived from production, stock changes and net imports of food including food aid, while the latter is usually the product of population and estimated calorie requirements per person, referred to as minimum dietary energy requirement (MDER). Another type of indicator, e.g., UNDP, employs detailed anthropometric surveys of individuals and households to determine nutritional outcomes. For example, the number of people below a body mass index (BMI) threshold of 18.5 kg/m<sup>2</sup> (adults aged 20-70) is counted as undernourished by UNDP.<sup>2</sup> More recent indicators rely on self-reported responses of a country's population on their food-related behavior, e.g., FAO's Food Insecurity Experience Scale (FIES).

Wide variation exists in both the level and direction of these indicators in many countries (Poudel and Gopinath, 2021). For the purposes of this study, consider the case of Nepal shown in figure 1. Four PoU estimates for which a consistent time series exists – FAO, IFPRI, UNDP and USDA – show not only variation in PoU levels but also alternative trends over time in

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<sup>1</sup> Agencies consistently publishing GFS indicators include IFPRI (Global Hunger Index), UNDP-OPHI (Multidimensional Poverty Index), and USDA (International Food Security Assessment). Occasional estimates are provided by EIU (Global Food Security Index). World Bank uses FAO's PoU for their poverty measurements (World Bank, 2018).

<sup>2</sup> While PoU is primarily an availability measure of food insecurity, other measures such as BMI, stunting and wasting of children, and disease-adjusted life years are based on nutritional outcomes (aligned with utilization and stability pillars).

Nepal. The range of PoU, 6% (FAO) to 28% (UNDP) in 2016, raises questions on the extent of food insecurity in Nepal. The declining PoU trend in FAO and IFPRI measures is certainly good news, but the PoU increase shown by UNDP in 2016 or the uneven pattern of USDA's estimate does not provide a consistent picture of the trend in food security over time. Furthermore, as Haen *et al.* (2011) pointed out, these PoU measures at the national level do not address key questions such as: where are the food insecure people within the country? How many are there by location? Who are they (demographics)?

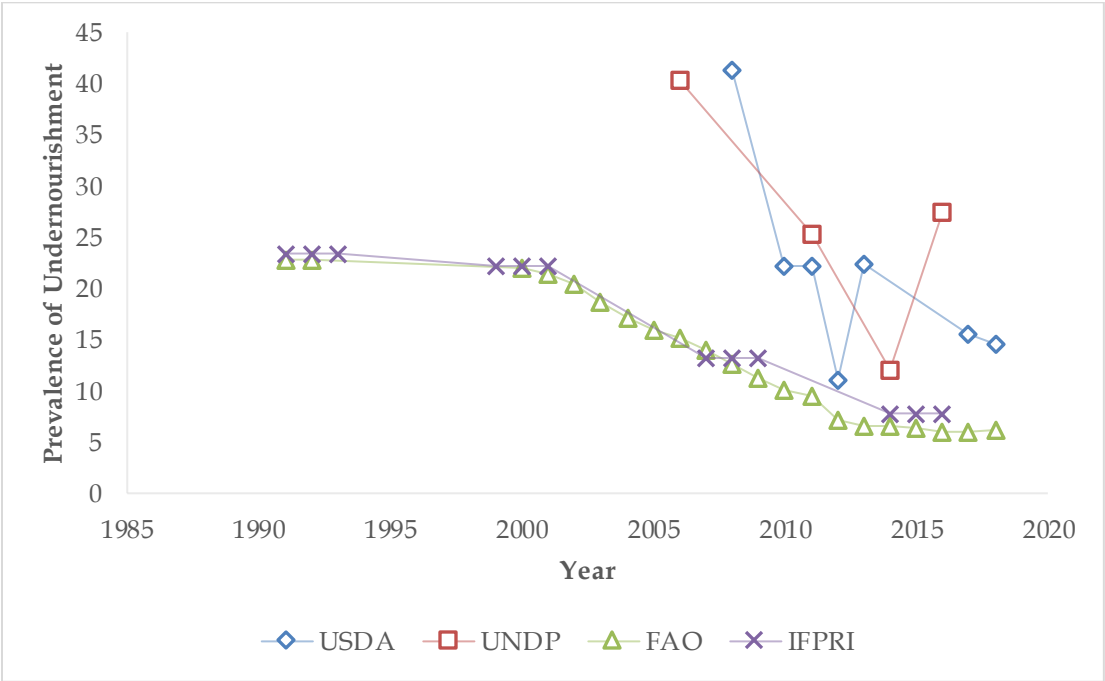


Figure 1: Prevalence of Undernourishment trends for Nepal (1991-2018)

With such PoU estimates masking the substantial heterogeneity within countries, several studies have called for and conducted a sub-national analysis of food security (Barrett, 2010; Joshi *et al.*, 2011). For example, Wichern *et al.* (2018) identified large patterns in food availability and regional differences in food insecurity within Uganda. Similarly, Menon *et al.* (2009) computed state-level hunger indices for India, while Rawal *et al.* (2019) estimated PoU across

Indian states using a modified FAO methodology. Cross-sectional evidence on Nepal suggests that western Nepal and agricultural households tend to have a higher incidence of food insecurity in 2011 (Joshi *et al.*, 2011). In general, there has been limited attention to understanding the intra-country variation in food security estimates and their underlying sources. Moreover, very few studies have tracked intra-country variation in food security over time.

The objective of this study is to derive PoU for regions of Nepal using household data over three decades. In particular, this study uses three rounds of household data from the National Living Standards Survey (NLSS) – 1995, 2003 and 2011 – also referred to as Living Standards Measurement Survey (LSMS) by the World Bank. FAO’s methodology for PoU is adopted at a micro-level and appropriate sampling weights are used to derive PoU estimates at the district, provincial and national levels. In doing so, the study answers key questions on where, within Nepal, are the food insecure households, how many in each region, and what characteristics describe them. This information should be helpful in a global context to understand the intra-country heterogeneity of PoU estimates and in the Nepal context, to better target the vulnerable population with assistance.

The study is organized as follows:

Chapter 2 describes past findings across and within countries as well as on Nepal.

Chapter 3 provides the specific objectives of the study.

Chapter 4 describes the methodology, followed by Chapter 5 explaining data collected and processed for this study.

Chapter 6 summarizes results and discusses regional estimates of food insecurity, including visualization of changing patterns over time.

Finally, Chapter 7 draws conclusions of the study with a summary.

## CHAPTER 2

### LITERATURE REVIEW

With food security as a grand challenge, meeting people's food demand has been the top priority of governments around the world and international agencies (West *et al.*, 2014; FAO, 2021). Despite growth in agricultural production and technological advances over the past several decades, SOFI (2020) reports that one in ten people in the world faces severe food insecurity. Moreover, as Foley *et al.* (2011) and Laborde *et al.* (2020) note, economic shocks, e.g., COVID-19 pandemic, and the accompanying price volatility further exacerbate food and nutrition insecurity.

Recall that food security is said to exist when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for active and healthy life (WFS, 1996). The traditional pillars of food security include availability, access, utilization and stability (SOFI, 2020). Availability is defined as the "supply" side that includes total food available through production, carry-over stocks and trade (also includes aid and gifts). The accessibility pillar involves physical and economic capability to acquire food. Similarly, sufficient energy and micronutrient uptake, including food diversity, preparation, and intra-household distribution of accessed food, fall under utilization. Finally, the stability dimension asks, "what if your food intake is only adequate today and is not stable over time due to dynamic weather parameters, political economy, etc.?" (EC-FAO, 2008).

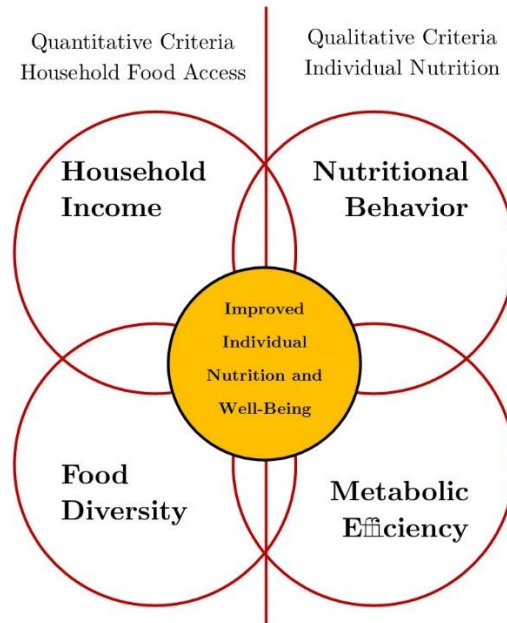


Figure 2: Dimensions of improved food and nutrition access (adapted from Pingali and Ricketts, 2014)

Food security has quantitative and qualitative dimensions (figure 2): while household food access (*income* and *food diversity* – quantitative criterion) can be measured, nutrition (*behavior* and *biological/metabolic efficiency* – qualitative criterion) is generally hard to define for every individual (Pingali and Ricketts, 2014). Similar is the variation among socio-cultural, ecological, political, economic and agricultural systems of nations and regions (Adger *et al.*, 2007). Efforts of scientific communities to design multiple indicators have been welcomed by decision-makers and stakeholders; however, because of the varied energy requirements and varied risks among the individuals, measuring food insecurity in every region and every community remains incomplete (Rawal *et al.*, 2019; Pereira *et al.*, 2021). Indeed, there exists huge heterogeneity in the four pillars: *food availability, access, utilization and stability* across and within countries (WFS, 1996; EC-FAO, 2008; Pereira *et al.*, 2021). If the food is available, it may not be accessible; and if it is accessible, it may not be well-utilized and stable over time. During the evolution of metrics, agencies experimented and measured food insecurity with a combination

of one or more pillars (World Bank, 1986; USAID, 1992; Heady and Ecker, 2012; see Coates, 2013; Burchi and De Muro, 2016). This chapter reviews the major efforts to measure food security using these scientific pillars. It also highlights how intra-country analysis can help answer the who, how many and where questions on identifying the vulnerable population (Haen *et al.* 2011).

### ***2.1. Across-Country Analysis***

Many national and international agencies have developed indicators of food security, which can be applied to individual nations or in the global context. The traditional approach, so-called first-generation measures, has been to appraise the gap between food supply or availability and consumption needs of a nation's population. The former is derived from production, stock changes and net imports of food including food aid, while the latter is usually the product of population and estimated demand or calories per person, the later referred to as MDER. The alternative approach employs anthropometrics such as BMI or stunting or wasting, especially among children. Primary among such measures are FAO's SOFI (2019), UNDP-OPHI's Multidimensional Poverty Index (2019), IFPRI's Global Hunger Index (2017), and USDA's International Food Security Projection and Assessment (2019) (SOFI, 2019; OPHI and UNDP, 2019; von Grebmer *et al.*, 2017; Thome *et al.*, 2019).<sup>3</sup> Likewise, EIU's Global Food Security Index (2016) uses secondary information on several pillars of food security to compute rank for each country using a dynamic quantitative and qualitative scoring model (GFSL, 2016). A more recent approach employs survey instruments such as FAO's Voices of the Hungry (FAO, 2017), a FIES which consists of eight questions regarding people's access to adequate food. Based on the self-

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<sup>3</sup> Note FAO's indicators are outcomes of the collaborative efforts of World Food Programme (WFP), World Health Organization (WHO), United Nations International Children's Emergency Fund (UNICEF) and others.

reported responses to questions on food-related behaviors, the proportion of the population facing mild to severe food insecurity is identified. Table 1 lists the major “across-countries” indicators of food security along with information on their most recent methodology, frequency, and other related information.

**Table 1: Indicators available for food insecurity measurement across countries**

Agency	Level of Analysis	Dimension	Approach	Definition	Most Recent Methodology	First Publication or release date
FAO's Prevalence of Undernourishment (PoU) (SOFI, 2019, 2020)	National (104 countries)	Availability Accessibility	a) Until 2008, projections based on food balance sheets  b) Since 2008, a statistical approach using the distribution of daily energy consumption with its parameters projected from consumption, population and FIES survey data	An estimate of the percentage of individuals in the total population that consume calories below a threshold.	The indicator is obtained as the cumulative probability that the habitual dietary energy consumption (DEC) is below the minimum dietary energy requirements (MDER). The distribution of dietary energy intake assuming to be lognormal, fully characterized by four parameters:  a) the daily DEC (projected from 2005 consumption survey) b) MDER is an estimate of the lower bound of the range of dietary energy requirements that are compatible with a normally active and healthy life for the average individual in a population (projected based on population surveys) c) the coefficient of variation of the distribution of energy requirements in the population (projected based on population surveys), and d) the coefficient of variation of the distribution of per capita levels of habitual dietary energy consumption in the population that can be associated with differences in the households' socio-economic characteristics that are independent of sex, age, body mass and physical activity (projected starting from 2015 or from the date of the last available food consumption survey).	1999
FAO's Food Insecurity Experience Scale (FIES) (FAO, 2017)	National (101 countries)	Accessibility Anxiety	Experience-based sample survey; Face-to-face interviews (Designed for individual level; can also be modified to household level)	Food insecure households are those who experience an inability to access food due to resource constraints.  The Voices of Hungry project set thresholds for moderate and severe food insecurity.	The metric is calculated from data on people's direct dichotomous responses to 8 questions regarding their access to food adequacy in the preceding 12 months.  Raw scores (0-8 based on affirmative responses) are equated to global standard to develop the probability of being food insecure based on severity: moderate or severe, and severe using the Rasch model.	2015; But FIES introduced in Gallup World Pool in 2014

IFPRI's Global Hunger Index (GHI) (von Grebmer <i>et al.</i> , 2017)	National (119 countries)	Undernourishment: Availability or access  Wasting, Stunting and Mortality: Nutritional Outcomes	Similar to FAO; Data on wasting, stunting and mortality are updated from UNICEF/WHO/World Bank and UNIGME	It is based on four indicators: undernourishment, stunting, wasting and mortality, which reflects calorie and nutrient deficiency.  IFPRI defines undernourishment as the share of the population whose caloric intake is below a threshold.	IFPRI makes adjustments to a three-year average of FAO's estimates of the PoU to use in GHI computations as follows:  $\text{Aggregate GHI Score} = \frac{1}{3} \times \text{Standardized Proportion of Undernourishment} + \frac{1}{6} \times \text{Standardized Child wasting} + \frac{1}{6} \times \text{Standardized Child stunting} + \frac{1}{3} \times \text{Standardized Child Mortality}$	2006 as Global Hunger Index
UNDP and Oxford Poverty and Human Development Initiative (OPHI)'s Multidimensional Poverty Index (MPI) (OPHI and UNDP, 2019; Alkire and Jahan, 2018)	National (95 Countries)	Nutritional Outcomes	Scientific - Nutritional Status Based	From three major indicators: health, education and standard of living. Within the health indicator, UNDP identifies undernourishment based on body mass Index (BMI) and related measures for individuals below the age of 70 years.	<u>Undernourished if:</u> Adults over age 20: BMI is below 18.5 kg/m <sup>2</sup> ,  Ages 15-19: Based on WHO age-specific BMI cutoffs, and  Children: z-score of their height-for-age (stunting) or weight-for-age (underweight) are more than two standard deviations below the median of the reference population.	MPI published in UNDP Human Development Report: 2010
USDA's International Food Security Assessment (IFSA) (Beghin <i>et al.</i> , 2017)	National (76 countries)	Economic Access	a) Until 2015, the food gap at the national level is derived from a projection of demand and supply;  b) Since 2016, supply is exogenous (area-yield projections), while demand is projected by a PIGLOG demand system	When projected demand falls below consumption targets for an income decile, the number of people in that decile are considered food insecure. Totalling people in the food deficit income groups provides the total number of food-insecure people.	The price-independent generalized logarithmic (PIGLOG) demand approach is used to consistently aggregate food demand across income deciles into average consumption per capita as a function of average income with a correction factor accounting for income distribution across population deciles. Price and quality effects also vary by income deciles. The model-projected demand by income decile is compared to the consumption target (2100 Kcal) to determine the number of food-insecure people.	Late 1970s: Food Assessment 1990-1992: Global Food Assessment 1993: Food Aid Need Assessment 1997: Food Security Assessment 2011: Name changed to IFSA  1995-2015: supply-oriented model  2016 - supply and demand-oriented model

2017-present:  
demand-  
oriented model

The EIU's Global Food Security Indicator (GFSI) (GFSI, 2016, 2021)	National (113 countries)  Continental Regions (6 regions)	Affordability (or Accessibility) Availability Quality Safety Vulnerability	a) Total of 28 indicators (3 categories) were used before 2016.  b) In 2017, the "natural resources and resilience" category is added. They use secondary data from multiple agencies: World Bank Group, IMF, FAO, UNDP, WHO, WTO, WFP, ASTI and statistical offices for 59 indicators that drive food insecurity to compute the final output variable.	It adopts WFS (1996) definition and computes the index using a dynamic quantitative and qualitative scoring model, constructed from 59 unique indicators, that measure the drivers of food security in developing and developed countries.	Altogether 59 indicators from a) affordability, b) availability, c) quality and safety, and d) natural resources and resilience from EIU expert analysis and consultation are weighted, normalized and categorical weighting (simple average) is done.  The final score is computed ranging from 0-100 (100 for most favorable outcome).	2012
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FAO produces one of the earliest estimates of the percentage of individuals in the total global or national population that consume calories below a threshold. Prior to 2008, FAO relied on food balance sheets (FBS) – compiled as the balancing item after considering production, trade, stock changes, non-food uses, and extra-household waste. Based on FBS and using food composition tables, the available food quantity is converted into calories and divided by the population to derive the per capita dietary energy consumption (DEC), expressed in kilocalories per day.<sup>4</sup> More recently, PoU is obtained as the proportion of population below the MDER from the cumulative distribution of DEC as described in table 1. For this purpose, FAO calibrated the base (2005) parameters of the log-normal distribution of DEC using household consumption and population surveys, including weights for demographics as well as potential population growth (pregnancy). Then, FAO projected the (four) parameters of the DEC distribution with the most recently available consumption or population survey data (SOFI, 2020).

IFPRI's GHI is based on four indicators: undernourishment, stunting, wasting and mortality, which reflects calorie and nutrient deficiency (utilization and stability pillars). For the purpose of this study, IFPRI's PoU (a weighted transformation of FAO's PoU) alone is used. Prior to 2016, USDA's international food security assessment estimated supply using acreage and yield functions, while an indirect method was used to project consumption by income groups. The methodological improvement since 2016 employs an advanced econometric model to directly estimate demand by income deciles as detailed in table 1 (Beghin *et al.*, 2017). The more significant difference in methods arises in the context of UNDP, which estimates the proportion of people below a BMI threshold for several age groups, e.g., 18.5 kg/m<sup>2</sup> for adults

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<sup>4</sup> Technically, FBS measures dietary energy availability or supply, but it is assumed to equal consumption as well (Haen *et al.*, 2011).

aged 20-70, (table 1). While FAO, IFPRI and USDA are considered ex-ante measures of food/calorie availability, UNDP is an ex-post indicator of nutritional outcomes (Haen *et al.*, 2011).<sup>5</sup> The other measure from FAO – FIES – relies on a direct survey of a population’s food-related behavior and experience, beginning with the Gallup World Poll in 2014. Similarly, EIU-GFSI measures food security in national and continental regions incorporating broad categories of food security pillars. Using 59 aspects of affordability, availability, quality and safety, and natural resources and resilience (from EIU expert analysis, consultation, and secondary data usage), national-level food security is indexed.

While FAO, IFPRI and EIU cover most countries, USDA and UNDP samples are limited by interests and data availability. In addition, the methodology used by both FAO and USDA to determine whether a population can meet a caloric consumption target may not be the most appropriate for high-income countries. In countries like the United States and the European Union, the poorest population is often the beneficiary of a variety of food assistance programs. Attaining a caloric consumption target in high-income countries is easier to do, but not guaranteed because of poor targeting by or lack of access to assistance programs. In the continuum of food security, high-income countries are likely concerned about an attainable quality of nutrition.

In addition to the agencies listed in Table 1, other available indicator includes analysis of crisis status by the Food Security Information Network in partnership with United Nations, European Union and United States Agency for International Development (USAID) for selected nationalities (see FSIN and GNAF, 2020).

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<sup>5</sup> Other outcome-based indicators include the global burden of disease e.g., disability-adjusted life years (Stein, 2014; Gödecke *et al.*, 2018).

## 2.2 Within-Country Analysis

Table 2 presents other food security indicators using household data, which tend to provide an answer to the who, how many and where questions on identifying the vulnerable population (Haen *et al.* 2011). These indicators often complement metrics in table 1 and are based on surveys of food access-related experiences of individual/household/community over a reference period. USAID has developed many of these indicators – Household Food Insecurity Access Scale (HFIAS), Household Hunger Scale (HHS), Household Dietary Diversity Score (HDDS), Demographic and Health Survey (DHS) – primarily to measure utilization and stability pillars through self-reported experiences (table 2).

USDA’s Household Food Security Monitoring (HFSM) employs 18 questions in supplement to the Current Population Survey of the U.S. Census Bureau to measure annual food security status in the U.S. (USDA, 2020b). HFIAS, an adaptation of the HFSM, uses a 9-questions module to categorize households based on behavioral and psychological manifestations of insecure food access. HHS is also derived from HFSM and HFIAS for cross-cultural use. It employs three questions regarding the occurrence and frequency of food deprivation scenarios to assess the most severe situations of food insecurity. HDDS calculates household’s access to different food groups to categorize food security based on dietary diversity. They assume a more diversified diet is correlated with caloric and protein adequacy and socioeconomic status. Likewise, DHS is a comprehensive survey that includes the measurement of anthropometric outcomes among children and women (men in some recent cases). These measurements help to analyze the consequences of food insecurity at the regional and national level (Swindale and Bilinsky, 2006; Coates *et al.*, 2007; Ballard *et al.*, 2011; Coleman-Jensen *et al.*, 2019; USAID-DHS, 2019).

Latin American and Caribbean Food Security Scale (ELCSA) is based on HFSM, HFIAS, and Brazil's and Colombian Food Insecurity Scale to explore experience-based food security at the household level. It uses a 15-question module to categorize the severity of food insecurity. Coping Strategies Index (CSI) is used for rapid measurement of household food security along with the impact of food aid in emergencies and long-term food insecurity. It is based on the behavior (and frequency) of communities or households when they cannot access enough food. Similarly, Food Consumption Score (FCS) is WFP's approach to account for dietary diversity and frequency of consumption weighted by the relative nutritional value of the food group. FCS and HDDS are often correlated with each other and with overall food security (Maxwell and Caldwell, 2008; WFP-VAM, 2008; Ballard *et al.*, 2013).

These indicators (table 2) are not only used as primary metrics but also as complements to other tools (e.g., table 1), especially for intra-country analysis in a number of countries, for e.g., Emergency Food Security Assessments (EFSA) and Comprehensive Food Security and Vulnerability Analysis (CFSVA). EFSA uses HFIAS and self-rating techniques with tools like the economy approach and International Food Security Phase Classification (IPC).<sup>6</sup> Likewise, CFSVA uses a combination of FCS, wealth index and CSI to locate household food insecurity and vulnerable rural areas (as in the case of DR of Congo) (WFP, 2009; CFSVA-DR Congo, 2014). Similarly, other approaches involve Australia's Food Security Assessment for own country, and Famine Early Warning System (FEWS) Network's approach for selected regions (Sheales and Gunning-Trant, 2009; ABARES, 2017; ABARES, 2020; FEWS-NET, 2021). FEWS assesses economic and physical access to food using secondary information that classifies

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<sup>6</sup> IPC classifies households and areas according to a five-phase scale: Minimal, Stresses, Crisis, Emergency and Famine (FEWS-NET, 2021).

vulnerable regions within and across countries, according to IPC classification (Jones *et al.*, 2013).<sup>7</sup> Thus these “with-in country” indicators aid agencies/ researchers to answer where exactly the households are facing mild to severe food insecurity, but mostly based on survey responses on experience or behavior related to food consumption.

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<sup>7</sup> FEWS is created by USAID in 1985 which provides evidence-based analysis on approximately 30 countries from combination of multiple information including real-time satellite rainfall records, temperature, agricultural production, prices, trade, economic shocks, political instability and livelihoods (FEWS NET, 2021).

**Table 2: Indicators available for food insecurity measurement within countries**

Agency	Level of Analysis	Dimension	Approach	Definition	Most Recent Methodology	First Publication or release date
USDA Household Food Security Monitoring (HFSM) (Coleman-Jensen <i>et al.</i> , 2019)	Household (Domain: United States)	Accessibility (economic or resources) Anxiety Quantity Quality Diversity	Experience-based survey; Extent and severity of food insecurity in the US households are assessed using an annual and representative survey with 18 questions. Data are collected from the Food Security section supplement to the Population Survey. (12 months recall)	Food insecurity is calculated from the responses to a question about conditions and behaviors that households exhibit when they have difficulty meeting basic food needs. Higher the experience of inaccessible food conditions, higher will be the chances of a household falling into the food insecure category.	Altogether 3 questions about the household food condition, 7 questions about adult's food condition and (if children present) 8 questions about children's food condition are asked.  <i>Food Secure</i> : No to only 1 or 2 food-insecure conditions in the past 12 months <i>Food Insecure</i> : 3 or more food-insecure conditions.  Further, they classify "household having food insecure children", "Low to very low food security" for food-insecure households.	1995
USAID's Household Food Insecurity Access Scale (HFIAS) (Coates <i>et al.</i> , 2007)	Regional Household	Accessibility (economic and resources) Anxiety Quantity Quality Preference Food Diversity	Experience-based; adaptation of HFSM for developing countries; This survey captures households' behavioral and psychological manifestations of insecure food access.  It is being used as a part of several household surveys. (30 days recall).	Those households that have reduced the number of meals consumed or cut back on the quality of food due to lack of resources and experienced higher anxiety for food access are categorized 'severe' in the food insecurity gradient.	Altogether 9 questions for occurrence followed by 9 questions for frequency (rarely, sometimes or often) of occurrence (30 days recall) is surveyed.  a) Continuous score = $\sum_{Q=1}^9 Score_Q$ where, Q stands for questions (1-9). For each question, a score from 0-3 is assigned - can sum up to 27. This score can help to average the HFIAS score and computing prevalence.  b) Categorical Indicator: 4=Severe, 3=moderate, 2=mild food insecurity and 1=food secure; based on responses given by households in each question (see Table 4, pp:20-21 in Coates <i>et al.</i> , 2007).	2006
USAID's Household Hunger Scale (HHS) (Ballard <i>et al.</i> , 2011)	Regional Household	Anxiety Accessibility Availability	Experience-based survey; derived from HFSM and HFIAS - consists only of the most severe manifestations of food insecurity; assesses hunger in food-insecure regions; useful for cross-cultural setting. (30 days recall).	If households experience hunger more often, they fall at a higher level on the severity scale.	Questions: 3 for "occurrence" and 3 for "frequency-of-occurrence". If the given condition is experienced, the question is scored (0-2) for each question.  a) Continuous score = $\sum_{Q=1}^3 Score_Q$ Can sum from 0-6.  b) Categorical indicator: 0-1 is little to no hunger, 2-3 is moderate hunger and 4-6 is severe hunger.	After HFIAS 2006

USAID's Household Dietary Diversity Score (HDDS) (Hoddinott and Yohannes, 2002; Swindale and Bilinsky, 2006)	Regional Household Individual	Food Diversity Nutritional Quality Accessibility	They assume higher the food diversity, the higher will be caloric and protein adequacy, the percentage of protein from animal sources, and the household income. It gives the household's ability to access food and their socioeconomic status. (basically, 24 hours recall).	HDD is the total number of food groups consumed by a household over a given reference period.	Each 12-food group ( $m$ ) is assigned a score of 1 (if consumed) or 0 (if not consumed) for $A_m$ and average HDDS is calculated for a population under survey:	2006
Some revisions by Kennedy <i>et al.</i> (2011) for EU-FAO					$\text{Average HDDS} = \frac{\sum_{m=a}^l A_m}{N}$	
USAID's DHS Anthropometric Analysis (USAID-DHS, 2019)	National (77 countries) Regional Household Individual	Nutritional Outcomes (Food Utilization)	Survey of representative samples; measures height and weight for children below five and women aged 15-49. Men's waist circumference is being measured in some cases in recent surveys.	Anthropometry is the indicator of nutritional outcome. Poor BMI, height-for-age, weight-for-height or weight-for-age provides insight into the nutritional deficiency.	In most cases, anthropometry for children under five are measured in a sub-sample of households. Those values are assigned with z-scores (based on the WHO Child Growth Standards) considering sex, age, height and weight. Stunting, wasting, underweight and their severity are calculated after computing the mean and SD of z-scores. See Croft <i>et al.</i> (2018)	1985
Latin American and Caribbean Food Security Scale (ELCSA) (FAO-EU, 2012; Ballard <i>et al.</i> , 2013)	National Regional Household	Anxiety Accessibility Availability	Experience-based survey; this approach is founded based on HFSM, Brazil FI scale, HFIAS, Colombian FI scale; severity of insecure food access in the population. (3 months recall)	If the household has experienced a certain manifestation of food insecurity in the past three months. If they had, they will be categorized to different severity scales (higher experience leads to higher score).	Asking 8 questions (additional 7 questions if household have children) regarding food security experience (1=Yes and 0 otherwise) Scoring: Household without children = $\sum_{Q=1}^8 \text{Score}_Q$ Household with children = $\sum_{Q=1}^{15} \text{Score}_Q$  Categorization: 0: No Food Insecurity 1-3 or 1-5: Mild Food Insecurity, 4-6 or 6-10: Moderate Food Insecurity 7-8 or 11-15: Severe Food Insecurity	2010
For a set of survey questions: see Perez-Escamilla <i>et al.</i> (2009)						
Coping Strategies Index (CSI) (Maxwell and Caldwell, 2008)	National Regional Household	Quantity Quality Accessibility (economic and resources)	Individual Survey and focused group discussion (FGD) asking, "What do you do when you don't have adequate food, and don't have the money to buy food?"  This approach assesses a) food aid needs, and b) whether most food insecure households received food aid, c) long-term change in food security.	High CSI score means extensive use of negative coping strategy leading them to be at a higher rank in food insecurity.  It is an early warning and food security monitoring (especially emergencies) and assessment that measures people's behavior when they cannot access enough food.	Local people are surveyed (and FGD) to identify the 'most frequent' and 'severity' of coping strategies.  Perceived severity is assigned weights (1, 2 and 3; 3 being most severe). Individual survey assesses the frequency of using coping strategy over recall period.	2003; developed in Uganda, Ghana and Kenya
					$\text{CSI Score} = \sum_i \text{Weight}_i \times \text{Frequency}_i$	
					where, 'i' is the household. 0-50: Low CSI, 51-100: Medium CSI and >100: High CSI (these categories subject to modification based on context)	

Food Consumption Score (FCS) (WFP-VAM, 2008)	National Regional Household	Accessibility Quality Diversity	FCS is the core indicator of consumption recommended by Vulnerability Analysis and Mapping (VAM).  Frequency of consuming eight food groups is reported, which is weighted by its presumed nutritional value for each food group. (7 days recall)	The FCS is a composite score provided from their dietary diversity chart and their nutritional contribution. Higher the score, the better it will be.	Standard weights for food groups (generally eight) are used and frequency data are collected (see WFP-VAM, 2008; pp:8).  $FCS\ Score = \sum_{m=1}^N Frequency_m \times Weight_m$ <p>where, "m" is a food group. FCS Score if 0-21: Poor, 21.5-35: Borderline and &gt;35: Acceptable.</p> <p>Food Consumption Groups can be created using these estimates. The food groups and weights may vary with countries (also communities).</p>	1996; developed in South Africa as a part of community household surveillance
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Additional References: (IDDEP, 2021; Pérez-Escamilla *et al.*, 2017; Jones *et al.*, 2013; Deitchler *et al.*, 2011)

In addition to the efforts in table 2, primarily by USAID, to measure food insecurity at a regional level, a number of other studies have investigated intra-national food security patterns. India, a case in point, shows wide heterogeneity in nutritional status among regions (Cavatorta *et al.*, 2015; Pingali and Sunder, 2017; Rahman *et al.*, 2018). Menon *et al.* (2009) computed state-level hunger indices for India: *Punjab* and *Kerala* ranked higher in food security indicators while the situation in *Jharkhand* and *Madhya Pradesh* was significantly worse than the national indicator reported by FAO and IFPRI. Many other studies have identified patterns of food security in major urban centers such as Mumbai, New Delhi, Chennai, Bangalore and others (Agrawal *et al.*, 2009; Chatterjee *et al.*, 2012; Mastiholi *et al.*, 2018; Rani *et al.*, 2018; Anand *et al.*, 2019; Rautela *et al.*, 2020).

Besides India, authors in other settings (developing and developed countries) have carried out sub-national analysis using indicators detailed in tables 1 and 2. They also discussed the underlying regional characteristics shaping food security in the region. For example,

- Using HFIAS, GHS-South Africa (2015) showed that inadequacy in food access was 26.4%, while Hendriks *et al.* (2016) in Eastern Cape province showed how the food insecurity outcomes vary based on the selection of sub-national indicators for regional analysis. They realized the need because of prominent variation in South African national food insecurity in 2007: 4.6% (FAO) and 3.7% (IFPRI) and in 2015, it was 5.7% (FAO), 2.7% (IFPRI), 4.8% (UNDP) and 42.9% (FIES).
- In *Prey Veng* province, Cambodia, in 2012, HFIAS and HDDS measures assessed the prevalence of food insecurity and dietary diversity among 900 rural poor households. They showed 83% of the households were facing some form of food insecurity (37% moderate and 13% severe) (McDonald *et al.*, 2015).

- In rural Nigeria during 2006, lower food insecurity (better nutrition and anthropometric result) was prevalent across households with higher income growth (Babatunde and Qaim, 2010).
- In rural Malaysia (2005) and Bangladesh (2007-2009), the food security of poor strata was adversely affected by food price shocks. Education and income have had an impact on household food security (Shariff and Khor, 2005; Akter and Basher, 2014).
- In urban *Karachi*, Pakistan (2000) and rural Ethiopia (2014), food security in households with children and women was significantly poor (Baig-Ansari *et al.*, 2006; Betebo *et al.*, 2017).
- Sisha (2020) analyzed 5000 households (from three rounds of LSMS survey – 2011, 2013, 2015) in Ethiopian regions: share of population not having enough food was 30.6%, 18.6% and 13.6% in a rural area, small town and large town, respectively in 2015.
- In addition, in sub-regions of Eritrea (2012), 65% of the population were undernourished when Sahelian countries were involved in armed conflict. Regional political instability, local violence and civil unrest have an impact on food security outcomes (SOFI, 2012; Hendrix and Brinkman, 2013).

These studies provide evidence of disparity or heterogeneity of food insecurity incidence within countries. As noted earlier, they tend to be cross-sectional in nature for selected countries as well as rely on experience surveys.

### 2.3. Regional Food Insecurity: Approaches and Implications for Nepal

While many studies focused on measuring PoU at the national level (figure 1), a few studies have examined the regional and demographic dimensions of food insecurity within Nepal. These studies have used indicators described in tables 1 and 2 or their modifications to assess “within-country” food insecurity in Nepal. In this section, a review of major findings of these intra-Nepal studies is provided:<sup>8</sup>

- FAO (2004) reported marginal farm households in hills followed by *Terai* and mountains, and agricultural labor households in *Terai* were highly vulnerable to food insecurity.<sup>9</sup>
- In 2006, as a result of an adverse climatic event, some districts in provinces 1, 2 and 6 (eastern *Terai*, central *Terai* and western mountains) faced a decline in cereal output by 16%, 9% and 5.3%. Increased food insecurity due to food deficit was estimated in 42 districts (FAO-WFP, 2007).<sup>10</sup>
- Small Area Estimation project (SAE) estimated 45%, 42% and 37% of PoU in mountain, hills and *Terai* during 2003, while the NLSS-2003 estimated 40%, 37% and 33%, respectively (CBS *et al.*, 2006).

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<sup>8</sup> Most of the cross-sectional studies are focused among children and women considering their relative vulnerability.

<sup>9</sup> Marginal farm households are houses with <0.5 ha of land including landless households and sharecroppers. Non-marginals are households with >1 ha of land.

<sup>10</sup> The worst affected districts include *Saptari*, *Siraha*, *Mahottari*, *Dhanusa*, *Rautahat* and *Sarlahi*, all in province 2.

- In provinces 6 and 7 (mid and far-west), 300,000 food insecure people were found in 9 districts during 2008. They highlighted that the decline in local self-sufficiency was the primary predictor of their vulnerability (Relief Web, 2008 in Paudel *et al.*, 2010).
- In *Kailali* (province 7) during 2009, 69.2% of 368 households (with infants) were lacking access to adequate food (Osei *et al.*, 2010). This study used modified (5 questions) HFIAS and anthropometric measurements. Higher food insecurity was associated with lack of education, lower income, lower access to assets/resources and short-term debt. Similarly, Shively and Sununtnasuk (2015) found income, agricultural yield and consumption of own production to be primary factors to achieve food security in regions of Nepal.
- Province 5, 6 and 7 in western Nepal, especially agricultural households, were found to have a higher incidence of food insecurity in 2011 (Joshi *et al.*, 2011).
- CBS (2013), using NLSS-2011, reported that mountain areas had a higher incidence of seasonal food insecurity. Nepali *et al.* (2020) showed that province 2 (which is only in the *Terai* belt) population, especially in rural areas, was relatively vulnerable in 2016.
- During 2013 and 14, Shrestha *et al.* (2018) used HFIAS and anthropometric measurements to conduct household surveys in 21 regions distributed across all provinces and belts. They reported that 59% and 73% of households were food insecure, respectively.
- In 2016, 41% were food insecure, with 7% severe cases among 4309 households across provinces (MOHP-Nepal *et al.*, 2018). Rural areas were found to be relatively more food insecure than urban areas.

- In the urban area of *Bhajang* in 2018, 417 households were surveyed using HFIAS and HDDS modules: 54% of the households are food insecure, among which 14.9% are severe cases (Singh *et al.*, 2020).
- In *Chitwan* (province 3), 24.8%; *Kaski* (province 4), 83.7%; and *Upper-Mustang* (province 4), 60.6% of households were food insecure during 2013 (Pandey and Bardsley, 2019). This survey used HFIAS across 360 rural households focusing on *Terai*, middle mountain and trans-Himalayan districts.

The above studies indicate substantial variation in food access and food insecurity within Nepal. While they provide some answers to “where, how many, and who” questions for some districts, provinces, belts, urban/rural domains – cross-sectional and selected locales – few have examined intra-Nepal heterogeneity, especially over time. The latter - where, how many, and who within Nepal are food insecure during the past three decades– is the objective of this study as described in the next chapter.

## CHAPTER 3

### STUDY OBJECTIVES

The objective of this study is to examine food insecurity at a regional level in Nepal. While many studies focus on measuring PoU, i.e., food insecurity, for the entire country, few have answered questions on the location of the vulnerable population within Nepal. In addition, this study describes the typical characteristics of food-insecure households in Nepalese regions. More importantly, this study aims to track regional PoUs over three decades using data from three comprehensive surveys of Nepal, each about a decade apart. The specific objectives of the study are:

- a) To compute household energy consumption and requirement by regions: wards, districts, and provinces,
- b) To identify the food-insecure households by region, and calculate the share of food-insecure households in each region's population, i.e., the prevalence of undernourishment,
- c) To compare PoU across regions, and
- d) To describe household characteristics closely aligned with the undernourishment status.

## CHAPTER 4

### METHODOLOGICAL FRAMEWORK

Since 1999, FAO measures food deprivation, referred to as the prevalence of undernourishment (PoU), which compares an individual's daily energy requirement with energy consumption. Many revisions to FAO's methods have occurred since 1999, and the most recent approach uses a probabilistic framework to measure PoU (Sukhatme, 1961; see SOFI, 1999; Naiken, 2002; Naiken, 2007). The recent approach defines PoU as the state of consuming food below the individual requirement to maintain acceptable body weight and physical activity level (PAL). While food (energy) consumption is derived from observable data, FAO (2008) computes minimum dietary energy requirements (MDER) based on the Joint Expert Consultation on human energy requirements (FAO, 2001). Since FAO is the most widely used reference for global hunger monitoring, this study adopts its methodology to derive PoU for Nepal (Haen *et al.*, 2011; Wanner *et al.*, 2014).

The PoU is the probability that selecting one individual at random from the population, that person is found to be consuming, on a regular basis, an amount of food that provides less energy than his or her own energy requirements. For a geographical unit, PoU is obtained as the cumulative probability that the habitual dietary energy intake ( $X$ ) of the randomly selected reference population is below the MDER. To compute PoU in a given population, the probability distribution (pdf) of  $X$  (expressed in kilocalories per capita per day, hereafter, kcal) for the average individual is modeled as:<sup>11</sup>

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<sup>11</sup> An example of the derivation of PoU, step-by-step, for Kathmandu district is provided in Appendix 4.

$$PoU = P(X < MDER) = \int_{X < MDER} f(X|\theta). dX = F_X(MDER), \quad (1)$$

where,

- $f(X)$  is the probability distribution function of dietary energy consumption (DEC), characterized by a vector of parameters  $\theta$ , and
- $F_X$  is the cumulative distribution function.

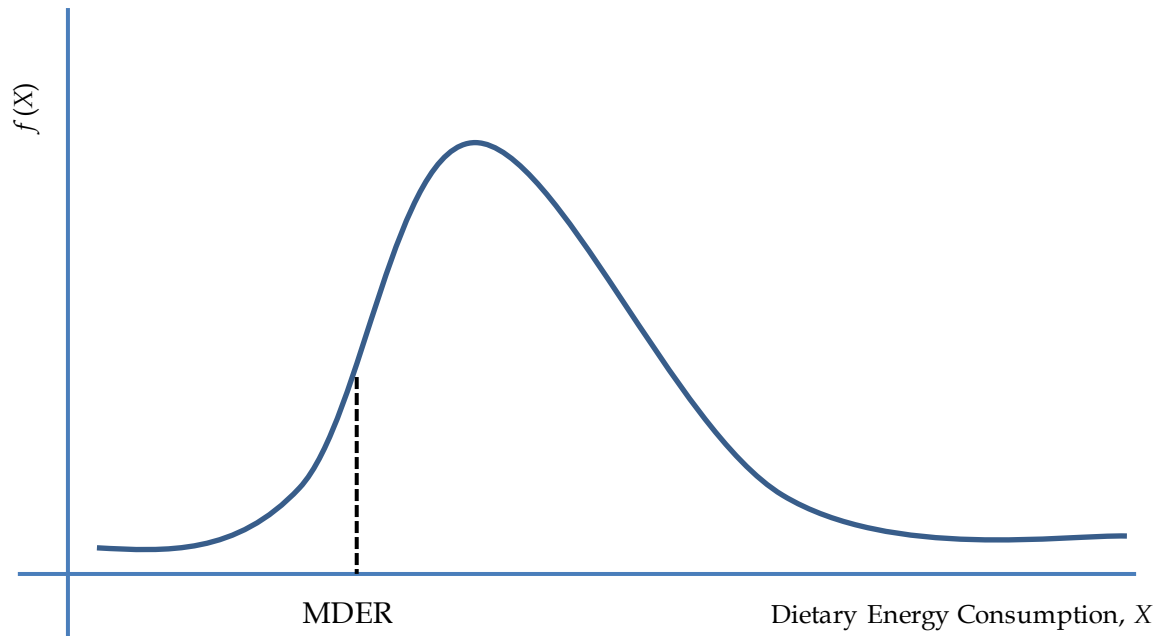


Figure 3: Probability distribution function of DEC

The curve  $f(X)$  in figure 3 is the proportion of population corresponding to different  $X$ s (DEC). The lognormal distribution of  $X$  is fully characterized by two parameters: a) the mean

dietary energy consumption ( $\bar{X}$ ), and b) its coefficient of variation (CV).<sup>12</sup> The procedure to obtain required parameters and to calculate PoU (flowchart in appendix 3) are:

$$\sigma_X = \sqrt{\ln(CV^2 + 1)}, \quad (2)$$

$$\mu_X = \ln \bar{X} - \left\{ \frac{\sigma_X^2}{2} \right\}, \quad (3)$$

$$PoU = \Phi \left( \frac{\ln MDER - \mu_X}{\sigma_X} \right), \quad (4)$$

where,  $\Phi$  is the standard normal cumulative distribution. To compute  $\sigma_X$ ,  $\mu_X$  and PoU, dietary energy consumption and requirement should be defined first.

#### 4.1. Household Energy Consumption

In this study, total energy consumption is calculated from household food consumption data reported by respondents. The chosen geographical unit is the ward, i.e., primary sampling unit (PSU), which is the smallest administrative division in Nepal. Values of  $\sigma_X$  and  $\mu_X$  in equations (2) and (3) are calculated from the  $\bar{X}$  and CV as described below.

- a) Mean Dietary Energy Consumption ( $\bar{X}$ ): SOFI (2020) notes that data on food consumption should ideally come from nationally representative household surveys like LSMS or Household Incomes and Expenditure Surveys (direct estimation). However, FAO projects  $X$  from a base-year (2005) consumption survey data, which is referred to as indirect estimation in this study.<sup>13</sup> Note that the direct estimation using representative surveys allows the derivation of sub-national estimates while the indirect approach

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<sup>12</sup> Wanner *et al.* (2014) suggested some refinements in obtaining CV and skewness, and using different functions with three-parameter skew-normal or skew-lognormal distribution. Also, see discussion in Cafiero (2014) for recent innovations in hunger measurements.

<sup>13</sup> Before 2008, projections were based on the FBS considering production, trade, stock changes, non-food uses, and extra-household waste. Similarly,  $CV|v$  is computed from linear interpolation of CVs in the years between surveys (indirect estimation).

provides estimates at a national level (FAO, 2008).<sup>14</sup> This study employs the direct estimation strategy and obtained the mean DEC ( $\bar{X}$ ) per capita per day as follows:

$$\bar{X} = \frac{\sum X_i}{\text{Recall Time Period} \times \sum \text{Adults Sample Size}_i}, \quad (5)$$

where, ' $i$ ' indicates households in the PSU (which can be aggregated to district level with appropriate weights). For data used in this study, the recall time period is 30 days, but for the 2011 sample, two options are available: 30 and 7 days. The total population in the PSU is converted to adult equivalents (described in the data section) for use in the denominator of  $\bar{X}$  in equation (5).

- b) Coefficient of Variation (CV): Household access to food is determined by their income, affordability, access to market as well as their energy requirements: calorie intake varies based on income/expenditure and individual's daily requirement. Thus, CV is the geometric mean of the CVs due to household-level income variation ( $CV|v$ ), and due to energy requirement ( $CV|r$ ).

$$CV = \sqrt{(CV|v)^2 + (CV|r)^2}, \quad (6)$$

There are two approaches to estimate  $CV|v$ : indirect estimates through projections based on population surveys, and direct estimation is done when reliable data on food consumption (for example, LSMS) is available: the latter captures the variation in DEC due to income/expenditure strata of the population.<sup>15</sup>  $CV|v$  are the averages of  $X$  by

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<sup>14</sup> Refer to Appendix 5 for differences in original FAO practice and this study's adopted procedure between methodology and data.

<sup>15</sup> FAO imputed  $CV|v$  using macroeconomic variables like GDP per capita, inequality in income (Gini index) and an index of the relative price of food. FBS cannot be used to estimate CV because they provide no information about food distribution among population stratified by income.

income/expenditure class  $j = 1, \dots, 10$  (usually ten deciles) and the number of households ( $i$ ) in each income/expenditure class ( $j$ ) for each PSU.

$$CV|v = \frac{\sigma(X|v)}{\mu(X|v)} = \frac{\sigma(X|v)}{\sum X/i}, \quad (6a)$$

$$\sigma(X|v) = \sqrt{\frac{\sum_{j=1}^{10} f_j (X|v)_j^2 - \{\sum_{j=1}^{10} f_j (X|v)_j\}^2 / i}{i - 1}}, \quad (6b)$$

where,  $f_j$  is the number of sample households in each  $j$ ,  $(X|v)_j$  is the average household DEC in each decile. DEC is different for different income/expenditure classes, which are averaged to obtain  $\mu(X|v)$  for total sample households. Thus,  $\mu$  is the mean of  $X$ s among those classes and  $\sigma(X|v)$  represents the standard deviation of  $(X|v)_j$ . Here, after obtaining 10 DECs,  $\mu$  and  $\sigma$  are obtained using equations (6a) and (6b).

Similarly,  $CV|r$  is the variability of the distribution of dietary energy requirements (DER) of a hypothetical average individual (assumed to be normal). Based on FAO (2008), it is assumed to be fixed with a value of 0.20, allowing for a deviation of  $\pm 20$  percent from his/her usual daily requirement.<sup>16</sup> Combining  $CV|v$  and  $CV|r$ , equation (6) computes CV for each PSUs.

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<sup>16</sup> According to SOFI (2020),  $CV|r$  can be derived as the inverse cumulative standard normal distribution of the difference between the MDER and ADER. ADER (average dietary energy requirements) is defined as the average of the minimum and the maximum values of the active or moderately active lifestyle.

#### 4.2. Household Energy Requirement

To compute MDER, FAO uses reference bodyweight for sex-age combinations based on World Health Organization's (WHO) weight-for-height in the BMI tables. In this study, MDER is computed at the PSU level as the sum of energy required – Basal Metabolic Rate (BMR) plus activity energy (A) – for each sex-age combination of family members in the sample households. Basal metabolic rate (BMR) is the energy required to maintaining cellular metabolism for 24 hours resting condition (Kumagai and Yahagi, 2013). In this study, weights to account for demographics, as well as potential population growth (pregnancy), are incorporated into MDER using equation (7) (Wanner *et al.*, 2014; SOFI, 2019, 2020). Specifically, for each PSU,

$$MDER = \left[ \sum_{as} \{(BMRA)_{as} \times P_{as}\} \right] + PA, \quad (7)$$

where,

- 'a' is an individual's age, and 's' is the biological sex of the PSU's population;
- BMRA is the daily energy required per person, including the activity energy;  $BMRA_{as}$  is taken from IFPRI's moderate level activity reference levels (Smith and Subandoro, 2007). With an agricultural economy, Nepal's households are assumed to have a light to a moderately active lifestyle (FAO, 2001; Picchioni *et al.*, 2020).
- $P_{as}$  is indicating the proportion of each sex and age group in each PSU; PA represents pregnancy allowance.
- PA is the product of the national birth rate (total born per thousand) and daily additional energy requirement for pregnant and lactating mothers (280 kcal × 75% of the year (i.e., nine months)) (FAO, 2008).

Finally, given stratified sampling, an adjustment is made to the PoU obtained at the PSU level for aggregation purposes, as shown in equations (8) and (9). For this adjustment, weights are taken from CBS surveys as follows:

$$Adjusted\ PoU = PoU \times \frac{W_{pq} \times Population}{\sum_{p=1}^n (W_{pq} \times Population)}, \quad (8)$$

$$Adjusted\ PoU_d = \sum_{p=1}^n Adjusted\ PoU_p, \quad (9)$$

where,  $W_{pq}$  is the product of ward/PSU ( $p$ ) and stratum ( $q$ ) based sampling weights assigned by CBS based on a baseline population survey of Nepal. 'Population' is the sample population of the data collection, ' $n$ ' is the total number of PSUs which differs from each round of the survey, and ' $d$ ' stands for districts. Similar to district-level, further aggregation can be done at higher levels: provinces or national.

## CHAPTER 5

### DATA

For the purpose of calculating PoU in Nepal, microdata from three rounds (1995, 2003 and 2011) of the Nepal Living Standard Survey (NLSS), also known as Living Standard Measurement Survey (LSMS), are used. NLSS is a comprehensive household survey conducted by the Central Bureau of Statistics of His Majesty's Government in 1995 and 2003, and the Government of Nepal (GON) in 2011.<sup>17</sup>

In the first round (NLSS-1, 1995), a two-stage stratified sampling procedure was used to select the data sample and data were recorded from face-to-face interviews. Sampling frame listed all the wards, the smallest administrative division, and corresponding sizes (size is defined by a total number of households; based on 1991 Population Census). Each ward, the primary sampling unit (PSU) was then assigned a probability proportional to its size (PPS). With four strata - mountain, urban hills, rural hills and *Terai* - a total of 275 PSUs were selected with PPS from all strata in the first stage.<sup>18</sup> In the second stage, 12-16 households were sampled with equal probabilities in each PSU (NLSS, 1995).

Second round of the survey (NLSS-2, 2003) employed six strata and two stages: in the first stage, 334 PSUs were selected, similar to NLSS-1 and the second stage involved selecting 12

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<sup>17</sup> The technical and financial assistance is provided by the GON, the World Bank, the United Nations, the USAID and the UK Department of International Development.

<sup>18</sup> Each district were coded from 1-75 (this coding is before 2015's transition to federalism) representing all 75 districts, though only 73 were sampled with 99.5% response rate in first round. Codes are correspondingly assigned starting from eastern to the western part of Nepal (figure 4; appendix 1).

households in each PSU with systematic sampling (NLSS, 2003). Third round of the survey (NLSS-3, 2011)'s sampling frame was based on the 2008 Nepal Labor Force Survey (NLFS) with 14 strata.<sup>19</sup> In the first stage, 800 PSUs were selected with PPS, out of which 500 PSUs were selected in the second stage for NLSS-3 covering all 14 strata. Finally, in the third stage, 12 households (plus 6 for replacement purpose in case of non-response) in each PSU was surveyed with equal probabilities (NLSS, 2011a).

The NLSS surveys provide detailed data on the consumption of all food and non-food items. In this study, only cross-sectional data from each of the three rounds are used since tracking the same households across the three rounds did not yield a large enough sample for PoU computation. Total sample size is 3,370 households in 1995 (20,160 individuals), 3,912 households in 2003 (21,531 individuals) and 5,988 households in 2011 (28,670 individuals). International Labor Organization estimates Nepalese employment in agriculture to be 80.52%, 73.57% and 69.70% in 1995, 2003 and 2011, respectively, consistent with the NLSS surveys which included 83.1%, 77.5% and 73.9% of agricultural households of Nepal in 1995, 2003 and 2011 (WDI, 2021; NLSS, 2011b). These data enable PoU computation at the PSU level, which can then be aggregated to provincial and national estimates. However, with a limited number of PSUs within each district, estimates at the district level are less reliable, and are placed in Appendix 6.

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<sup>19</sup> Six strata in NLSS-2 were: mountains, Kathmandu valley urban area, other urban areas in the hills, rural hills, urban *Terai* and rural *Terai*. Fourteen strata in NLSS-3 were: Mountains, urban areas of the Kathmandu valley, other urban areas in the hills, rural eastern hills, rural central hills, rural western hills, rural mid-western hills, rural far-western hills, urban *Terai*, rural eastern *Terai*, rural central *Terai*, rural western *Terai*, rural mid-western *Terai*, and rural far-western *Terai*.



## 5.2. Household Calorie Consumption

In section 5 of the NLSS questionnaire, households reported the food consumption information based on a 30-day recall timeline (for 2011, both 30-day and 7-days recall data are available). See appendix 2 for the list of (72) food commodities considered in this study. Three types of food consumption data were collected in NLSS: home-produced commodities' consumption, market-purchased commodities' consumption and other food consumption (aid, gift, in-kind receipts). Since the other food consumption and most market-purchased consumption are in value terms, all three types of consumption are initially expressed in value terms. For home-produced commodities, quantities are converted to values using market prices from *Kalimati Vegetable and Fruit Market of GON* and, other online and grocery stores (e.g. *Bhatbhateni Supermarket*). Then, the consumer price index from World Development Indicator (WDI) is used to deflate the values and obtain consumption quantities. Then, the total edible portion of each commodity (excluding the non-edible portions like peel, skims, bones, etc.), expressed as a percentage of the total quantity, is derived using edible coefficients as suggested in Cafiero *et al.* (2014). Finally, CBS (1998) and USDA's conversion ratios are employed to translate consumption quantities into dietary energy (kcal), as shown in appendices 2 and 4.

Data cleaning involves removing the outliers, reporting errors and weights, values or prices which are reported as zero. Household reporting very high weights (for example, 1 kg rice for 1 adult per day) are replaced using sample means. Further, households with adults equivalent consuming more than 12,000 kcal were omitted, considering them to be erroneously reported.<sup>22</sup> These big purchases or quantities were likely for resale or total harvest rather than consumption over the recall period (Smith and Subandoro, 2007).

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<sup>22</sup> 9 out of 3370 samples (NLSS-1), 14 out of 3912 samples (NLSS-2) and 25 out of 5988 samples (NLSS-3) were dropped.

### 5.3. Household Calorie Requirement or MDER

Individual daily energy requirement is the function of body weight-height, sex and age, and the PAL. Household calorie requirement is the sum of basal metabolic rates plus energy for activities (BMRA) or calorie required for all household members to maintain normal activities. In section-1 of the questionnaire, each household lists its members' information – sex and age. Based on Smith and Subandoro (2007), the energy required for each member is computed depending on age and sex, and adding moderate PAL. Suppose a household has four members: a male adult (aged 45 years), a female adult (aged above 60 years), a male child (aged 14 years) and a female child (aged 14 years). For a male aged 45 years, the BMRA is assumed to be 2900 kcal. So, for this hypothetical household, the total energy required is 2900 + 2100 (female adult) + 2400 (male child) + 2100 (female child) = 9500. Now, the adult-equivalence of this household is equal to 3.27 (which is  $\frac{9500}{2900}$ ).<sup>23</sup> Using the energy requirements of each individual in the PSU, as computed above, and the equation (7), MDER is derived at the PSU level.

For each PSU (appendix 1),  $\bar{X}$  and CV (using CV |  $v$  and CV |  $r$ ), are generated based on equations (5) and (6), which are then aggregated to provincial and national levels adjusted using PSU-level weights ( $W_{pq}$ ). Appendix 3 demonstrates the procedure for 1995 using one PSU of the Kathmandu district as an example.

- a) Mean Dietary Energy Consumption ( $\bar{X}$ ): Monthly household energy consumption is added to PSU level (considering it as total energy consumed by the PSU), which is later divided by total adult equivalent and total recall days as in equation (5) to generate  $\bar{X}$ .
- b) Coefficient of variation (CV): The food expenditure deciles for each PSU and their corresponding calorie consumption are derived from the household DEC data. Mean

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<sup>23</sup> An allowance for pregnancy was added to minimum energy requirement using WDI data on birth rates.

and standard deviations of DEC from these deciles are used to generate  $CV | v$  as described in equations (6a) and (6b).

Recall that  $CV | r$  is assumed to be 0.20, implying that the daily requirement of energy can deviate by 20% from the normal requirement of a human body (FAO, 2008). Then,  $CV | v$  and  $CV | r$  are combined as in equations (6) and (2) to generate the standard deviation of energy consumption at the PSU level.

With  $\bar{X}$  and  $CV$ , all components in equations (2)- (4) are identified to derive PoU for each PSU (refer to Appendix 3 and 4 for the stepwise procedure). Finally, adjusting the PSU values by using sampling weights assigned by NLSS-1, 2 and 3, aggregation at multiple levels is done as given by equations (8) and (9). NLSS (1995) suggests using sampling weights when compiling representative statistics from the survey data. Sampling weights are provided by CBS for each round of the survey, which is the product of multiplicative factors assigned to each ward and stratum based on household count as per baseline population survey (Census 1991 or NLFS 2008) (see NLSS, 1995).

Similarly, data on household characteristics are collected from a respective round of NLSS and processed. The following section of the survey is used in other computations:

- Household Size and Head's Information – Section 1A in all rounds
- Household Non-Food Expenses – 6A and 6B in all rounds
- Household Education – 7B in all rounds
- Household Land Holding – 12A in NLSS-1, 11A in NLSS-2 and 13A1 in NLSS-3
- Household Occupation – 1C in NLSS-1 and NLSS-2; 10B in NLSS-3

## CHAPTER 6

### RESULTS AND DISCUSSION

To answer “where, how many and who” questions, this study carries out a regional assessment of PoU at the PSU level, which is then aggregated to other sub-national administrative units (districts and provinces). This section describes where do Nepal’s food-insecure households reside, the heterogeneity of PoU across regions, and what household characteristics are associated with the undernourishment status. Additionally, it explores differences in PoU across ecological belts and urban/rural domains.

#### ***6.1. Household Calorie Consumption and Requirement***

The level and direction of regional PoU estimates are driven by the range of underlying parameters. These parameters –  $\bar{X}$ , CV and MDER – are computed from series of steps shown in chapter 4 and 5. The first set of results are on the distribution of consumption and energy requirement parameters (weighted at PSU level) shown at the district level in figure 5, 6 and 7. Each figure shows the scatter plot of computed  $\bar{X}$ , CV and MDER in the y-axis against the districts in the x-axis (see appendix 1 for the codes) serially from eastern to western Nepal (figure 4). These figures reveal the range and concentration of the parameters underlying PoU. Most of the districts’  $\bar{X}$  ranges between 2000-4000 kcal during 1995 and 2011 (figure 5); however, one-third of districts exceeds consumption of 4000 kcal in 2003. For most of the districts, the value of  $\bar{X}$  is increased from 1995 to 2003 and again decreased in 2011 (proportional change in  $\bar{X}$  is -23 to 137% in 2003 while -60 to 17% in 2011). That is, the total food consumption reported in almost all districts was significantly higher during 2003. The distribution of higher DEC is

concentrated towards the western districts (i.e., provinces 4, 6 and 7) as seen in the scatter plot (figure 5). The national production during 1995-2003/4 increased by 40.34% (FAOSTAT), which might have contributed to increasing DEC across districts. Although much rapid increase (179%) was observed in total production 2003/4-2011, the average consumption decreased. That is, availability increases may not necessarily yield widespread accessibility to achieve food security.

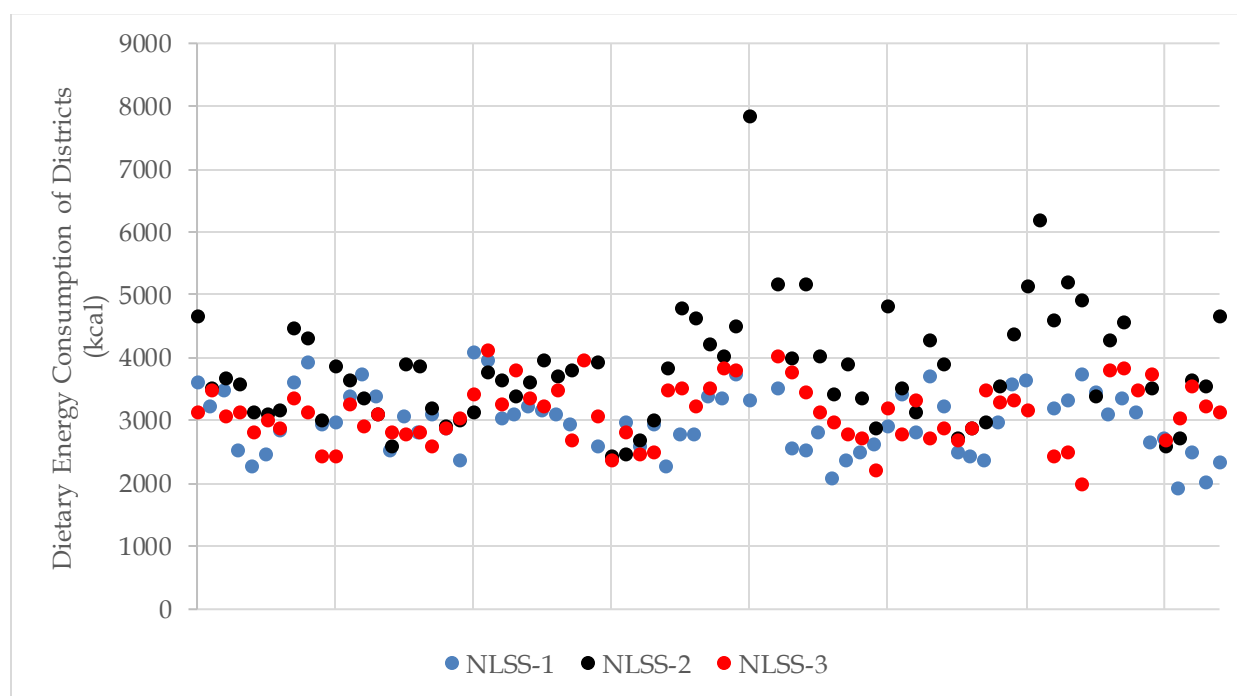


Figure 5: Distribution of DEC at the district level

In figure 6, most of the districts' CVs fall between 0.3-0.5 during 1995 and 2011, which is relatively higher. Proportional change in CV from 1995-2003 was between -45 to 44% across districts while in 2003-2011 it changed between -36 to 88%. This represents the high inequality in the ability across districts to match consumption and requirements.

Similarly, figure 7 illustrates that the distribution of energy requirements is mostly bounded between 2100 and 2300 kcal. There has not been a significant change in the level of energy requirements during 1995-2011, relative to that in  $\bar{x}$ . The relative change in MDER was -

5 to 12% from 1995 to 2003 and -8 to 7% from 2003 to 2011. The proportional change in CV and MDER is not concentrated in a particular district; instead, it is randomly distributed (figure 6 and 7).

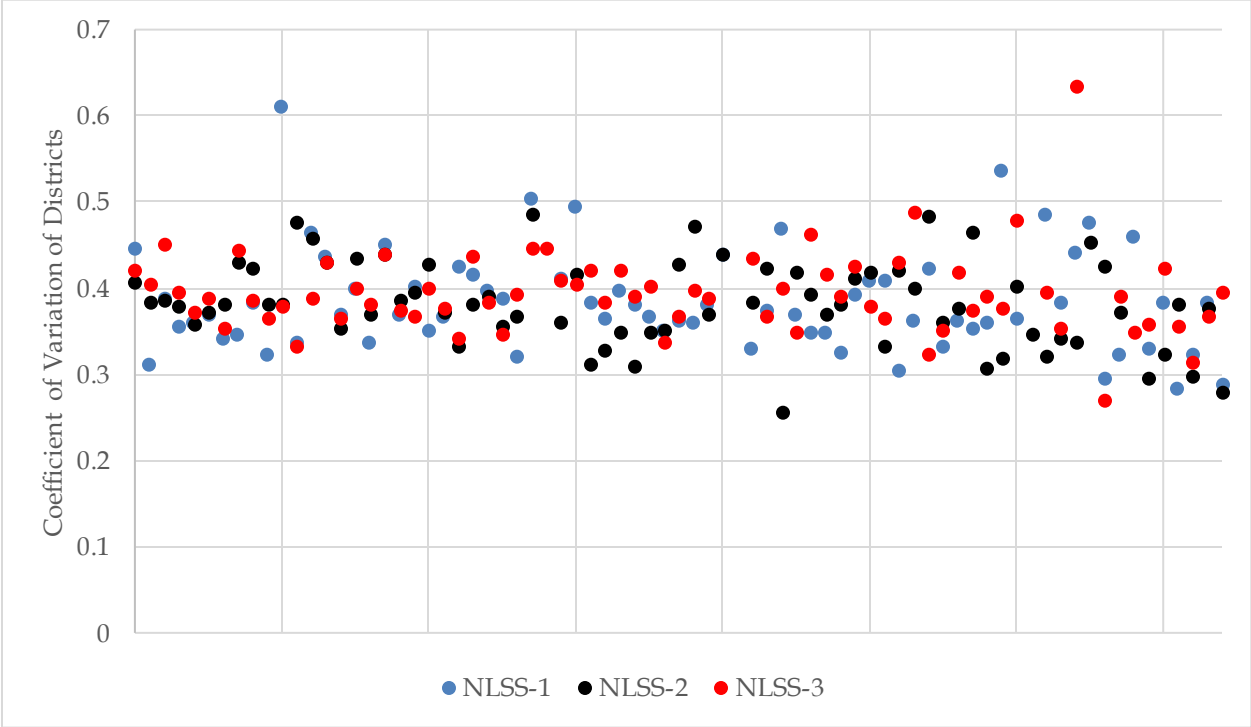


Figure 6: Distribution of CV at the district-level

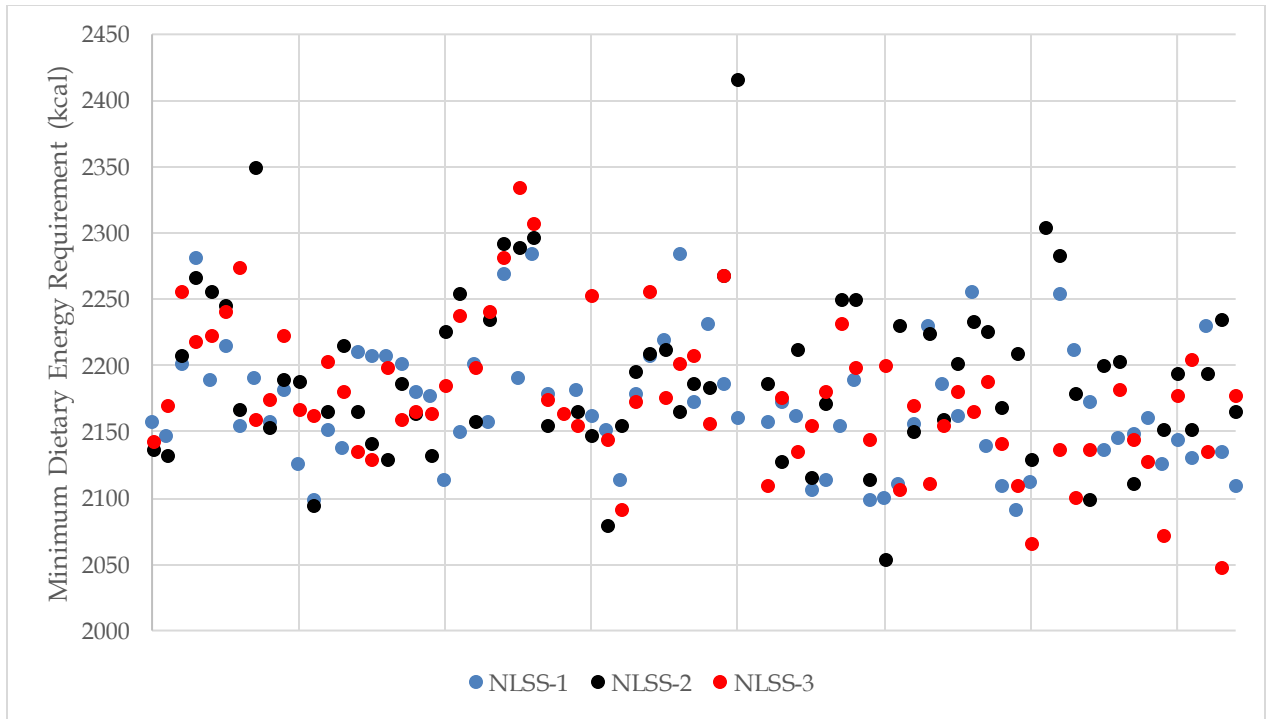


Figure 7: Distribution of MDER at the district-level

Results in table 3 show estimates of  $\bar{X}$ , CV and MDER in 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> column in each round for the 7 provinces and at the national level. Provinces in Nepal are numbered 1 through 7, while some continue to hold a name. In this study, provinces will be referred to using their numbers. The first column of table 3 reports, from each round, the total sample households in the study. As pointed out by the district-level distribution in figure 5, aggregation of  $\bar{X}$  to the province level also shows a higher DEC in 2003 relative to 1995 and 2011. The relative increase in  $\bar{X}$  during 2003 is higher in province 4 (45%) while lowest in province 2 (10%); and relative decrease in 2011 is higher in province 6 (29%) while lowest in province 3 (6%).<sup>24</sup> This indicates provinces 3 and 4 has been able to maintain their consumption levels than other provinces, but province 2 and 6 have not.

<sup>24</sup> Province 6 (followed by 4) has the highest  $\bar{X}$  in 1995, and Province 4 (followed by 6, and 3) in 2003 and 2011. The standard deviation of provincial  $\bar{X}$  is highest in provinces 1 and 7 and lowest in 2 and 3.

The national  $\bar{X}$  increased by 23% in 2003 from 1995 and decreased by 13% in 2011 relative to 2003. At the national level,  $\bar{X}$  during 1995, 2003 and 2011 are 2924, 3593 and 3129 kcal, respectively. These estimates are higher than the estimates of FAO and WFP (which are supply estimates rather than consumption), for e.g., 2855 kcal in 2011.<sup>25</sup> Relative to consumption Gini (2010/11), which was lower and stable from 1995/96, estimated national food consumption  $\bar{X}$  has shown variation over time elsewhere as well (World Bank-Nepal, 2016).<sup>26</sup>

**Table 3: Mean DEC, CV and MDER at the National and Provincial Levels (1995-2011)**

Provinces	Round 1: NLSS-1 (1995)				Round 2: NLSS-2 (2003)				Round 3: NLSS-3 (2011)			
	Total HH	$\bar{X}$	CV	MDER	Total HH	$\bar{X}$	CV	MDER	Total HH	$\bar{X}$	CV	MDER
<b>National</b>	3361	2923.9 (458.4)	0.38 (0.05)	2188.1 (53.8)	3898	3592.5 (688.8)	0.38 (0.04)	2204.8 (60.5)	5963	3128.5 (424.0)	0.39 (0.03)	2204.3 (63.4)
<b>Province 1</b>	582	2955.9 (552.9)	0.38 (0.06)	2189.9 (49.9)	744	3469.1 (458.9)	0.39 (0.03)	2217.5 (52.0)	1051	2990.2 (231.5)	0.39 (0.03)	2215.0 (31.5)
<b>Province 2</b>	516	2837.1 (189.9)	0.38 (0.03)	2183.2 (31.7)	623	3122.2 (530.7)	0.37 (0.04)	2152.8 (32.1)	768	2717.8 (148.5)	0.40 (0.03)	2152.9 (28.5)
<b>3 Bagmati</b>	934	3014.8 (407.3)	0.38 (0.06)	2224.7 (55.6)	1031	3591.8 (379.9)	0.37 (0.04)	2238.7 (62.9)	1722	3367.2 (365.5)	0.39 (0.02)	2267.6 (52.7)
<b>4 Gandaki</b>	393	3092.8 (537.0)	0.38 (0.03)	2189.8 (35.1)	497	4494.5 (666.6)	0.39 (0.05)	2222.3 (51.8)	697	3495.3 (405.5)	0.39 (0.02)	2207.1 (49.6)
<b>5 Lumbini</b>	419	2623.2 (402.7)	0.36 (0.03)	2152.4 (50.2)	536	3347.4 (586.3)	0.40 (0.03)	2188.4 (61.0)	911	2864.6 (355.1)	0.40 (0.04)	2171.3 (26.9)
<b>6 Karnali</b>	166	3287.2 (262.9)	0.42 (0.07)	2149.3 (53.1)	191	4251.8 (800.2)	0.36 (0.06)	2186.5 (50.9)	287	3034.5 (393.4)	0.39 (0.06)	2126.9 (25.7)
<b>7 Sudurpaschim</b>	351	2693.8 (470.2)	0.35 (0.06)	2142.3 (24.0)	276	3365.4 (806.0)	0.34 (0.04)	2174.2 (30.5)	527	3236.9 (408.2)	0.37 (0.04)	2145.4 (53.0)

*Figures in the parentheses are SD across districts.*

Similarly, CV (column 3 in each round in table 3) at the provincial level ranges from 0.35-0.42, 0.34-0.40 and 0.37-0.39 with the national mean of 0.38, 0.38 and 0.39, respectively in

<sup>25</sup> FAO-WFP (2007) illustrated  $\bar{X}$  for Nepal in 2003/04 is 2405 kcal; FAO (2016) reported 2772 kcal and 2855 kcal in 2008 and 2011. FAO (2016) estimated annual growth rate of dietary energy supply is 1.4% from 2008 to 2013. Also, South Asian  $\bar{X}$  trend is increasing from 1969 to 2005 (2000 to 2003 kcal) (FAO, 2015).

<sup>26</sup> The 2010/11 consumption Gini estimate for Nepal was 0.33 (remained stable from 1995/96 level). Consumption inequality was found lower than income inequality. In addition, the average Nepalese income grew between this time (World Bank-Nepal, 2016).

1995, 2003 and 2011. The SD of CV is consistently higher in province 6 and lower in provinces 3 and 4.

The level of MDER (column 4 in each round in table 3) is between 2150-2250 kcal at the provincial level. The relative change in MDER is highest in province 6 (1.73%) while negative in province 2 (-1.39%) from 1995 to 2003. Later in 2011, MDER decreased by 2.72% in province 6 while it increased by 0.07% in province 2. The national MDER has remained almost constant, i.e., 2188 kcal in 1995, and 2204 kcal in 2003 and 2011. Note that province 3 has the highest MDER since 1995. Higher MDER of province 3 can be attributed to centralized government with a concentrated population of workers and hassling lifestyle in *Kathmandu* (capital city) and major cities.<sup>27</sup> This result is consistent with the analysis of Picchioni *et al.* (2020) in province 3: average MDER for Nepalese men and women are 2526.41 and 2032.89 kcal. Level of MDER computed by FAO is lower (1658 kcal, 1670 kcal and 1724 kcal in 2000, 2003 and 2011) as it uses low-PAL for the Nepalese population (Knoema, 2020).

## ***6.2. Distribution of Regional Food Insecurity***

As noted in Chapter 2, PoU is primarily an availability measure of food security and has been computed by multiple agencies. To track the regionally heterogeneous intra-national food insecurity, this study aggregates PSU level estimates, first at the district's level.

Results in figure 8 present the distribution of regional PoU and compare it with the national estimates. Figure 8 – district-level distribution of PoU in Nepal by frequency bins – should be viewed with some caution since some districts had relatively few PSUs (appendix 6).

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<sup>27</sup> Highly concentrated population (1 million) of Kathmandu and centralized government until 2015 have largely contributed to employment and living style of population in province 3 (WDI, 2021).

The observed pattern of PoU across districts appears to change over the three decades considered here: the distribution curve is negatively skewed during 1995, became more uniform in 2003 and again negatively skewed in 2011. These estimates point to wide variation in regional factors likely driving intra-country PoU heterogeneity. For instance, the 2011 PoU distribution in figure 8 when compared with the national estimates by FAO (9%) and IFPRI (around 8%) identify only one district at 9%, while other 76 districts have a PoU estimates ranging from 5 to 40%. Again, USDA's PoU estimate of 22.2% is similar to that obtained in this study for 10 districts and that of UNDP (25.23%) relates well to 16 districts.

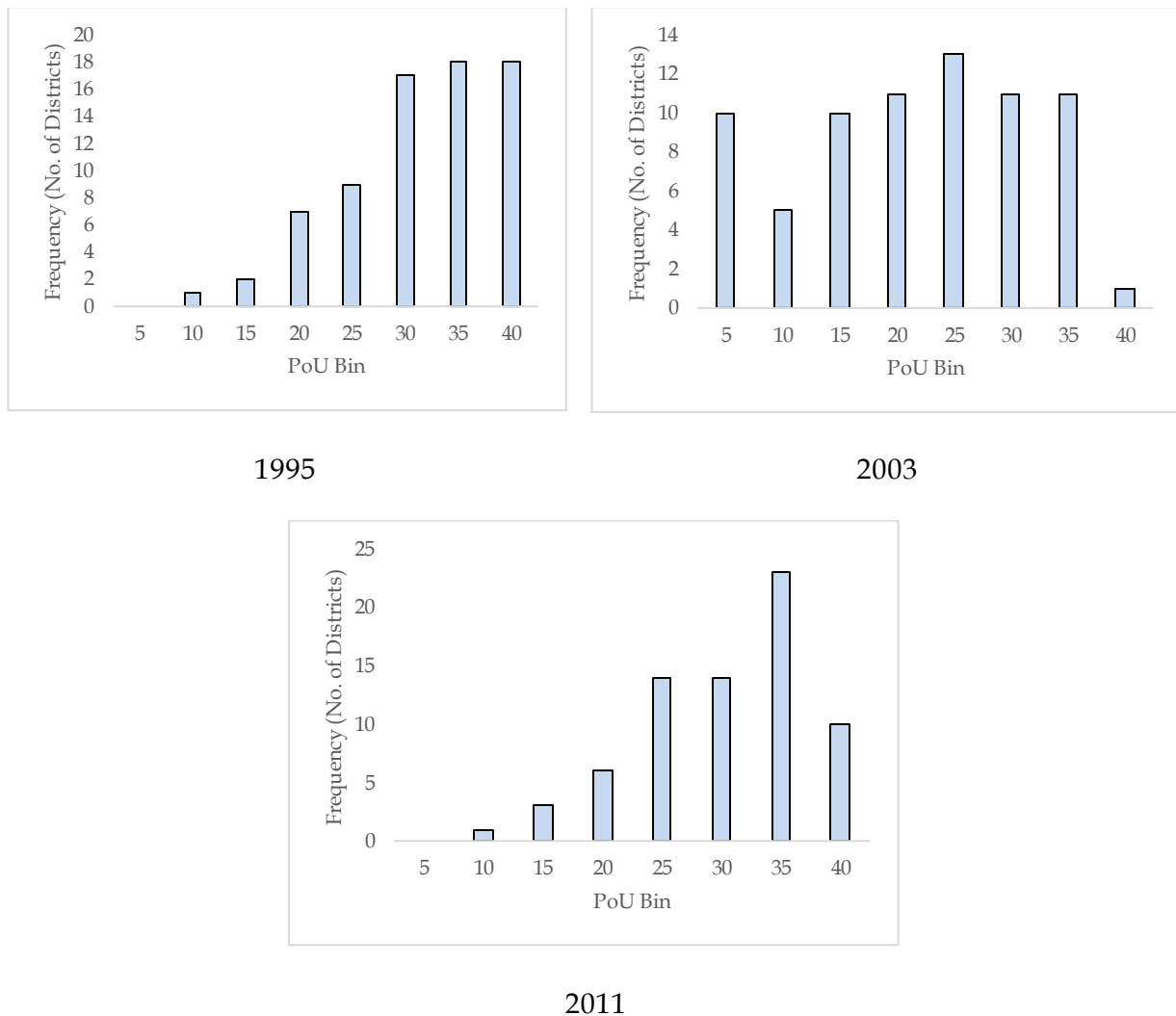


Figure 8: Distribution of PoU across districts

### 6.3. Provincial and National Food Insecurity

Recall that the estimation of regional food insecurity is motivated by the differences in level and direction of PoU trends (figure 1; Haen *et al.*, 2011; Pérez-Escamilla *et al.*, 2020; Pereira *et al.*, 2021). Thus, the primary objective of this study is to determine the regional PoU, identifying where and how many food-insecure households reside in a particular location within Nepal. This can provide insights for targeting assistance and hence, lowering the absolute number as well as share of food insecure population.

This section presents the change in provincial PoU along with the national estimates during 1995-2011. Results in table 4 and figure 9 shows PoU levels with standard deviations and ranges across provinces. For each round, first column (table 4) gives the total number of PSUs used in the analysis. The second column shows the provincial PoU estimates of this study, while the range is presented in the third column. Considering the dense population in province 3, it has the highest sample of PSUs in all 3 survey rounds. However, province 6 has the lowest number of PSU samples than the average in all sampling periods.<sup>28</sup>

Provinces 5 in 1995 (32.5%) and province 2 in 2003 (27.7%) and 2011 (32.5%) have the highest undernourished households (table 4). Similarly, lowest level of PoU is reported in province 6 (26.4%) followed by 4 (27.6%) in 1995; province 6 (11.3%) followed by province 4 (11.5%) in 2003; and province 4 (23.4%) followed by province 7 (24.3%) in 2011. All provinces decreased their PoU during 2003, with the highest progress in province 4 and lowest in province 2. But their PoU levels rapidly increased in 2011 with a huge negative impact in provinces 4 and 6 (doubling of PoU between 2003 and 2011).

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<sup>28</sup> The average PSUs in 1995, 2003 and 2011 are 43, 52 and 79 (without province 6). Omitting province 6, however, did not substantially change the national PoU estimate.

**Table 4: PoU at the National and Provincial Levels (1995-2011)**

Provinces	Round 1: NLSS-1 (1995)			Round 2: NLSS-2 (2003)			Round 3: NLSS-3 (2011)		
	Total PSU	PoU	Range (Min, Max)	Total PSU	PoU	Range (Min, Max)	Total PSU	PoU	Range (Min, Max)
<b>National</b>	274	29.6 (7.7)	9.4, 39.3	326	21.4 (8.9)	0.9, 36.3	499	28.0 (5.8)	5.9, 39.1
<b>Province 1</b>	49	29.4 (7.7)	14.1, 37.2	62	24.4 (6.0)	9.2, 32.2	88	31.0 (3.5)	21.0, 38.9
<b>Province 2</b>	43	30.7 (4.5)	21.3, 37.3	52	27.7 (7.7)	14.5, 36.3	64	32.5 (2.4)	29.5, 38.3
<b>3 Bagmati</b>	78	29.2 (6.7)	9.4, 38.9	86	20.0 (5.7)	11.2, 32.7	144	25.6 (3.9)	13.7, 33.4
<b>4 Gandaki</b>	33	27.6 (8.8)	16.5, 37.4	42	11.5 (6.3)	1.4, 21.1	59	23.4 (5.5)	14.4, 32.8
<b>5 Lumbini</b>	35	32.5 (5.3)	17.1, 37.0	45	25.1 (7.3)	8.1, 34.7	76	31.5 (4.9)	21.1, 37.2
<b>6 Karnali</b>	14	26.4 (4.2)	15.9, 34.7	16	11.3 (8.7)	0.9, 29.3	24	28.6 (5.7)	22.9, 39.2
<b>7 Sudurpaschim</b>	22	29.8 (6.7)	19.5, 39.3	23	21.5 (12.4)	1.3, 34.3	44	24.3 (8.9)	5.9, 35.8

*Figures in the parentheses are SD across PSUs.*

With the highest range of PoU in provinces 3 and 7, low to higher food-insecure PSUs fall in these regions. Over time, the western corner of Nepal (provinces 4, 5, 6 and 7) experienced more fluctuations in PoU, but the eastern corner (provinces 1 and 3) except 2 remained around the national average. This highest fluctuation in province 6 (proportional decrease in PoU by 57% in 2003 and increase by 151% in 2011) can be attributed to the highest fluctuations in food consumption pattern ( $\bar{X}$ ) over time (table 3). This region was considered prosperous in subsistence agriculture in the past; however, food deficits due to the severe impact of extreme climate events, diseases and price volatility have increased the vulnerability of this region (Paudel *et al.*, 2010).<sup>29</sup> Using FIES in 2016, province 6 was reported the most food-

<sup>29</sup> Paudel *et al.* (2010) reported two-thirds of the Village Development Committees in province 6 were involved in conflict with severe impact on their livelihood. Major reason of food insecurity in *Karnali* region was lack of self-sufficiency due to decline in local production. These days it has remained a food deficit region but in past, rich food culture and production diversity for low population and internal exchanges help mitigating their consumption needs.

insecure province of Nepal (MSD *Karnali*, 2019; GON *et al.*, 2018).<sup>30</sup> While concerns were expressed on province 6 in some of the earlier studies, there has been limited attention to its transformation from one of the most food-secure to the most insecure region within a decade. Thus, these results provide how many and where, in the provinces, do the food insecure household reside in Nepal.

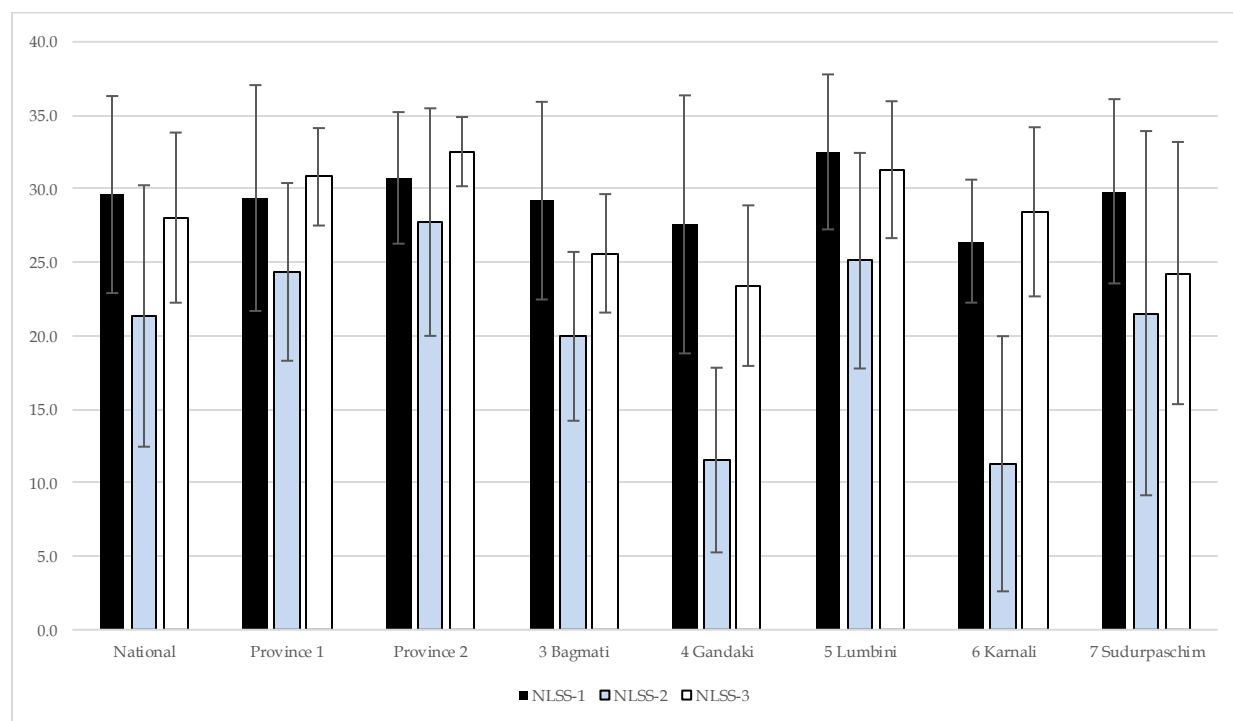


Figure 9: Food Insecurity at the National and Provincial Levels (1995-2011)

Likewise, figure 9 illustrates the pattern of food insecurity at the national level. As in table 4, PoU is decreasing from 1995 to 2003 (29.6% to 21.3%) and increasing in 2011 (28%). Out of total 3361 households (274 PSUs) that participated in NLSS-1, 995 households were undernourished (equivalent to 6.4 million Nepalese population in 1995). Similarly, among 3898

<sup>30</sup> Along with high food insecurity, 55% child stunting (provinces 4 and 3 have 29% stunting), 36% child underweight, 10% women and 6% men were obese (39% women and 29% men in wealthiest household were obese) (MSD *Karnali*, 2019; GON, WFP and FAO, 2018).

and 5963 sample households (326 and 499 PSUs) in NLSS-2 and NLSS-3, 830 and 1670 households were undernourished (equivalent to 5.4 million and 7.6 million in 2003 and 2011), respectively (figure 9; table 4). Though the relative food insecure population is lower (in 2011 compared to 1995 levels), the absolute number has increased by more than 1 million in 2011 compared to 1995 levels. This indicates the highest absolute prevalence in 2011 since the 1990s. To minimize such “hunger metrics mirage”, intra-country analysis accounting for population growth has been recommended (Pingali, 2016). The trend uncovered in this study points to an upward trend from 2003 to 2011, unlike the decline observed in estimates of FAO and IFPRI (figure 1).<sup>31</sup> Also, the GON reported higher estimates of food inadequacy in 1995 (50.9%) and 2003 (31.2%), respectively, but lower estimates in 2011 (15.7%) (NLSS, 2011b) relative to the results of this study. However, the GON estimates are derived from direct questioning rather than estimation of calorie consumption and requirement.<sup>32</sup> These regional and national findings can be attributed partly to the post-insurgency impact and the resulting instability in governing Nepal.<sup>33</sup> Albeit the country had achieved high agricultural production growth during 2003-2018, the unstable governance since 2006, i.e., 8 Prime Ministers between 2003-2011, continued

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<sup>31</sup> As a part of sensitivity analysis, comparison is done between the headcount approach and probabilistic approach (i.e. this study’s approach) – counting the head of undernourished people result higher estimates during 1995 and 2003, while lower estimation during 2011 which is consistent to government’s report.

<sup>32</sup> Question in Section-17 of NLSS survey was “Concerning your family’s food consumption over the past one month, food was ..... for your family needs. a) Less than adequate, b) Adequate c) More than adequate, d) N/A”

<sup>33</sup> Maoists started the struggle in 1995 from *Rukum* and *Rolpa* districts in province 5, and the people’s war lasted from 1996-2006 (peace treaty was done in 2006). Eleven years of political and civil unrest with huge loss of human lives and economic structures contributed negatively towards PoU with more post-war effects, given that conflicts, violence and government instability (changed in every 9-12 months after 2008) disrupt the supply chain, efficiency and production sector of an economy (FAO-WFP, 2007).

regional conflicts along the lines of the earlier insurgency, and natural disasters appear to have impacted regional food insecurity in Nepal.

#### ***6.4. Food Insecurity across Ecological Belts***

Nepal is categorized distinctly into three ecological belts. *Terai* is the plain in southern Nepal, ranging from 100 to 610 meters above sea level (masl). Hills ranges from 610 to 4800 masl, while mountains ranges from 4800-8839 masl. Even in the same province, the level of food insecurity may vary widely because of (latitudinal) topography in the case of Nepal. Likewise, natural resources, e.g., water, soil, are likely to exhibit significant heterogeneity within ecological belts. Though this difference may hinder the policy design, a belt-based approach has allowed to some extent of technological advances and other investments, especially in agriculture.

This section adds to the regional analysis and identifies which belt has the most food-insecure population. Results in figure 10 show the trend of PoU across these belts, and appendix 7 illustrates the belt-wise variation in PoU,  $\bar{X}$ , CV and MDER. Total households under the study are highest in hills, followed by *Terai* and mountains. Average  $\bar{X}$  is highest in mountains and lowest in *Terai* but CV is similar among the belts. Level of MDER is lowest in the mountain region, while highest in the hills. Thus, PoU is highest in *Terai*, followed by hills and mountains in all rounds of the survey.

*Terai*, plains of Nepal, is considered a food basket (IPC, 2014). Unfortunately, PoU is highest (33.5% in 1995, 26.8% in 2003 and 31.8% in 2011) in this belt (figure 10). The higher share of food insecure population in the *Terai*, in most of the provinces, can be attributed to the sources of food consumption. Results in table 5 provide insight into the share of food sources: home production, market purchases (local and distant) and other sources (aids, gifts, in-kind)

for 1995-2011. *Terai* region faced a huge drop in home production after 1995 while market purchase increased drastically. As the market developed, household reduced their reliance on household production which likely increased PoU in *Terai* (Pingali and Sunder, 2017). Despite the development of the market, given the higher vulnerability of *Terai* residents and lowest farm income, they appear unable to fulfill calorie requirements (see FAO, 2004; FAO-WFP, 2007). Similarly, the highest proportion of vulnerable marginal farm households residing in *Terai* have 1.7 times higher poverty incidence (and food insecurity) because of prominently lower assets, endowments and location-based inequalities.<sup>34</sup> *Terai* is more prone to external shocks, such as natural disasters, with the highest number of people at risk of nutritional deficiency relative to higher latitudes. For instance, food insecurity in *Terai* has been severely affected by the 2006 drought and floods (FAO-WFP, 2007). Also, note that most of the *Terai* region faces an annual flood, especially in province 2. It is likely that market purchases make these households vulnerable to price shocks (natural disasters and others), contributing to food insecurity.<sup>35</sup>

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<sup>34</sup> Total marginal farm households in *Terai*, mountains and hills are 48%, 45% and 35%, respectively (FAO, 2004). Note: Marginal farm households are houses with <0.5 ha of land including landless households and sharecroppers. Non-marginals are households with >1 ha of land.

Gini coefficient in 2011 is highest in hills (0.28) followed by *Terai* (0.21) and mountains (0.18) depicting the income inequality highest in hills (NDHS, 2012). Nonetheless present results exhibit status of calorie deficiency is highest in *Terai* relative to Hills and Mountains over time. It indicates that the determinants of food and non-food poverty are often different (Rawal *et al.*, 2019). However, mountain region's income equality was higher compared to other that may have some correlation with their lower levels of PoU.

<sup>35</sup> Despite agriculture being primary occupation, *Terai* is facing higher cost of production and low profit margin. Similarly, poor nutrition is evidenced by highest prevalence of stunting (51.1%) and anemia (51.1%) among children, and underweight (32.5%) and anemia (48.7%) is highest among women in 2011 in Province 2 (*Terai* region) while women underweight is lowest (7.8%) in Province 4 (hills and mountains) (Ghimire *et al.*, 2019).

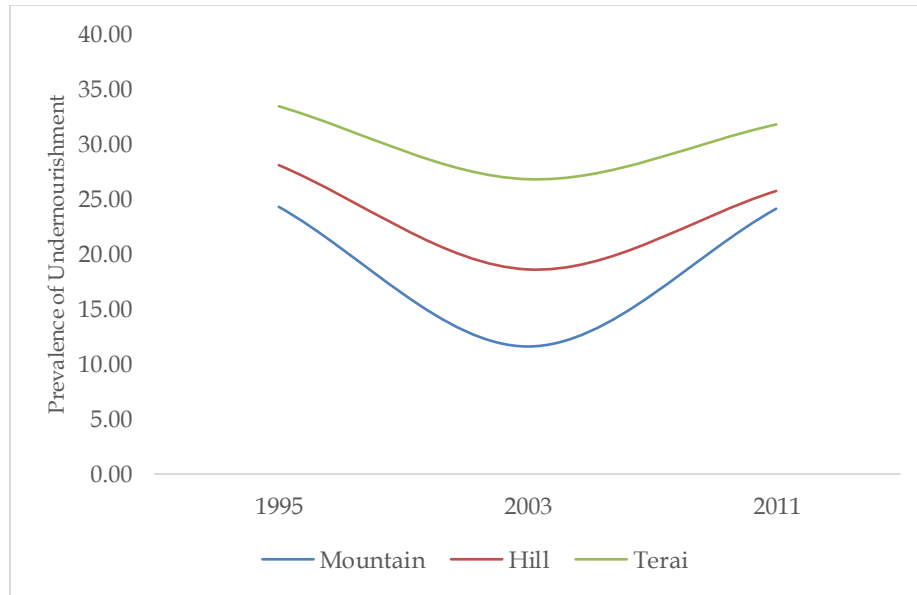


Figure 10: PoU distribution in ecological belts of Nepal (1995-2011)

Similarly, PoU is lower in mountains (24.3% in 1995, 11.6% in 2003 and 24.1% in 2011) followed by hills (28.1% in 1995, 18.6% in 2003 and 25.8% in 2011) – figure 10.<sup>36</sup> The higher food security in the mountain can be attributed to the highest share of household production and they primarily rely on agriculture and livestock (table 5).<sup>37</sup> Home production in the mountain remained higher still in 2003 and 2011, followed by hills. Similarly, in 1995, mountainous local-

<sup>36</sup> SAE project estimated 45%, 42% and 37% of PoU in mountain, hills and *Terai* during 2003, while the NLSS-2003 estimated 40%, 37% and 33%, respectively. Similarly, the SAE estimated child stunting of 61%, 52% and 47% in three respective geographical belts (CBS *et al.*, 2006).

<sup>37</sup> IFAD (2021) reports that subsistence farming is a very popular way of living in Nepal, and more than 80% of the total population in rural areas (highest in Mountains) depend on subsistence farming. Eighty-seven percent of Nepalese household rear livestock (IRIN, 2015). Livestock (especially, yak, nak, chauri, goats, chyangra) rearing is common and popular among mountain livelihoods.

In past, IPC (2014) analyzed 2005-2014 showing western and eastern mountains and western hills have severe chronic food insecurity with limited food availability, access, utilization and stability. And most of the *Terai* region is categorized as mild chronic regions explaining they have food availability but are affected by malnutrition.

market accessibility was also higher: 57.4% of food comes from a market that was not available in their home.

Likewise, strong social capital (food received from other sources) has contributed to the mountain region being more food secure over time. Out of total food consumption, 4.3%, 7.1% and 9.3% in 1995, 2003 and 2011 were received from some relatives or friends, aids or food receipts. Interaction in the community increases sharing of food and food-related information, which facilitates resilience (Nosratabadi *et al.*, 2020).<sup>38</sup> Thus ecological belt-based PoU comparison further provides a sharper picture of stratified regional food insecurity.

**Table 5: Share of food sources based on ecological belts (1995-2011)**

Year	Share of Food Source	Home Production	Market Purchase	Other (In-Kind, Gifts, Aid)
1995	<i>Terai</i>	68.3	27.9	3.8
	Hills	68.3	29.0	2.6
	Mountain	50.9	44.6	4.3
2003	<i>Terai</i>	22.6	72.7	4.6
	Hills	27.6	67.5	4.8
	Mountain	46.8	46.1	7.1
2011	<i>Terai</i>	18.6	77.5	3.9
	Hills	22.8	71.2	6.0
	Mountain	33.1	57.4	9.3

<sup>38</sup> Similarly, in less productive but subsistence agrosystem of mountains, production diversity (higher vegetables, poultry, cereals, goat and sheep) increases household dietary diversity thereby increasing balanced food intake and nourishment (Kant, 2004; Rah *et al.*, 2010; Jones *et al.*, 2014; Pellegrini and Tasciotti, 2014; Bhandari *et al.*, 2016).

### 6.5. Urban vs. Rural Food Insecurity

Globally, evidence on food insecurity suggests a rural-urban dichotomy (Babatunde and Qaim, 2010; Walsh and van Rooyen, 2014; Anand *et al.*, 2019). Inside each province, urban and rural areas are classified based on infrastructural development like roads, schools, health posts, and market access. Results in figure 11 and appendix 8 give an overview of urban and rural PoU across the province and national level (2003 and 2011).<sup>39</sup> This draws how these underlying sources of development shape regional food insecurity in Nepal.

At the national level (figure 11), urban PoU (21.3%) is almost equal to rural PoU (21.4%) in 2003, while rural PoU (28.6%) significantly overtook urban PoU (27%) in 2011. Similarly, results of the t-test at the PSU level for 2003 samples do not reject the null hypothesis of equality of means, but the 2011 sample does (appendix 8). That is, in each rural smallest division, food insecurity increased significantly in 2011. This estimation is consistent with FAO-WFP (2007) where urban and rural PoU was estimated to be 22.7% and 22.4%, respectively. Within all provinces, rural and urban PoU has increased from the reference period (2003). During 2003, urban PoU is consistently higher among most of the provinces except provinces 2 and 3. Despite having some major cities in provinces 1, 5 and 7, they had higher urban PoU in 2011. But, during 2011, provinces 2, 3, 4 and 6 have higher rural PoU.

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<sup>39</sup> Stratum for 1995 does not consist of rural and urban domains (see Chapter 5: NLSS survey's sampling procedure).

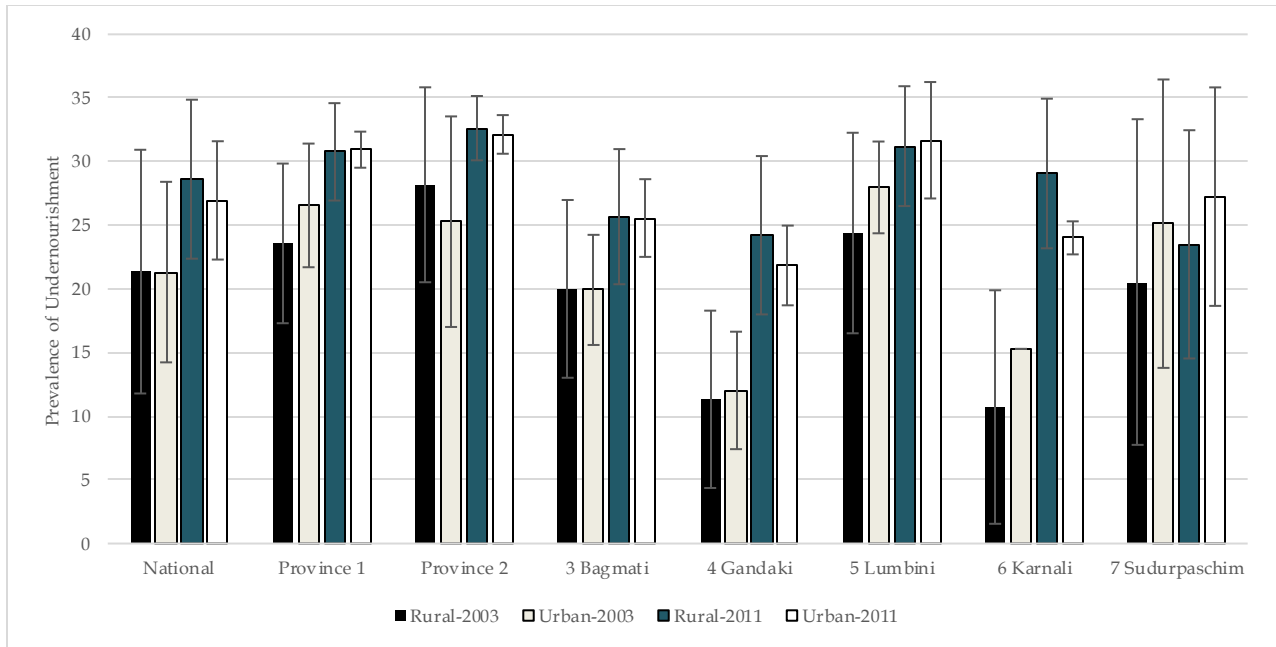


Figure 11: Rural vs. Urban PoU in provinces and national level (2003-2011)

### 6.6. Household Characteristics and Regional Food Insecurity

The third goal of this study is to examine household characteristics closely associated with the undernourishment status. Given the household level analysis in this study, this section attempts to point out characteristics commonly associated with falling into measured PoUs (Ritzema *et al.*, 2017; Pereira *et al.*, 2021). With information on the location of the vulnerable population, these results can further help in targeting assistance.

Table 6 shows the results of the household characteristics associated with PoU: household head's gender, household size, number of children, education, land holding, and primary occupation. Table 6 (row 1) shows how the pattern of PoU changed across provinces depending upon the household head's gender. It illustrates mixed result during 1995: most of the eastern provinces 1, 2, 3 (including 6 in western) has higher PoU in men-headed households

while western provinces (4, 5, 7) has higher PoU in women-headed households. The pattern shifted during 2003 and 2011. Men-headed households still have higher PoU in provinces 2, 3, 5 and 7 during 2003 but, in 2011, all the provinces with women-headed households have lower PoU. There were 13.4%, 19% and 26.47% sample households headed by women in 1995, 2003 and 2011 (most of the rural region has higher women-headed households except western provinces). Note that a household headed by a woman not only controls food-related behaviors, but also has a direct influence on every household activity.<sup>40</sup> Past results in a global context are mixed – suggesting higher or lower food insecurity in women-headed households (Negesse *et al.*, 2020). Consistent with this study, IFPRI’s report by Quisumbing *et al.* (1995) highlighted the key role of women in strengthening food security when faced with socioeconomic constraints.

Row 2 of table 6 shows how the household size impacts PoU across provinces in Nepal. The category is based on average Nepalese household size, i.e., 4.88 – “less than average”, “near average or medium-sized household” and “very large household” (NLSS, 2011b). All else constant, higher the household size, the higher is PoU. A simple regression of PoU coefficients on household size dummies shows that the slope increased with the household size, with a threshold at around medium-sized households.<sup>41</sup> Findings in the past were mixed in Nepal –

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<sup>40</sup> Most of the households and kitchen works are controlled by women in context of Nepal. This is because of substantial gender disparity in Nepal (country ranks 119 out of 175 countries in Gender-Related Development Index (GDI)-2003).

Note: “GDI is a composite index measuring average achievement in the three basic dimensions captured in the human development index – a long and healthy life, knowledge and a decent standard of living – adjusted to account for inequalities between men and women” (FAO, 2004).

<sup>41</sup> Regression coefficients: Less than average household size has 7.9% lower PoU and medium size household has 6% lower PoU relative to very large household size ( $R^2 = 0.53$  and  $N=62$  with significant ‘year’ fixed effect).

food security was found to decrease or increase with household size when assessed with HFIAS and HDDS indicators (Pandey and Bardsley, 2019; Kumar *et al.*, 2020).

Households with children (average 2 children per family) are classified into “below” and “above” average classes and compared with “households with no children” in table 6 (row 3). The observed pattern is consistent – during 1995, 2003 and 2011, households with more than 2 children have high PoU compared to households with less than 2 children (except in provinces 3 and 5). Higher number of children in the household places higher demand for food resources and management. All else constant, children residing with more than 2 siblings are more likely to be undernourished because accessed food has to be distributed among them. Those households without children have mixed patterns, i.e., higher PoU in all provinces except 1 in 1995 and 2003; and lower PoU in all provinces except 7 in 2011, indicating that PoU across households without children are normally lower during 2011.

Education is one of the primary components to alleviate food and non-food poverty. Row 4 in table 6 shows how the number of years of schooling is affecting the level of PoU across provinces. Based on a complete set of data available, only 2011 has been considered. The households are classified to “no formal education”, “near average (3 years)”, “above 4 to 10 years” and “above 10 years” of schooling.<sup>42</sup> As expected, households with lower schooling than average were found to be highly food insecure than households with educated members, with province 5 being an exception. The general result implies that a certain level of formal education above average is important for lowering household food insecurity. Findings by Pandey and Fisaro (2020) suggest that households with women who have obtained secondary education aid

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<sup>42</sup> Average years of schooling in mountain, hills and *Terai* are 2.2, 3.5 and 3.3 years (DHS, 2011). Considering all, this study adopted 3 years as average for classification.

a household from turning food secure. Results consistent with this study are also observed by GON and other studies (MOHP-Nepal *et al.*, 2018; SOFI, 2019; Nepali *et al.*, 2020; Kumar *et al.*, 2020).

Nepal is an agrarian society with an average landholding of 0.5 hectares (ha). Based on the average landholdings, households are classified into a household with “no land”, “land below average” and “land above average” (NLSS, 2011b; GHI, 2020). The results in row 5 of table 6 show whether households with more land or limited land have relatively higher PoU across provinces. Households with no land have more food insecurity in 1995 (primarily food comes from their land) compared to 2003 and 2011. There is not much difference in PoU between households with land less than 0.5 ha and more than 0.5 ha (except province 6). In 2011, households with more than average land are more food insecure than those with no land; however, the relationship is mixed. It is likely that lower productivity of land and unused land in the rural region (especially due to migration) are contributing to higher PoU among them. Note that “no land” households especially work as agricultural labor or for sharecropping. Provinces 1, 2, 3, 4 and 6 have noted lower PoU in households owning less than average land during 1995 and 2003; province 5 and 7 reported increasing PoU with land ownership. In general, households with near average land are more food secure, which can be attributed to subsistence farming in the Nepalese community.

Table 6 (row 6) explains if the household occupation is contributing primarily to food insecurity. Though Nepalese households are farm-based, provinces 2 and 5 have higher PoU in households involved in agriculture only. This is likely due to lower productivity, disasters, lack of input and markets, and lower agricultural profit margin (Belbase *et al.*, 1985; Katovich and

Sharma, 2014; GHI, 2020).<sup>43</sup> Non-agricultural households, involved in off-farm labor or other services, have higher food insecurity (except in provinces 5 and 7) during 1995. Household involved in both agricultural and non-agricultural occupation has relatively lower PoU than ones involved in either one; however, this difference is insignificant. Similarly, Gartaula *et al.* (2017) have found that though three-fifth of the sample population reported they are involved in agriculture only, the non-agricultural occupations are becoming increasingly important because households with more than one occupation have a better livelihood in Nepal.

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<sup>43</sup> A survey conducted by USAID KISAN in Province 5 and 6 (*Terai* and Hills of mid-west) showed a profit of USD 47.3 and 46.8 per ha for maize and rice, respectively. In the *Dang* (province 5) of Terai, farmers were facing a loss of USD 425 per ha in rice production (major staple crop) (Katovich and Sharma, 2014). Also, Nepalese farmers intensively rely on traditional farming practices that ended up with a marginal product of input like fertilizer and bullock is nearly equal to zero, and sometimes negative in the case of labor (Belbase *et al.*, 1985).

**Table 6: Household Characteristics of PoU across provinces**

		Province 1			Province 2			3 Bagmati			4 Gandaki			5 Lumbini			6 Karnali			7 Sudurpaschim		
		1995	2003	2011	1995	2003	2011	1995	2003	2011	1995	2003	2011	1995	2003	2011	1995	2003	2011	1995	2003	2011
<b>Gender of household head</b>	Women	29.3	25.1	28.9	31.4	25.5	31.0	30.7	19.7	22.9	30.1	11.2	20.2	32.6	22.6	30.4	26.3	10.3	28.7	30.2	20.4	22.9
	Men	31.0	24.5	30.2	31.4	28.6	31.9	30.8	20.0	24.6	28.7	10.6	23.6	31.1	26.9	32.0	28.6	9.7	29.0	29.8	21.2	25.4
<b>Household size (Avg: 4.88)</b>	Less than average	30.3	24.0	29.1	30.9	26.9	31.0	30.5	19.1	23.4	28.7	9.7	21.1	32.6	24.5	30.8	23.7	9.5	27.9	29.6	19.1	23.8
	Medium	28.4	25.3	31.8	31.7	28.4	32.5	30.9	21.0	27.1	30.8	13.1	25.9	32.1	26.6	32.8	28.9	9.6	29.9	30.3	22.0	25.6
	Very Large	33.6	32.9		32.8	37.1	35.0	36.7	28.5	30.9	30.7	21.9	36.9	33.5	36.4	34.2	39.8	23.5	36.6	32.5	34.1	29.4
<b>Total Children in household (Ave: 2)</b>	Above Average	33.3	22.6	35.2	30.6	29.3	34.9	24.9	19.8	29.1	33.3	14.9	26.3	29.4	30.9	32.4	27.8	19.3	34.6	32.5	26.6	20.1
	Below Average	27.8	24.3	30.3	30.6	27.4	32.3	29.8	19.6	24.3	29.4	11.3	23.1	33.0	25.0	32.0	26.1	9.8	28.7	29.0	20.4	23.3
	No Children	30.5	25.0	29.6	32.2	29.0	31.1	31.3	20.2	24.2	29.9	10.3	22.0	31.9	25.9	31.2	27.4	8.9	28.8	31.3	20.8	25.5
<b>Formal Education (years of schooling)</b>	No Formal Education			30.7			31.4			24.0			23.3		30.5			29.2			22.5	
	Near Average (3 yrs)			31.4			33.1			25.7			23.0		29.9			25.6			26.0	
	Above 4 to 10			29.7			32.0			24.6			22.6		31.9			29.5			26.3	
	Above 10			27.7			30.5			23.3			19.5		33.5			27.1			23.6	
<b>Land holding (Avg: 0.5 ha)</b>	No Land	35.9	23.5	30.7	32.4	30.6	29.7	32.4	20.5	23.8	31.0	9.7	20.9	30.8	23.2	34.6	36.4	10.8	28.7	27.0	14.2	26.5
	Less than average	26.3	27.2	29.2	30.8	26.5	33.0	30.0	18.0	24.7	29.1	17.5	22.7	32.6	27.6	29.9	22.6	5.6	29.0	30.3	29.2	24.3
	More than Average	27.9	26.7	29.9	31.1	26.9	32.2	29.2	16.3	24.6	30.0	16.3	22.9	32.7	29.5	31.9	28.6	10.4	28.8	30.2	33.2	24.3
<b>Occupation</b>	Ag Only	28.1	24.6	28.8	30.6	38.1	32.3	30.4	20.1	25.1	30.6	9.0	21.8	32.3	37.5	30.3	25.9		27.4	30.9		24.0
	Non-Ag Only	36.2	24.4	30.1	34.6	26.7	28.2	32.4	20.7	23.7	30.7	11.2	21.3	28.9	24.2	35.6	37.1	10.8	29.1	29.2	21.0	28.2
	Both Ag and Non-Ag	29.7	24.8	30.6	31.6	28.7	33.1	29.4	19.5	25.0	28.2	10.6	23.8	32.9	27.0	30.7	25.7	8.8	29.2	29.5	21.0	24.2

## 6.7. Mapping of Regional Food Insecurity

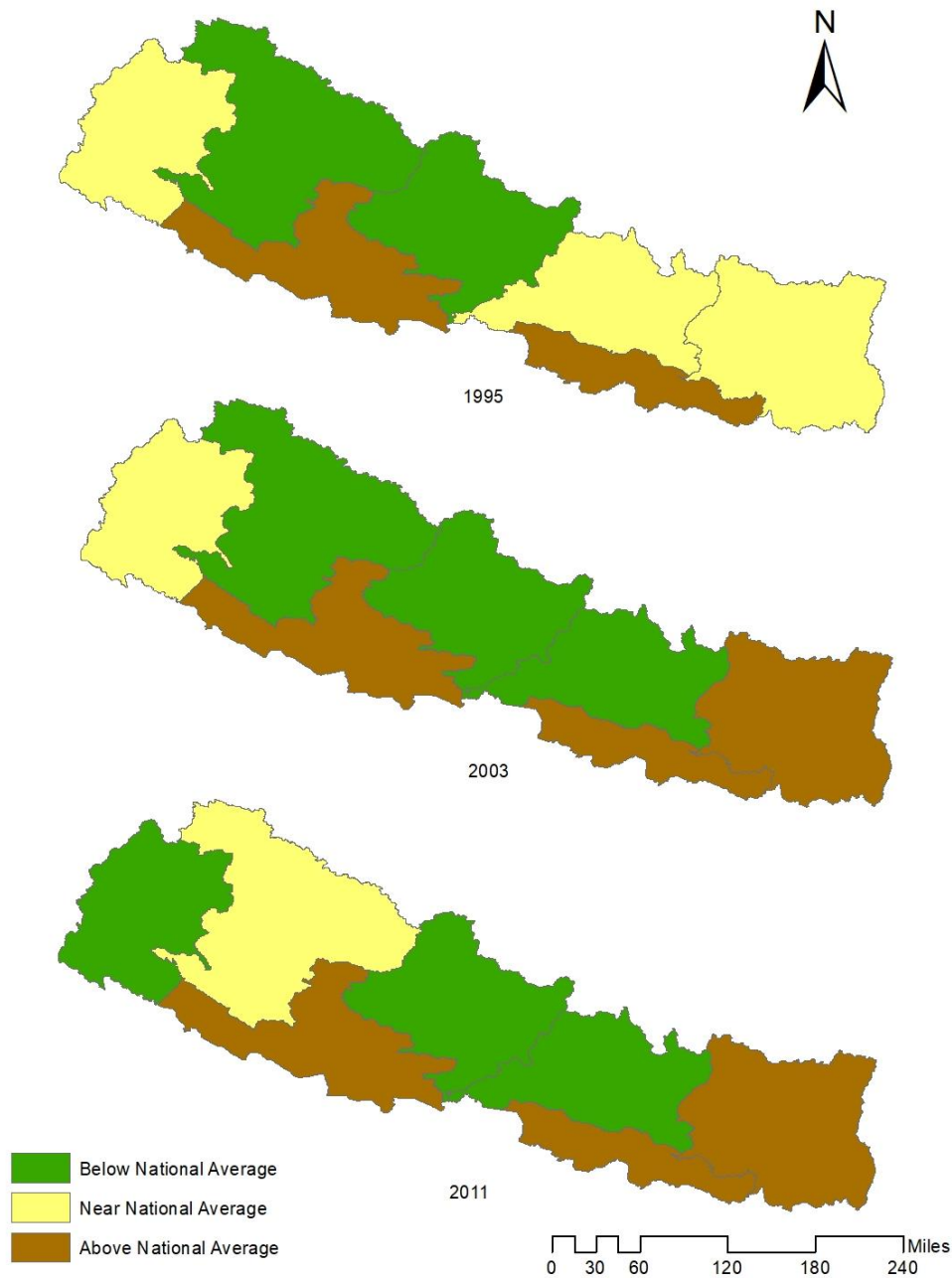


Figure 12: Map of provincial food insecurity in Nepal (1995-2011): While province 4 constantly maintained a food security level below the national average, the status of other provinces has moved both ways: increase or decrease in PoU levels. Provinces 1 and 6's food insecurity deteriorated over time. Provinces 2 and 5 have been constantly above the national average with the highest vulnerability. Likewise, provinces 3 and 7 progressed to below the national average over time.

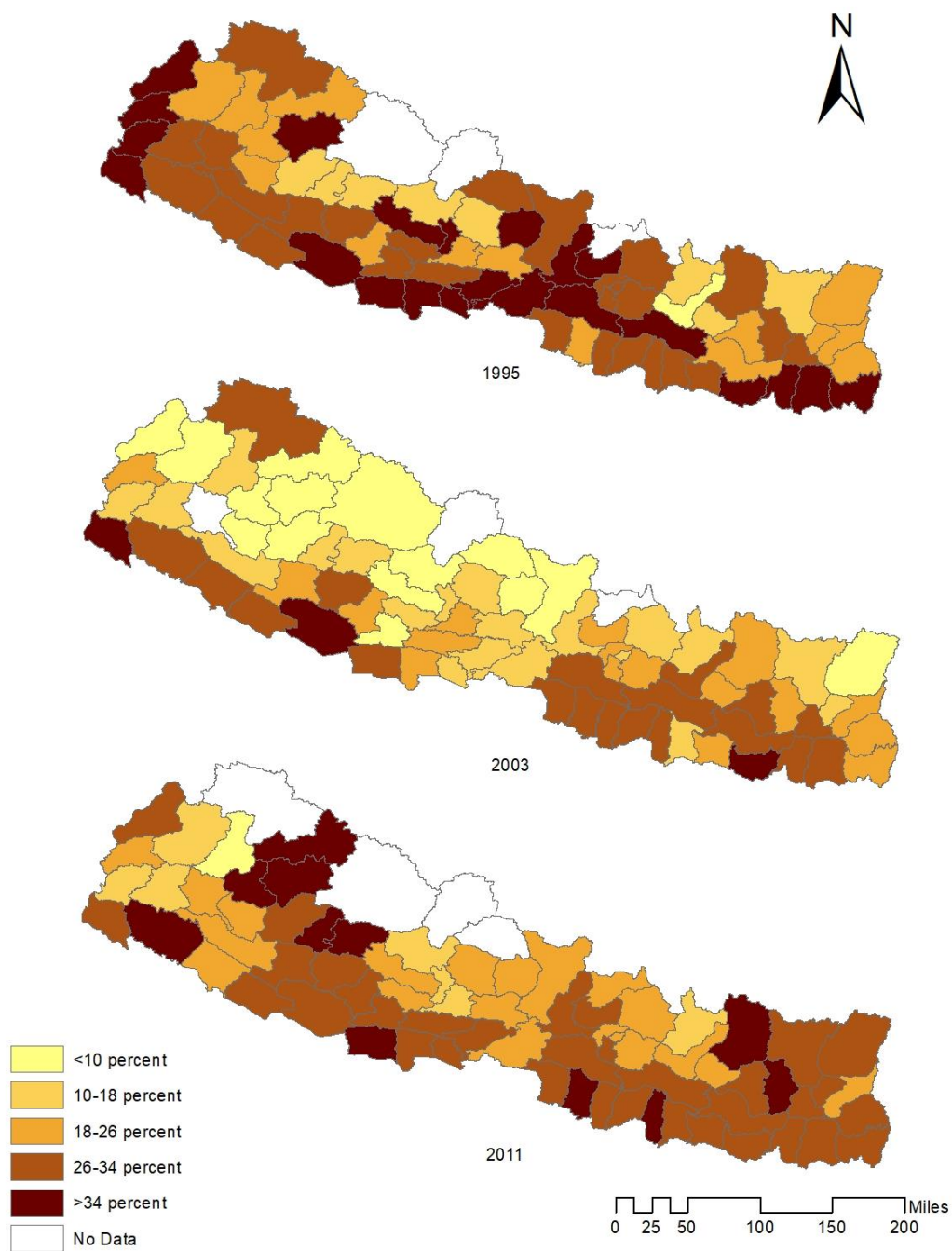


Figure 13: Map of district-level food insecurity in Nepal (1995-2011): Most of the districts in the plain agroecology (*Terai*) have progressed (reduced food insecurity) during 2003; however, relative share of PoU increased in 2011. Overall regional food insecurity at the district level is consistently poor over time.

Taken together, estimation of the food insecurity within Nepal – PSU level aggregated at district, provinces, ecological belts and urban/rural regions – helps understand the substantial variation across levels and trends in food insecurity. The observed level of food insecurity in Nepal has fluctuated between 1995 to 2011 – decreasing substantially between 1995 and 2003, but increased significantly between 2003 and 2011. Earlier studies pointed to either a declining trend (figure 1), but this study indicates that political instability, post-insurgency conflicts and natural disasters since 2003 may have contributed to this mixed (upward and then downward) trend in Nepal’s PoU.

There was large heterogeneity in PoU estimates across districts and provinces. Province 4 achieved higher progress in reducing food insecurity during 2003, but its PoU doubled in 2011 (as in province 6). Mostly western provinces (5, 6 and 7) along with province 2 faced the highest fluctuations in underlying energy consumption and requirement parameters; thus, can be referred to as highly vulnerable. Provinces 2 and 5 held a share of food insecure populations above the national average throughout the three decades. Similarly, the *Terai* region is found to be highly food insecure, and a stronger upward trend in PoU is observed in rural areas. Despite increasing agricultural production nationally, household production and subsistence agriculture appear to be shaping food accessibility across regions. Regional analysis suggests that increased market purchases with lower social capital seem to raise the vulnerability of households to price shocks and, thus, increase food insecurity.

The characterization of PoU pointed out that households headed by men, with a larger size and more children than average, with lower formal education, with zero or unused land ownership and relying on only one occupation tend to have higher food insecurity across all provinces. These characteristics, together with the above regional PoU estimates, should help

assistance programs better target aid to the vulnerable population. More recent data, after 2011, can aid in additional analysis to update the locational and household characteristics for identifying the food insecure population and achieving food availability and access (two of the four major pillars of food security).

## CHAPTER 7

### SUMMARY AND CONCLUSIONS

Efforts to identify and quantify populations with inadequate access to food across countries have aided the work of agencies – domestic and international – tasked with ensuring food security. However, wide variations in estimates of the prevalence of undernourishment, i.e., PoU by major agencies – FAO, IFPPRI, UNDP, USDA – calls for a more comprehensive and sub-national assessment that can answer where, how many and who, within the country, are food insecure? This study, hence, examines the intra-country variation in food security patterns and associated characteristics for three decades for Nepal.

Focusing first on the “where and how many” question, the PoU is estimated across regions using the FAO’s methodology in combination with NLSS household data from 1995, 2003 and 2011. The computation of habitual energy consumption and requirement at the primary sampling unit (PSU) captures the regional variation of PoU in 77 districts, 7 provinces as well as at the national level. The micro-level findings are aggregated and compared across districts, provinces, ecological belts, and urban and rural domains. This study accounts for physical activity level (PAL), demographics and population growth in computing core parameters –  $\bar{X}$ , CV and MDER – weighted at the PSU level. Likewise, addressing a variety of measurement issues – household-level consumption and calorie requirement for adult equivalents with the inclusion of conversion factors, standardized units, correction of error factors and accounting for non-edible portions for household production, market purchases, other sources (aid, in-kind, other receipts) and meals eaten away from home – helps with data consistency and accuracy of the PoU estimates.

Nepal's PoU estimate has fluctuated between 1995 and 2011 – decreasing substantially between 1995 and 2003, but increasing significantly between 2003 and 2011. This trend observed using household data differs from earlier studies, including FAO. Potential factors impacting this trend are political instability, post-insurgency conflicts and natural disasters since 2003.

This study identified substantial heterogeneity in PoU estimates across districts and provinces. Provinces 2 and 5 – the most vulnerable – held a share of the food insecure population above the national average throughout the three decades. Province 4 achieved higher progress in reducing food insecurity during 2003, but its PoU doubled in 2011 (as in province 6). In addition, western provinces showed the highest fluctuation in underlying energy consumption and requirement parameters; thus, can also be referred to as vulnerable. Similarly, the *Terai* region is found to be highly food insecure, and a stronger upward trend in PoU is observed in rural areas across all provinces. Despite increasing agricultural production nationally, household production and subsistence agriculture appear to be shaping food accessibility across regions. Regional analysis suggests that increased market purchases with lower social capital seem to raise the vulnerability of households to price shocks and, thus, increase food insecurity. Those residing on mountain and hill regions or relying on household production appear insulated to the substantial shocks to the economy during 2003-2011, and thus seem less vulnerable to inadequate food availability.

Focusing on household characteristics, this study found that households – headed by men, with a larger size and more children than average, with lower formal education, with zero or unused land ownership, and relying on only one occupation – tend to have higher food insecurity across all provinces.

Despite technological advances, sub-national heterogeneity in food security exists globally, as in Nepal. In this context, regional assessment, using alternative measures, can aid in policy design and delivery of assistance to alleviate food insecurity. This study has examined where, how many, and who are food-insecure within Nepal to provide a more accurate picture of the prevalence of undernourishment for improving the livelihood of its citizens.

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## APPENDICES

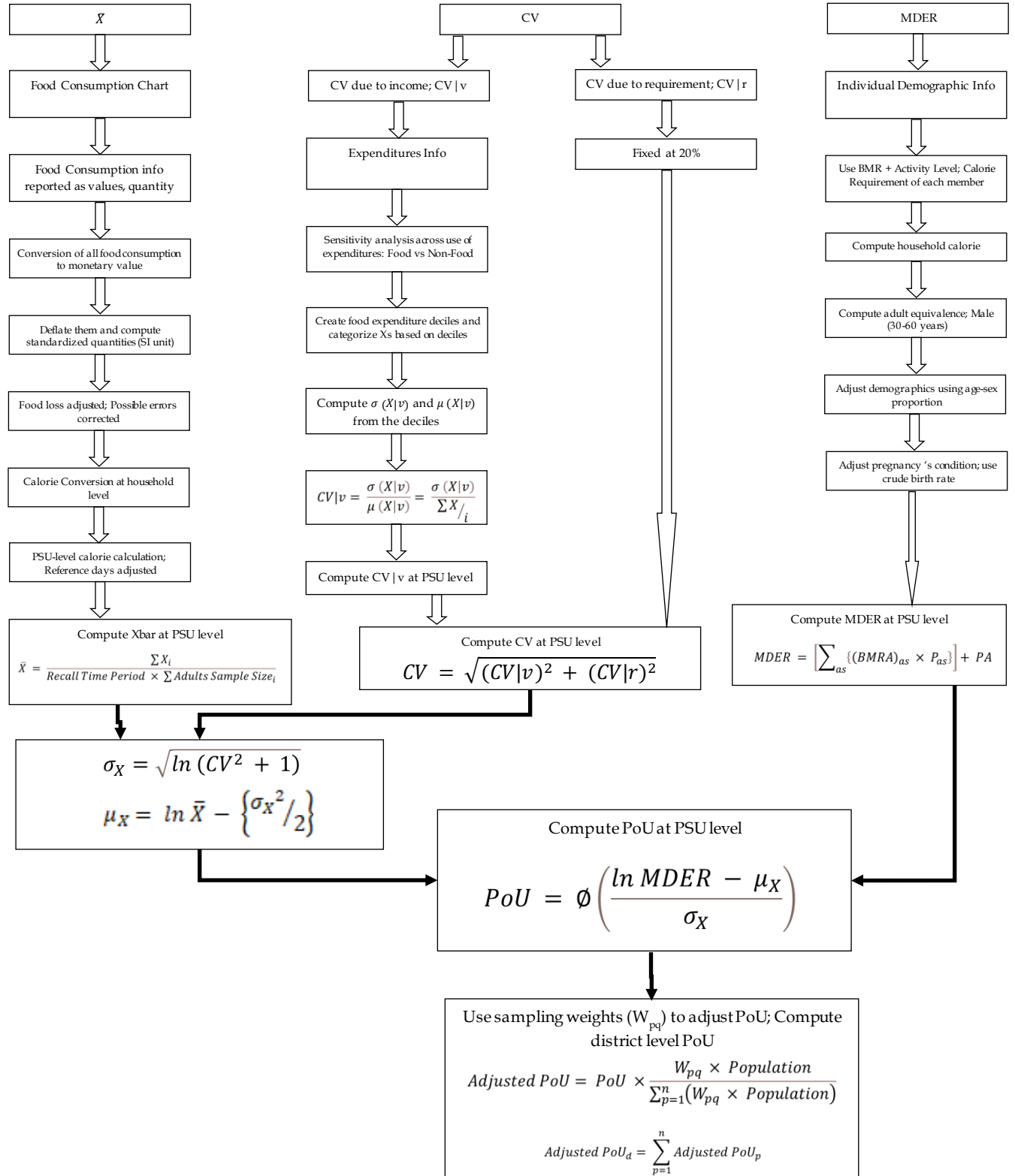
### Appendix 1: Provinces and Districts of Nepal with number of PSUs selected in each survey

	Province 1	Province 2	Province 3 BAGMATI	Province 4 GANDAKI	Province 5 LUMBINI	Province 6 KARNALI	Province 7 SUDURPASCHIM
<b>MOUNTAINS</b>	1 Taplejung		22 Dolakha	41 Manang		62 Dolpa	67 Bajura
	9 Sankhuwasabha		23 Sindhupalchowk	42 Mustang		63 Jumla	68 Bajhang
	11 Solukhumbu		29 Rasuwa			64 Kalikot	75 Darchula
						65 Mugu	
						66 Humla	
<b>HILLS</b>	2 Panchthar		20 Sindhuli	36 Ghorkha	46 Gulmi	55 Salyan	69 Aacham
	3 Ilam		21 Ramechhap	37 Lamgunj	47 Palpa	59 Surkhet	70 Doti
	7 Dhankuta		24 Kavrepalanchowk	38 Tanahun	51 Arghakhanchi	60 Dailekh	73 Dadeldhura
	8 Tehrathum		25 Lalitpur	39 Syangja	52 Pyuthan	61 Jajarkot	74 Baitadi
	10 Bhojpur		26 Bhaktapur	40 Kaski	53 Rolpa		
	12 Okhaldhunga		27 Kathmandu	43 Myagdi	54a East Rukum		
	13 Khotang		28 Nuwakot	44 Parbat	54b West Rukum		
	14 Udayapur		30 Dhading	45 Baglung			
		31 Makawanpur					
<b>TERAI</b>	4 Jhapa	15 Saptari	35 Chitwan	48a East Nawalparasi	49 Rupandehi		71 Kailali
	5 Morang	16 Siraha			50 Kapilbastu		72 Kanchanpur
	6 Sunsari	17 Dhanusha		48b West Nawalparasi	56 Dang		
		18 Mahottari			57 Banke		
		19 Sarlahi			58 Bardiya		
		32 Rautahat					
		33 Bara					
	34 Parsa						
<b>PSUs</b>							
1995	49	43	78	33	35	14	22
2003	62	52	86	42	45	16	23
2011	88	64	144	59	76	24	44

## Appendix 2: Food items and calories

Food ID	Food Items	Calorie per gram	Source	Food ID	Food Items	Calorie per gram	Source
11	Fine rice	3.49	CBS	63	Mangoes	0.74	CBS
12	Coarse rice	3.46	CBS	64	Apples	0.59	CBS
13	Beaten, flattened rice	3.46	CBS	65	Pineapple	0.46	CBS
14	Maize	3.42	CBS	66	Papaya	0.35	CBS
15	Maize flour	3.42	CBS	67	Other fruits	0.63	Average of fruits
16	Wheat flour	3.41	CBS	68	Dried fruits	5.53	USDA
17	Millet	3.31	CBS	71	Fish	0.97	CBS
18	Other grains/cereals	3.54	USDA	72	Mutton	1.94	CBS
21	Black Pulse	3.47	CBS	73	Buffalo	0.86	CBS
22	Masoor	3.43	CBS	74	Chicken	1.09	CBS
23	Rahar	3.35	CBS	75	Other meats (boar, duck, etc.)	3.37	USDA
24	Gram	3.6	CBS	81	Salt	0	CBS
25	Other pulses	3.53	USDA, Lentils	82	Cumin seed/black pepper	4.2	Fitbit
26	Other beans	3.47	USDA	83	Turmeric	3.53	Fitbit
27	Other beans	3.47	USDA	84	Ginger and garlic	2.345	Fitbit & USDA
31	Eggs	1.73	CBS	85	Chilies	0.4	Fitbit
32	Milk	0.67	CBS	86	Other spices and condiments	1.03	Fitbit
33	Condensed milk	3.21	USDA	90	Sweets and Confections	3.19	CBS
34	Baby milk/powder milk	4.96	CBS	91	Sugar	3.98	CBS
35	Curd	0.6	CBS	92	Gur	3.98	CBS
36	Other milk products	3.21	Fitbit	93	Sweets (mithai)	3.19	CBS
41	Ghee	9	CBS	94	Sugar candy, chocolate, etc.	5.35	USDA, Milk Chocolate
42	Vegetable oil	9	CBS	101	Tea	0	CBS
43	Mustard oil	9	CBS	102	Coffee	0	CBS
44	Other oil	8.84	USDA	103	Carbonated drinks, fruit juices	0.39	Coca Cola Inc.
51	Potatoes/pindaaloo	0.97	CBS	104	Other non-alcoholic drinks	0.54	USDA
52	Onions	0.5	CBS	111	Wine	0.85	USDA
53	Cauliflowers/cabbage	0.3	CBS	112	Gin, whiskey	2.5	USDA
54	Tomatoes	0.23	CBS	113	Beer/jandh	0.43	USDA
55	Green leafy vegetables	0.23	USDA	114	Other alcoholic drinks	0.43	USDA
56	Other vegetables	1.18	Peas, USDA	121	Cigarettes	-12.5	WebMD
57	Bitter gourd	0.19	My Fitness Nepal	122	Bidis	-12.5	WebMD
58	Other vegetables	1.18	Peas, USDA	123	Tobacco	0	My Fitnesspal
59	Colocassia	1.52	My Fitnesspal	124	Other (Jarda, khaini, betel nut)	1	My Fitnesspal
61	Bananas	1.16	CBS	131	Meals taken outside home	2.89	Fitbit, Samosa
62	Citrus fruits (oranges etc.)	0.48	CBS	132	Misc. other food expenditures	2.65	USDA, Bread

### Appendix 3: Flowchart of Steps



## Appendix 4: Methodological demonstration and calculation of PoU for one PSU of Kathmandu (Capital) district, 1995

Please note this example has been described in same pattern as methodology and data.

### Household Energy Consumption:

- a) Minimum Dietary Energy Consumption: From the survey, food consumption data is listed (72 food types) in following format:

Monthly Food Consumption Chart												
HH ID	Food	Home Production		Market Purchase		Food in Kind/Aid/Gift Price (NRs)	Total Price (NRs)	Price per kg (NRs)*	Total grams	Calorie per gram	Total Calorie from Food	Household Calorie
		Weight (kg)	Price (NRs)	Weight (kg)	Price (NRs)							
908	Rice	4.25	55#	8	104	-	159	13	12230.8	3.49	42685.4	
908	Orange		35	5	62.05	25	122.05	12.41	9834.8	0.48	4720.7	
908	Meals Away from home	-	-		200	-	200	38.08	5252.1	2.89	15178.6	489683
908	...										...	
909	...											
909	...											
909	...											

\* Price is inflation adjusted.

# Calculated from reported weights.

Note: Edible coefficients are used to adjust food loss.

Household Calories are reported in monthly basis. Considering an adult to be 30-60 year-old-male, 2900 kilocalories per capita per day has been used for their requirement (for an adult for moderate PAL). This generates total adults in each household. This will then be calculated for each PSU ( $p$ ) as:

HH ID	Household Calorie	Total Adults**	Recall Period
908	489683	6.95	
909	...	...	
910	333441.6	3.31	30 days
920	...	...	
Sum	$1.31 \times 10^8$ kcal	1308.41	

\*\* Total Adults are used from computation in Energy Requirement section

Finally,

$$\bar{X}_p = \frac{\sum X_i}{\text{Recall Time Period} \times \sum \text{Adults Sample Size}_i}$$

$$\bar{X}_p = \frac{1.31 \times 10^8}{30 \times 1308.41} = 3337.38 \text{ kcal per capita per day}$$

b) Coefficient of Variation:

i) CV due to expenditure variation ( $v$ )

Deciles based on Annual Food Expenses	$X v$ (kcal)	Total Households in each decile ( $j$ )
1	3144.89	34
...		
4	3305.05	33
...		
10	5187.19	10
$\mu(X)$	3664.62	

$$CV|v = \frac{\sigma(X|v)}{\mu(X)} = \frac{564.09}{3664.62} = 0.15$$

Assuming  $CV|r = 0.20$

$$CV_p = \sqrt{(0.15)^2 + (0.20)^2} = 0.25$$

### ***Household Calorie Requirement***

From the individual members information, for each household, the total calorie requirement and adults equivalents has been generated.

HH ID	Member ID	Age (a), years	Sex (s)	BMRA <sub>as</sub>	P <sub>as</sub>	Household Energy	Adults
908	1	40	Male	2900	0.0054		
908	2	22	Female	2100	0.0108		
908	3	76	Female	1950	0.0018	20170	6.95
908	...	...	...	...	...		
908	9	0 (or <1)	Male	820	0.0060		
909							
909							

$$Total\ Adults_i = \frac{\sum_{as} BMRA_{as}}{2900}$$

And,

$$MDER_d = \left[ \sum_{as} \{BMRA_{as} \times P_{as}\} \right] + PA$$

$$MDER_d = \left[ \sum_{as} \{2900 \times 0.0054\} \right] + \frac{35.95 \times 210}{1000}$$

$MDER_d = 2302.35$  kcal per capita per day

### ***Prevalence of Undernourishment***

Using equations (2), (3) and (4), POU is calculated as follows:

$$\sigma_{xp} = \sqrt{\ln (CV_p^2 + 1)} = \sqrt{\ln (0.25^2 + 1)} = \sqrt{\ln 1.0625} = 0.248$$

$$\mu_{xp} = \ln \bar{X}_p - \left\{ \frac{\sigma_{xp}^2}{2} \right\} = \ln 3337.38 - \left\{ \frac{0.248^2}{2} \right\} = 8.082$$

$$POU_p = \Phi \left( \frac{\ln MDER_d - \mu_{xp}}{\sigma_{xp}} \right) = \Phi \left( \frac{\ln 2302.35 - 8.082}{0.248} \right) = \Phi(-1.371) = 0.0852$$

Finally, this POU is adjusted using weights at PSU level before aggregation.

$$Adjusted\ PoU_p = PoU_p \times \frac{W_{pq} \times Population_p}{\sum_{p=1}^{60} (W_{pq} \times Population_p)} = 0.0852 \times \frac{1145.25 \times 12}{5754043} = 0.000203$$

$$Adjusted\ PoU_d = \sum_{p=1}^{28} Adjusted\ PoU_p = 0.2648$$

Adding 28 PSU's Adjusted PoU values, PoU of Kathmandu is 26.5% during 1995.

**Appendix 5: Methodological and data sources comparison: FAO's original approach and this study's approach**

<b>Parameters</b>	<b>Original FAO Approach</b>	<b>This study's Approach</b>
<i>Energy Supply/Consumption</i>	<i>Food Availability</i>	<i>Food Accessibility</i>
$\bar{X}$	Supply: FBS before 2008; projected from 2005 consumption surveys But suggests using household survey data.	NLSS Household Survey - Food Consumption, Section 5
CV v	Projected starting from 2015 or from the date of the last available food consumption survey; ideally should come from household surveys	NLSS Household Survey – Food and Non-Food Expenditures, Section 5 and 6
CV r	0.20 (FAO, 2008); projected based on population surveys in SOFI (2020); MDER and Average Dietary Energy Requirements (ADER) calculation proposed	0.20 (fixed component)
Skewness	Exception: three-parameter skew-normal or skew-lognormal distribution is considered (SOFI, 2019)	Not used
<i>Energy Requirement</i>	<i>Anthropometric</i>	<i>Anthropometric</i>
MDER	Projected based on population surveys; reference body weight from WHO BMI Tables	NLSS Household Survey – Member Information, Section 1; and, BMR with moderate PAL requirement data from IFPRI

## Appendix 6: Regional undernourishment (percentage) for 77 districts of Nepal (1995-2011)

Code	District	Province	NLSS-1	NLSS-2	NLSS-3	Code	District	Province	NLSS-1	NLSS-2	NLSS-3
1	Taplejung	1	24.8	<10	30.3	39	Syangja	4	25.6	21.1	17.0
2	Panchthar	1	21.8	20.2	24.5	40	Kaski	4	16.7	10.5	21.2
3	Illam	1	24.3	20.5	30.9	41	Manang	4	28.8	<10	
4	Jhapa	1	36.6	22.9	29.9	42	Mustang	4			
5	Morang	1	37.2	28.8	32.7	43	Myagdi	4	16.5	<10	16.3
6	Sunsari	1	36.4	28.7	31.0	44	Parbat	4	36.3	17.0	14.4
7	Dhankuta	1	31.8	28.4	31.5	45	Baglung	4	37.4	<10	23.4
8	Tehrathum	1	18.1	16.0	29.5	46	Gulmi	5	31.2	15.7	25.9
9	Sankhuwasabha	1	14.1	13.4	28.3	47	Palpa	5	31.2	23.8	33.3
10	Bhojpur	1	29.6	23.6	38.2	48 a,b	Nawalparasi	4	37.1	16.3	32.7
11	Solukhumbu	1	26.8	18.0	39.3	49	Rupandehi	5	37.0	25.1	32.9
12	Okhaldhunga	1	17.6	23.9	21.5	50	Kapilbastu	5	36.7	31.5	36.8
13	Khotang	1	24.1	28.7	29.6	51	Arghakhanchi	5	33.5	<10	26.7
14	Udayapur	1	25.5	32.2	30.1	52	Pyuthan	5	22.1	21.1	33.3
15	Saptari	2	37.3	36.3	30.2	53	Rolpa	5	31.0	30.6	27.7
16	Siraha	2	30.6	19.8	33.1	54 a,b	Rukum	5	17.2	14.2	36.6
17	Dhanusha	2	33.1	14.5	33.4	55	Salyan	6	29.8	22.5	30.4
18	Mahottari	2	31.5	29.6	35.1	56	Dang	5	35.6	34.7	33.2
19	Sarlahi	2	32.1	32.4	30.2	57	Banke	5	34.0	29.6	33.6
20	Sindhuli	3	37.8	27.5	28.5	58	Bardiya	5	32.8	27.3	21.2
21	Ramechhap	3	<10	32.4	21.9	59	Surkhet	6	27.0	15.3	24.8
22	Dolakha	3	12.7	17.6	13.6	60	Dailekh	6	25.2	<10	22.5
23	Sindhupalchowk	3	30.8	14.3	23.6	61	Jajarkot	6	15.9	<10	30.4
24	Kavrepalanchowk	3	29.5	23.0	21.0	62	Dolpa	6		<10	
25	Lalitpur	3	29.6	22.6	26.6	63	Jumla	6	34.7	<10	39.3
26	Bhaktapur	3	28.8	15.9	25.0	64	Kalikot	6	25.3	<10	37.3
27	Kathmandu	3	26.5	19.6	25.6	65	Mugu	6	22.5	<10	36.5
28	Nuwakot	3	36.6	23.7	32.9	66	Humla	6	28.4	29.3	
29	Rasuwa	3			19.5	67	Bajura	7	22.4	14.0	<10
30	Dhading	3	38.9	12.8	30.5	68	Bajhang	7	19.5	<10	16.5
31	Makawanpur	3	37.8	32.7	33.4	69	Aacham	7	28.7		19.0
32	Rautahat	2	30.5	34.0	31.0	70	Doti	7	33.8	12.0	16.7
33	Bara	2	21.3	33.8	38.2	71	Kailali	7	27.7	32.9	35.8
34	Parsa	2	26.2	26.8	31.2	72	Kanchanpur	7	34.3	34.3	29.2
35	Chitwan	3	34.5	11.2	24.3	73	Dadeldhura	7	39.3	13.5	12.7
36	Ghorkha	4	33.6	<10	25.5	74	Baitadi	7	37.2	22.2	21.0
37	Lamgunj	4	37.0	<10	23.7	75	Darchula	7	36.3	<10	29.0
38	Tanahun	4	22.4	15.4	22.7						

## Appendix 7: PoU, DEC, CV and MDER at the Ecological Belts (1995-2011)

Belts	Round 1: NLSS-1 (1995)							Round 2: NLSS-2 (2003)							Round 3: NLSS-3 (2011)						
	Total PSU	PoU	Range (Min, Max)	Total HH	$\bar{X}$	CV	MDER	Total PSU	PoU	Range (Min, Max)	Total HH	$\bar{X}$	CV	MDER	Total PSU	PoU	Range (Min, Max)	Total HH	$\bar{X}$	CV	MDER
Mountain	32	24.3 (7.4)	12.7, 35.8	405	3319.0 (621.9)	0.39 (0.11)	2163.7 (44.6)	32	11.6 (6.6)	0.9, 29.3	379	4299.7 (856.1)	0.37 (0.08)	2183.8 (86.3)	34	24.1 (9.9)	5.9, 39.2	405	3438.1 (812.8)	0.38 (0.08)	2184.6 (65.2)
Hill	142	28.1 (6.6)	9.3, 39.3	1732	2982.2 (571.5)	0.38 (0.08)	2205.9 (88.0)	158	18.6 (7.6)	1.3, 32.5	1889	3833.7 (758.8)	0.38 (0.08)	2221.1 (92.0)	267	25.8 (4.9)	12.9, 38.8	3186	3392.1 (685.8)	0.39 (0.08)	2223.7 (103.6)
Terai	100	33.5 (4.2)	21.8, 37.5	1224	2587.4 (498.2)	0.37 (0.07)	2187.0 (68.1)	136	26.8 (7.2)	11.5, 35.8	1630	3176.8 (612.3)	0.38 (0.09)	2205.5 (92.7)	198	31.8 (3.5)	21.1, 38.3	2372	2860.0 (539.9)	0.39 (0.09)	2193.5 (78.4)

*Figures in the parentheses are SD across districts.*

## Appendix 8: PoU at the Urban and Rural Regions (2003-2011)

Provinces	NLSS2 (2003)				NLSS3 (2011)			
	Rural		Urban		Rural		Urban	
	Total PSU	PoU	Total PSU	PoU	Total PSU	PoU	Total PSU	PoU
National	229	21.4 (9.6)	97	21.3 (7.1)	325	28.6 (6.2)	174	27.0 (4.6)
Province 1	46	23.6 (6.3)	16	26.6 (4.9)	63	30.8 (3.8)	25	30.9 (1.4)
Province 2	44	28.2 (7.7)	8	25.3 (8.3)	51	32.6 (2.5)	13	32.1 (1.5)
3 Bagmati	42	20.0 (7.0)	44	19.9 (4.3)	54	25.7 (5.3)	90	25.6 (3.1)
4 Gandaki	29	11.3 (7.0)	13	12.0 (4.6)	39	24.2 (6.2)	20	21.8 (3.1)
5 Lumbini	36	24.4 (7.9)	9	28.0 (3.6)	62	31.2 (4.7)	14	31.7 (4.6)
6 Karnali	14	10.7 (9.2)	2	15.3 (0.0)	21	29.1 (5.9)	3	24.0 (1.3)
7 Sudurpaschim	18	20.5 (12.8)	5	25.1 (11.3)	35	23.5 (9.0)	9	27.3 (8.6)

t-test	df=324, t=0.03 H <sub>0</sub> : $Mean_{Rural} - Mean_{Urban} = 0$ p=0.97	df=497, t=3.09 H <sub>a</sub> : $Mean_{Rural} - Mean_{Urban} > 0$ p=0.001
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Figures in the parentheses are SD across PSUs.