

Creating an Index to Measure Food Security: Identifying
the Components and Determinants and Testing Usefulness

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1. Executive Summary

Food security measurement indices can identify the food secure and insecure households within communities and try to predict how the different segments of the population will be affected by unexpected adverse events. Such an identification mechanism can be used to design appropriate pre and post-shock institutional assistance strategies. This study proposes the creation of a food security measurement index for a society of foragers and farmers, the Tsimane', native to the Bolivian Amazon. Data from the years 2005 and 2006, from 275 Tsimane' households were used to generate a composite food security index. This index was used to determine the differences between the food secure and food insecure households in 2005. The index was also applied to the 2006 data, the year in which the Tsimane' received heavy rainfall. Findings of the analyses show that: (i) there are demographic and anthropometric differences between the food secure and food insecure populations, (ii) the food secure rely more on the market and outside institutions for assistance after shocks, (iii) the food-insecure households rely more on themselves and their families and are more likely to reduce food consumption in post-shock situations and (iv) institutional help might not be reaching the most vulnerable.

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3. Acronyms

FAO	Food and Agriculture Organization
LSRO	Life Sciences Research Office
FICCI	Food Insecurity Coping Capacity Index
pcf	principle components factor analysis
TAPS	Tsimane' Amazonian Panel Study
USDA	United States Department of Agriculture
CSI	Coping Strategy Index

4. Introduction

The idea behind creating and testing an index to measure food security comes from the growing interest there is in developing food insecurity measures that are better able to reflect individual household experiences (Coates et al. 2006). The importance of measuring food security at the household level stems from the fact that households at different levels of food security are affected differently by, and thus will react differently to, covariant shocks. Covariant shocks, such as a floods or earthquakes are “large unanticipated, adverse events that affect a large area” (Godoy et al. 2007). Thus by their nature, these shocks affect everyone in the society. However within the society, the impact that a covariant shock has on individual households varies significantly due to the differences in the “private coping capabilities” (Webb and Braun 1994) of households. Coping strategies are “rational and calculated response to minimize the intensity or duration of crisis, to maximize limited resources, and to preserve long term livelihood security” (Adams et al. 1998). Ensuring security in the post-shock scenario is not just restricted to livelihood protection; it has to be extended to include food security as well. This is because disruption of access to food and fluctuations in food availability become two of the most important considerations after a shock. Based on their individual characteristics, households will adopt coping strategies that are different from each other. Not only is the pre-shock food security level important in determining how the household will react to the covariant shock but it will also determine how and to what extent the household will be affected by the shock.

There are many definitions of food security, but the one most commonly used is the one given by the Food and Agricultural Organization (FAO) which states that, “Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life” (FAO 1996, Rome Declaration 1996). The Life Sciences Research Office’s (LSRO)¹ definition of food insecurity closely follows the FAO definition and states that food insecurity is the “limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways” (Bickel et al. 2000). We can see from these definitions that measuring food insecurity involves examining the current and future food availability, access to food that is available as well as issues of nutritional adequacy and social acceptability of the food and the means used to access it. What further complicates food security measurement is the fact that although we have established standard pre-requisites for food security, the level of access to, current and future availability and nutritional adequacy of food are determined by factors that vary from region to region and from household to household. A few of these factors can be identified as poverty, low agricultural productivity, political crisis, lack of nutritional knowledge, lack of education, over population, income inequality, poor infrastructure, covariant shocks such as droughts and earthquakes and idiosyncratic shocks such as death and disease.

¹ LSRO is part of Federation of American Societies for Experimental Biology

This study proposes the creation and use of a composite food insecurity index, the Food Insecurity Coping Capacity Index (FICCI) which also follows the generally accepted definition of food security but it only concentrates on the availability and access dimensions and not on food utilization. The index has been created for a society of foragers and farmers, the Tsimane', who are natives of the Bolivian Amazon. Household level data, i.e. information on the area under cultivation, the types of food items consumed, the types of crops planted, availability of seeds, availability of stored food and the value of modern assets owned, from the 2005 panel survey (more on the data in Section 5) was used to create the composite index. The justification for using six different criteria instead of just one comes from the fact that food insecurity is not a simple problem brought about by a single factor; it is a multidimensional issue, as shown by the definitions of food security. Based on this knowledge using a single proxy variable to measure household food insecurity can, at best, only explain a part of the whole household insecurity problem. The index for this study, therefore, has been created using different criteria that determine the level of food availability and access for the household.

To create the FICCI, principle component factor (pcf) analysis was used that produced a household specific z score ranging from -2.35 to +2.76. Once created, the index was first used on the data from the 2005 dataset to determine the demographic, anthropometric and expenditure differences between food secure and food insecure households (Table 1). Data from 2006, when the Tsimane' received heavy rainfall causing floods, was used to study (a) whether households reduced food consumption to cope with the shock and whether households at different levels of pre-shock food security altered food consumption differently (Table 2) and (b) the types of other coping strategies adopted by households at different levels of food security (Table 3). Finally the study explores variability in FICCI scores (Table 4). By doing so the study tests the hypotheses that: (i) food security measurement indices such as FICCI are useful in identifying the vulnerable population and that there are fundamental differences between the households identified as secure and those that are identified as insecure, (ii) households at lower levels of food security reduce food consumption to cope with an external shock, (iii) food secure households rely more on their private coping abilities whereas the food insecure households receive more of external institutional help, and (iv) characteristics of the household head explain variation in the index.

Figure 1 walks us through the components and hypotheses of the study. At the top are what the study proposes to be the determinants of the components of the household food security, i.e. the household head's (mother and father) level of education; traditional knowledge of plants; asset ownership; and parental attributes (such as education), household's access to markets, and household size. Following on from that, the framework shows the six criteria used to generate the index, i.e. : (i) kilocalories of food consumed; (ii) the availability of seeds; (iii) the availability of food stocks; (iv) the variety of crops planted; (v) the monetary value of modern assets owned by the household; and (vi) forest area cleared for cultivation. The interaction of the six

components determines whether or not the household has access to adequate food. A household is considered to be *Highly Food Secure* (positive FICCI) when conditions of absolute access and absolute availability exist. As we move towards the right of the FICCI line the conditions of perfect food availability and access start to weaken until we reach the point of *Extreme Food Insecurity* (negative FICCI). Right below the FICCI line, the Framework shows the predicted coping strategies that households at different levels of the index adopt after a covariant shock occurs. According to the hypotheses, at higher levels of food security, individuals will rely more on their own private coping abilities and the market to cope with the shock, whereas individuals with lower food security scores are more likely to reduce food consumption and receive more institutional assistance.

5. Learning Objectives

The main objective of this research was to test that households that are food secure and households that are food insecure adopt different methods to cope with adverse covariant shocks. Therefore, central to the whole research was the creation of an index on the basis of which the population could be placed at different levels of food security. However, before that could be done, a clear understanding of what food insecurity is and what its symptoms and implications are was required. In order to gain this knowledge I took courses that explore these issues in detail. These courses (listed below) were taken outside the Heller School, at the Friedman School of Nutrition at Tufts University:

1. Food Security, Nutrition and Development
2. Food Policy Institutions and Analysis

From these courses I learned that food insecurity is a multi-dimensional problem and it affects different segments of the population differently, which has implications for the nutritional status of the population. I discovered that measuring food insecurity was not a simple task and that despite the desire to create a universally applicable indicator or measure of food insecurity, bringing such an idea to fruition was hampered by the wide geographic, social, demographic and economic differences between and within societies. Therefore, I realized that, whereas at the moment it might not be possible to create a universal indicator for food insecurity measurement, it is possible to generate a region-specific index that can contribute to the growing body of other studies that try to generate situation-specific food security indices.

Creating the index and analyzing the post-flood coping strategies of the households required the use of statistical analysis techniques. Therefore in order to learn to work with the statistical analysis software (STATA 8) and to learn how to interpret the results of statistical/empirical analyses I took the following courses at the Heller School:

3. Household Economics
4. Introduction to Qualitative and Quantitative Analysis
5. Data Survey Design
6. Introduction to Econometrics
7. Application of Econometrics

Without knowledge of the techniques used to conduct statistical analysis and the ability to interpret the results of the analysis, which I was able to learn through courses 3, 6 and 7, I would not have been able to do the type of empirical study that I intended to do. Courses 4 and 5 particularly helped me in formulating a clear succinct model, my hypotheses and my problem statement. Besides taking these courses I registered for a Directed Readings course that allowed me to dedicate more time to applying the techniques that I learned in these courses to the data for my own research. By doing so I was able to experiment with the different data analysis techniques and also learn different ways of presenting the results.

6. Sustainable Development Problem

6.1. Why Use a Food Security Measurement Index?

Efforts to develop indices that capture inequalities in resources and capacities of households have become an essential part of finding solutions to the problems of poverty and hunger. Aid agencies and development organizations continue to face challenges of needs assessment and targeting interventions since there is a lack of mechanisms that can be used to differentiate food secure from food insecure or at-risk households (Webb et al. 2006). Food security measurement indices, such as the FICCI, offer the solution to these challenges since they place households and individuals at different levels of a scale, assign scores or values to households and individuals, based on certain characteristics that households possess that are related to the access and availability of food. Such indices can be used in pre-crisis or pre-shock situations to identify the vulnerable or food insecure sections of the population; to preempt how the food insecure households will be affected by and how they will react to an external shock; and to fortify their coping capacities to protect them from slipping further into insecurity.

It is important to strengthen the coping abilities of the vulnerable against covariant shocks since the shocks, adversely affect the level of individual and household food security especially in poor rural communities. The coping strategies adopted by households depend on the severity of the shock and the control that the households have over different resources. There are important implications of adopting these strategies, especially for the food insecure households, which manifest themselves as a slide into a state of greater vulnerability, deteriorating nutritional status and breakup of families (Webb and Rogers 2003). It becomes important to identify the food insecure sections of the society and predict how they will react to an adverse shock. Once the insecure or at-risk households are identified and we know what resources they lack, interventions can be designed to provide the households with those resources, thus fortifying their coping capacities.

The application of the index should not just be restricted to the pre-shock segregation of the secure and insecure population; it can also be used as a tool for ex-post evaluation of interventions to enhance food-security. If the intervention has worked then the food security situation of households that were insecure before the introduction of the intervention should improve as reflected in the improvement in the index scores for those households. Using a composite index ensures that most of the dimensions of food security are covered by the intervention and the evaluation of the intervention. The use of such a measure can also be extended to the post-shock scenario where it could be used as a tool to direct institutional assistance to ensure that those who need help the most get it.

6.2. Why Measure Household Food Insecurity?

Food insecurity is not a problem endemic to any one particular geographic region of the world. The 2002 FAO review of global food security status says that, “To put it bluntly, the state of food insecurity in the world is not good” (FAO 2003 in Webb and Rogers 2003, 1). Studies aimed at designing more realistic and useful food insecurity measures have stated clearly that food insecurity is a problem found in every corner of the world and is a “daily reality” (Webb et al. 2006, 1405) for millions around the world. Its assessment requires measures that can bring forth the causes and symptoms of food deprivation or risk of deprivation that are specific to the circumstances of the area and its population. Measuring any concept or phenomenon not only aids the process of inquiry (Webb et al. 2006, 1406) but also promotes clarity and precision through standardization (Kaplan 1998 in Webb et al. 2006, 1406). Since food security is a multi-dimensional problem there is a need to capture this concept in the form of an accurate measure to ensure that its critical components are not overlooked. The creation of FICCI is an attempt to collect in one measure the different variables that seem to underlie the availability and access dimensions of food security.

Hunger and malnutrition are the direct consequences of food insecurity and they have important implications for the well-being of individuals, households and societies. According to the Millennium Project Hunger Task Force Report the labor productivity losses associated with malnutrition and hunger are on average between 6 and 10 percent of GDP and significant losses in children’s cognitive abilities are also directly associated with malnutrition (Sanchez et al. 2005). The report also points out that food insecure and hungry people face political and social exclusion. Another study shows that at the household level food insecurity leads to “physical impairment” through hunger and illness; “psychological suffering” through stress, fear and departure from norms; and “socio-familial perturbations” through distorted means of food acquisition and modification of eating patterns (Hamelin et al. 1999).

Since many regions around the world face the problem of food insecurity and since its implication are so severe, there is a need to accurately measure the components and determinants of food insecurity and to devise appropriate context-specific solutions.

6.3. Why Study Household Coping Strategies?

What do households do to cope with the affects of the covariant shocks and why do we need to study how they cope? The answers to the first part of the question will vary from place to place and from household to household for reasons of differences in coping capacities. In their study of the effects of the Ethiopian famines, Webb and Braun (1994, 55) ask the same question, “What do people do when faced with the threat of starvation?”

and then answer it by saying “In most cases, almost everything in their power”. What is in people’s power is an outcome of their control over different resources or what Sen (1999, 162) refers to as “entitlements”, Sen says, “What is crucial in analyzing hunger is the substantive freedom of the individual and the family to establish ownership over an adequate amount of food, which can be done by growing the food oneself or by buying it in the market.” He calls this concept of substantive freedom and ownership “entitlement” and states that it is when people cannot establish their “entitlement over an adequate amount of food” that they suffer from hunger. In this study the six variables used to create the index try to determine the degrees of entitlements of households.

Different studies present a variety of different coping strategies that the households are likely to adopt when faced with food shortage. For instance when faced with famine, Ethiopian villagers were shown to draw on their savings, use food reserves, diversify sources of income and reduce expenditure on non-food items in the initial stages on the famine; whereas during the later stages of the famine they switched to consuming famine foods and even migrated (Webb and Braun 1994). A study from Sahel shows that when faced with the shock (conflict) induced food shortage, household were forced to drastically reduce their food consumption and even resort to more socially unacceptable options such as begging (Molnar 1999). In Bangladesh households facing flood-created food shortages reported reducing the number of meals per day, changing the types of food items that they consumed and borrowing food from neighbors (Frongillo et al. 2003).

Adopting any of the coping strategies described above has implications for the household and its members and that is why we need to study these strategies. For instance, changes in food consumption patterns, due to a reduction in the number of daily meals or a decline in the quality of food consumed, can be deleterious to the health of household members especially to the long-term well being of children (Arimond and Ruel 2004). Similarly sale of livestock could make poor and insecure households more vulnerable and push them (further) into poverty; once sold a cow/ox cannot be used as an input for farming activity and thus selling livestock will adversely affect agricultural income (Webb and Braun 1994). Out migration directly influences not only the household but also the larger society because the area to which the food insecure people migrate would need to provide for the immigrants as well as its local population. Therefore studying and anticipating these strategies becomes important. Only when we are able to anticipate the reaction of the food insecure can we design pre-emptive measures to strengthen the resilience of households against shocks without them having to suffer the adverse consequences of resorting to potentially harmful coping mechanisms.

6.4. The Hypotheses and Models

The hypotheses developed and the models used to test those hypotheses are as follows.

Hypotheses	Models
(i) A composite food insecurity measurement index, such as the FICCI is useful in identifying the vulnerable population and the demographic, anthropometric and expenditure differences between the secure and insecure households.	<p>1. FICCI = area under cultivation + types of food items consumed + availability of stored seeds + availability of stored food + types of crops planted + monetary value of physical assets</p> <p>2. Segregate population based on the FICCI into food secure and food insecure and test for similarity of the two groups in the means of the following variables: age; sex; years of residence in community; physical stature, weight-for-age Z scores; self-perception of food adequacy; and expenditure on food.</p>
(ii) Households identified as being food insecure will reduce their food consumption in response to an adverse covariant shock.	3. Test the Index against changes in food consumption between 2005 and 2006 to determine whether households with lower FICCI scores reduced food consumption
(iii) The food insecure individuals rely more on external assistance whereas the food secure individuals have greater capacity to cope with covariant shocks on their own.	4. Regress each type of coping strategy, i.e. coping alone, relying on market, relying on local institutions, relying on agencies from outside the community and doing nothing on FICCI, while controlling for confounds
(iv) Attributes of the household head and certain household characteristics are associated with inter-household differences in food security scores.	5. Regress FICCI on education, language and math skills, asset ownership and parental education variables for household head and distance from town and household size variables

7. Methodology

7.1. The Data & Sample

The data for this study comes from a panel study (Tsimane' Amazonian Panel Study (TAPS) 2005 & 2006) among the Tsimane' a foraging and farming society in the department of Beni, Bolivia. The total Tsimane' population is about 8,000 people who live in 100 villages along rivers and logging roads at the foothills of the Andes, in the Bolivian Amazon. Their main subsistence activities include farming, hunting, fishing and plant gathering. The 2005 dataset comes from a survey conducted over June-September 2005 among 275 households, 1,578 people of which 598 are adults (i.e. people older than 18 years) in 13 villages. The 2006 data comes from a survey done over June-October, 2006 with the same population.

Data used for the creation of the index comes from the 2005 survey. Table A below gives a summary of the questions from the different sections of the survey that provided information on the components of the index.

Table A: Relevant Components of the Survey

Section of the survey	Questions relevant to the index components	Unit of measurement
Agriculture	(i) How much forest area did the household clear for cultivation in the last year? (ii) Did someone in the household plant maize, rice, plantain or pigeonpeas? (iii) Did the household have maize, rice, plantains or other crops stored over from the previous harvest? (iv) Did the household have seeds stored over from last year?	(i) Hectares (ii) Yes/No (iii) Kilograms (iv) Yes/No
Consumption	How much of beef, chicken, duck, pork, fish, game meat, eggs, lard, flour, bread, noodles, rice and eggs were consumed by the household in the 7 days before the day of the interview?	Kilograms (converted into kilocalories for the purpose of this analysis)
Modern Wealth	(i) How many bicycles, radios, watches, mosquito nets, shotguns, rifles, big pots, axes and hooks did the individual own? (ii) What were the village prices of these items?	(i) Number of assets (ii) Boliviano value of assets

From the 2006 survey, information from the section on shocks was used. In this module, the subjects over 16 years of age were asked to report: (i) the shocks, including floods, which they had faced over the past 12 months; (ii) what they did to cope with the shocks; (iii) whether or not they migrated due to the flood; (iv) whether or not they received institutional assistance; and (v) which institutions they received help from if they did receive outside help.

7.2. Creating the Index

The variables used to create the FICCI were: (i) kilocalories of food consumed; (ii) the availability of seeds; (iii) the availability of food stocks; (iv) the variety of crops planted; (v) the value of modern assets owned by the household; and (vi) forest area cleared for cultivation. These variables are presented in Figure 1.

7.2.1. Reasons for Using the Variables

The first criterion, kilocalories of food consumed, was taken as a proxy for nutritional well-being of the household since availability of sufficient quantities of nutritionally adequate food is a prerequisite for food security. Stored food and seeds, while not necessarily measures of present food security, can predict how well a household will be able to cope with food shortages that might occur in the future. Stored food allows the family to sustain itself during periods of temporary food shortages whereas stored seeds would enable the household to survive through more prolonged spells of general food shortage. Since household food insecurity is an outcome of present and future constraints on access to and availability of food (Phillips and Taylor 1990), ensuring that the food security index measures a household's ability to insure itself against the risk of future food shortages becomes necessary. Hence factors (ii) and (iii) (from 7.2) were added to the index.

Since the population under study is part of a community that depends on subsistence farming for a great part of its sustenance, it seemed logical to include the variety of crops planted (item four in the index) as a proxy for dietary diversity. Dietary diversity has long been recognized as being an essential determinant of a nutritionally adequate diet (Arimond and Ruel 2004) and thus of food security. Along with being a determinant of nutritional adequacy, the variety of crops planted would also be a proxy for agricultural income. A wider variety of food crops for self-consumption means that the household can provide for itself a diversified diet whereas planting a greater variety of cash crops means the household can sell the crops and use the income to diversify its diet. The fifth component of the index captures household wealth and wealth is a buffer against uncertainty and risk. If the household has modern assets that can yield returns on sale, it

would have some sort of a safety net to fall back on in case it faces the threat of starvation without having to resort to the sale of, say agricultural assets such as livestock that are more valuable in the longer-term and crucial for livelihood generation.

The sixth and the final component of the index is forest area cleared for cultivation by the household. Agricultural land is common property among the Tsimane' and is not available for sale, which means that everyone has access to agricultural land. However the 2005 survey indicates that the forest area cleared for cultivation differed among households. Land under cultivation is used as a proxy for agricultural output in the index, so the greater the amount of forest area cleared for cultivation, the more food secure the household should be.

7.2.2. Incorporating the Components into the Index

For the first variable, kilocalories of food consumed, the amount of food consumed by the household in the seven days before the day of the interview was converted into kilocalories of proteins, carbohydrates and fats. The basic formula for conversion (Appendix 2) was to multiply the amount of a particular food item consumed by the household with the product of the edible proportion of the food item and the amount of proteins/carbohydrates/fats known to be present in one kilogram of that food item. Once the kilocalorie contents of the three food groups were derived, they were added to generate the total amount of food calories consumed by households.

For the availability of seeds, the availability of food stocks and the variety of crops planted, separate dummy variables were created so that the household was assigned a value of one if it had stored crops, if it had stored seeds or if it had planted a particular crop (maize, rice, plantain, pigeonpeas) and a value of zero if it did not have stored seeds, or stored crops or if it did not plant a particular crop. The forest area cleared for cultivation was measured in hectares. The value of modern assets was measured in bolivianos (the Bolivian currency), where one boliviano was approximately equal to US\$ 0.125 in 2005.

Principle components factor (pcf) analysis was used to generate the index and an Eigen value of 1.3 was specified as the cutoff point for retaining the factor(s). The Index was constructed using STATA 8, statistical data analysis software for Windows. All the original six variables were loaded into one factor that explained the most variance in the original components. This factor is the index or the FICCI with a minimum score of -2.76 and maximum score of +2.80.

8. Literature Review

This section will present the views of other authors and the findings of other studies on the topics of (i) Importance of Measuring Food Security; (ii) Approaches to Measuring Food Security and the Use of Indices; and (iii) Shocks and Coping Strategies.

8.1. Importance of Measuring Food Security

Webb et al. (2006) while discussing the importance and difficulties of measuring household food insecurity say that, “Food insecurity is a daily reality for hundreds of millions of people around the world” (Web et al. 2006, 1405). They further go on to say that food insecurity is directly responsible for malnutrition and deaths of children in places like Niger; for outbreaks of nutrient-deficiency related diseases in refugee camps such as those in Nepal; and for forcing vulnerable households in places like North Korea to eat such foods as tree bark and rotting seaweed. For these reasons, they say, it is important for us to find better measures urgently. The authors have used Sen’s (Sen 1981 in Web et al. 2006, 1405) observation regarding poverty which is that we do not require “cunning measures” to identify “raw poverty”, however its identification is not that simple and that there are less obvious conditions that need to be captured using more sensitive approaches. Webb et al. apply this concept to the identification of food insecurity and say that although raw food insecurity is visible, the degrees of food insecurity faced by different households might be very different- while some households might be at risk but not face immediate hunger, others might be in “desperate straits”. Thus, for interventions to be effective in reducing food insecurity it is essential for institutions to be able to distinguish between food secure and food insecure households. According to the authors, it is the lack of clear identification mechanisms that prevents aid and development agencies from undertaking effective targeting.

Kennedy (2002) says that “Food insecurity is an essential element of overall well-being”, and that over the last few decades the elimination of food security and hunger has received considerable attention. Countries and organizations all over the globe have agreed on availability, access and nutritional adequacy dimensions of food insecurity and with that, says Kennedy, there is renewed interest of policy-makers devising measurement methods that are “simple to use and easy to analyze”. According to her, even though development of food insecurity measures is a time consuming, and often an expensive process, it would be extremely useful if researchers could identify “core items” that could be part of any food security measure so as to save time and effort and to facilitate cross country analysis.

On the importance of measuring food security, Bickel et al. (2003, 7) have said something very similar to what Kennedy (2003) has said, i.e., it is “an essential, universal

dimension of household and personal well-being”. The authors say that food deprivation is not only unacceptable “in its own right” but it also has nutritional, health and developmental implications. By measuring food security we can identify the fundamental aspects of regions, sub-groups and households. The authors say that such measurement is crucial for nations to be able to achieve the goal of halving hunger by the year 2015². They also say that even though food insecurity is an outcome of constrained financial resources, using traditional income and poverty measures does not suffice for the purpose of measuring food insecurity since studies, at least in the US, have shown some low-income level households might be food secure whereas non-poor households might be food insecure.

According to Haddad et al. (1997) there are many objectives of “food-related” measures and one of them is to “help target scarce resources toward the food insecure.” The authors point out that although the use of measures to target the food insecure is not new, the practice has become more important now because of the increasing opportunity cost of funds. They call for creating measures and targeting systems that are easy to use and that can be relied on for identifying the at-risk population. Haddad et al. study the post-famine conditions, during the early 1990s in India to determine whether measurement of food insecurity was required even after the crisis had ended. They found that despite there being improvements in food availability at the national and regional levels, chronic household level food insecurity had not been eliminated and that the child malnutrition rates were still high. Moreover they discovered that the relief and rehabilitation interventions could have been undertaken utilizing fewer resources if measures were used to target the vulnerable groups. According to their analysis, if a targeting mechanism were used, the chances of the most vulnerable benefiting from a food security or nutrition intervention (“true positives”) would have increased by 26% in case of general programs and as much by as much as 97% in case of vitamin supplement programs and program leakage costs, i.e. program resources going to unintended beneficiaries, would have decreased by 35% (Haddad et al. 1997, 55).

From the analysis of existing literature on food security measurement the main reasons for measuring food security can be identified as: (i) for the sake of standardization and accuracy; (ii) to differentiate between the food secure and the insecure; (iii) to facilitate more cost-effective targeting of aid and development resources; (iv) to prevent the food security situation of the insecure and vulnerable from deteriorating after a crisis and; (v) to design food security and nutrition enhancement or protection programs that are suited to the requirements and needs of the target population.

² Millennium Development Goal 1 is to halve the prevalence of extreme poverty and hunger by the year 2015.

8.2. Approaches to Measuring Food Security and the Use of Indices

In their study of the famine-affected areas of India, Haddad et al. (1992) collected data from four villages and developed both qualitative and quantitative methods to identify the most suitable indicators of food security. The qualitative methods that they used included ethnographic case studies of insecure households, where people's own perceptions and the ethnographer's observations related to food security were recorded. In addition, food charts and seasonality charts were also used. The quantitative method used information from economic and nutrition surveys of 325 households over 1992/93. The qualitative analysis was used to generate a list of indicators which were then validated by comparing them to quantitative benchmarks for measurement. The quantitative measures were derived from dietary recall, anthropometric and blood data. Once the correlations between the benchmarks and the qualitative indicators were determined, both sets of measures were used to determine the impacts of targeting food aid distributions. The authors concluded that either qualitative or quantitative method could be used to measure food security and that the choice of method depended on factors such as time available to carry out the assessment, the human and financial resources available to the organization and the type of secondary data that is available. Large organizations such as governments or international donors might be better able to carry out quantitative or mixed-methods (qualitative & quantitative) analysis whereas a local NGO might prefer to carry out a qualitative analysis. According to Haddad et al., while the qualitative methods require less time and might better reflect the experiences of people, their reliability depends on the abilities of the ethnographers and their applicability is restricted to the population that they come from. Quantitative methods on the other hand can be applied to other populations as well and are more rigorously calculated with less interviewer bias. However it might be difficult to interpret such data if the context of the study is not known; therefore qualitative information might still be required.

Coates et al. (2003) quote one of the major conclusions of an FAO sponsored symposium, held in 2002, which says that, "no individual measure suffices to capture all aspects of food insecurity" and that a widely endorsed suggestion was to develop several indicators to cover the different dimensions of food insecurity (Coates et al. 2003, 2). Coates et al.'s report was a response to the strong demand for simple and rigorous food security measures among the Title II³ Private Voluntary Organizations (PVOs) to "guide, monitor and evaluate operational interventions." The study was undertaken over 2002/03 to determine the applicability of the Household Food-Security/Hunger Survey, developed during the 1990s to measure household food security in the United States, to developing country settings, hence the site of the study was Bangladesh. The Survey was designed by the US Department of Agriculture (USDA) and its most significant component was "the 18-item core module". The questions asked the respondents to report: any anxiety regarding the household food budget or food supply; actual experiences of running out of food; perceptions about the adequacy of food quality and quantity; any reductions in food

³ Title II is the emergency food aid program of the USAID

consumption or switching to the consumption of lower quality foods, and so on. Based on the responses to these questions a scale was developed and households were placed in either one of four categories: food secure, food insecure without hunger, food insecure with hunger (moderate), and food insecure with hunger (severe).

Using the core module from the US Food Security Survey Coates et al. (2003) adopt an approach similar to that taken by Haddad et al. (1992). Coates et al. identify and validate indicators from locally recognized behaviors that distinguish secure and insecure households, then they determine the correlation between those indicators and the conventional indicators of food security such as income, nutrition and food intake and finally they test the newly developed indicators by applying them to secular trends to identify improvements in food security status of households over time as a result of interventions. As in Bickel et al.'s (2000) *Guide to Measuring Household Food Security* a household food security measurement scale was developed by converting qualitative data into quantitative data. From their analyses and tests, Bickel et al. conclude that the core module could be modified and applied to developing countries- the original 18-question module was reduced to nine questions and was called the FAST module- and that the survey questions were strongly correlated with the prevalence of food insecurity and also reflected changes in food security status over time. The authors have also concluded that ideally the FAST module should be used along with other more widely used measures of nutritional status and food production but that on its own it is a very accurate indicator of the "access dimension" of household food security.

Maxwell et al. (2003) have also created a scale but they use coping strategies rather than household or individual attributes; they call it the Coping Strategies Index (CSI). The CSI was created for use in emergency aid distribution programs and as an early warning system for African countries. The pilot study was conducted over 1999-2000 in two of the drought affected areas of Kenya. According to the authors the CSI is a tool that is easy to administer and analyze and provides real time information to program managers. The scale was based on assessing the severity and frequency of coping strategies used by households over time and then combining them in a single score. The higher the index score the more insecure the household was considered to be. Other traditional proxies of income and wealth were not part of the index but they were controlled for. The questions regarding coping strategies that were asked in the survey inquired about whether households; switched to consuming less preferred foods; borrowed food; relied on wild foods; sent household members elsewhere to eat; reduced number of meals per day or went the whole day without eating. All of these questions were accompanied by the question of how long the strategy was adopted for, ranging from never to 3 to 6 times per week to every day and each category of frequency was ranked. Coping strategies of similar levels of severity were grouped and each group was assigned a weight (4 to the most severe and 1 to the least) before adding the strategies together. Maxwell et al.'s study takes more of a quantitative approach; however it does make use of the participatory appraisal approach to determine people's perceptions about the severity of their coping strategies.

Thus from the existing studies what can be concluded about food security measurement is that: (i) both qualitative and quantitative measures are important and that they should be used together whenever possible; (ii) they should take account of the context in which they are being applied; (iii) they take time and resources to be developed and tested; (iv) the use of either qualitative or quantitative methods depends on the availability of time, resources and expertise; (v) once developed the measures can be used for many purposes; and (vi) developing and using food security/food insecurity measurement indices is a common practice in the field of vulnerability and food security assessment.

8.3. Shocks and Household Coping Strategies

In their book *Famine and Food Security in Ethiopia: Lessons for Africa* Webb and Braun (1994) study the effects of the Ethiopian famine of the 1990s and explored the coping strategies of the most vulnerable households in the absence of external help. According to the authors some studies in the past (e.g. by Hutchinson, 1991; Keller 1992) have recommended that dealing with food crises should be left to traditional coping systems. However, Webb and Braun warn of the dangers “idealizing private coping capacity”. They stress the importance of studying the networks and methods that households use to cope with post-shock food insecurity in order to design public interventions that increase the resilience of the vulnerable households against food insecurity and to prevent households that are not food insecure from slipping into an insecure position. Their analysis further reveals that coping strategies depend on pre-crisis household characteristics. The authors also discovered that coping mechanisms that the households adopted formed a continuum of strategies from “risk minimization” to “risk absorption” and finally to “risk taking”. Risk minimization involved asset accumulation, saving and income diversification. Risk absorption follows on from risk minimization and involves drawing on savings and existing food reserves and often restriction of consumption of food and non-food items. The final stage is risk taking which involves the households taking desperate measures such as breaking up the family through migration, consumption of survival or famine foods and sale of private possessions. Many of the household responses, especially during the last phase clearly have irreversible impacts on household well being and conditions get worse unless external assistance arrives. Due to the irreversible nature of the risk taking strategies and their adverse impact on post-crisis recovery, households would be reluctant to sell assets, especially agricultural assets in an agrarian community, and would only do so as a measure of last resort. According to Webb and Braun, in the case of Ethiopia, households preferred obtaining food on credit, if that meant that they did not have to sell their assets. Moreover their study also found that the value of assets held by food insecure households was generally very low and so it would only benefit the food secure households to sell assets, i.e. if they needed to. The sales of livestock were also seen to increase with the worsening of famine conditions and lack of or absence of outside help in Ethiopian villages.

Maxwell et al. (2003) have identified a similar pattern of responses and divide them into long-term and short-term coping strategies. Short-term strategies include “the immediate and short-term alteration of consumption patterns” and long-term strategies include “the longer-term alteration of income earning or food production patterns, and one-off responses such as asset sales” (Maxwell et al. 2003, 5). They say that while it is important to understand longer-term livelihood strategies, in emergency situations management of short-term consumption strategies can accurately reflect the food security situation. The authors have identified four types of household coping strategies:

- (i) Households may change their diet i.e. they might switch food consumption from preferred foods to cheaper, less preferred substitutes;
- (ii) Household can attempt to increase their food supplies using short term strategies that are not sustainable over a long period, for instance borrowing, or purchasing on credit or consuming wild foods;
- (iii) Households can try to reduce the number of people that they have to feed by sending some of them elsewhere; and
- (iv) Households can attempt to manage the shortfall by rationing the food available to the household.

Other studies (e.g. Oldewage-Theron and Napier, 2006; Dore et al., 2003; Adams et al., 1998 and Frongillo et al., 2003) have also identified similar strategies that households employ to protect themselves against food insecurity. These strategies include changes in food consumption patterns, rationing food intake, migration, liquidation of assets and borrowing money. In some extreme cases (such as conflict based displacement) individuals and households have had to turn to less socially acceptable means such as begging and sexual exchange (Molnar 1999).

In their study of the three-year household panel data from Pakistan, Alderman and Garcia (1993) saw that households coped with seasonal fluctuations by relying on social networks and taking on credit from local lenders and shopkeepers but not formal banks. Households showed the ability to maintain caloric intake at almost the same level throughout the year. Therefore households were shown not to adopt the strategy of reducing food consumption; rather they relied on their past savings, stored grains, remittances and social networks to cope with food insecurity.

To summarize, the literature reviewed suggests that there are several different strategies that households can adopt when faced with conditions of food insecurity. The adoption of particular mechanisms such as reduction in food consumption, migration and sale of assets depends not only on the severity of the food insecurity created by the external shock but also on the pre-crisis food security situation of the household. Whereas there is no simple scale to measure food insecurity, the importance of developing situation-specific food security measurement indices is only growing because we need to know

who the most food insecure are, how they can be targeted, how can their vulnerability be reduced and how increasingly shrinking resources can be put to better use.

The existing literature provides us with an in-depth understanding of the conditions and implications surrounding food insecurity and the factors to be kept in mind while measuring food insecurity. There are nevertheless some gaps in the existing studies. Firstly, since almost all of the studies (for e.g. Webb and Braun 1994; Maxwell et al. 2003 and Haddad et al. 1997) about food insecurity measurement have concentrated on areas affected by droughts and famines, we do not know whether food insecurity measurement differs in areas affected by other shocks such as floods or whether there is a need for developing food insecurity measures for tropical areas that are different from the measures developed for arid regions. Secondly, no studies were found that did a pre and post shock/crisis analysis using a food security measure that was based on household characteristics before the shock to determine how different households coped with the shock. This study will contribute towards filling these gaps.

9. Evidence and Analysis

This section will discuss the results of the statistical analyses that were conducted to test the four hypotheses formulated by the study. The test results for the four hypotheses are presented in Tables 1 to 4 that are discussed in four separate sections and the variables that are used in the analyses are described in Table 5 (Appendix 3).

9.1. Differentiating Food Secure Households from Food Insecure Households

Households in the dataset for 2005 were segregated using the mean FICCI value, so that households with negative FICCI scores were identified as being food insecure and households with positive scores were classified as food secure. It is possible to segregate households into more groups than the two created for this analysis; however the basic idea is to test whether there are significant difference between secure and insecure households. After dividing the sample population, tests were run on the demographic, anthropometric, psychological and expenditure variables of the two groups. The results of the analysis are presented in Table 1 on page 23.

Demographic differences

Overall there appear to be more males and females in the food insecure group and there is a difference between the proportion of males and females in the two groups; around 48% of the males and 45% of the females are secure and 52% of the males and 55% of the

Table 1: Analysis of Differences between the Food Secure and Food Insecure Households among Tsimane', 2005

Variables	Test Type	Secure (FICCI +)			Insecure (FICCI -)			Difference in the population means
		N	\bar{X}	Std. Dev	N	\bar{X}	Std. Dev	
Demographic								
Proportion of secure/insecure adults males	Chi square	371	47.99%		402	52.01%		
Proportion of secure/insecure adults females	Chi square	325	45.26%		393	54.74%		
Adult population (age ≥ 18)	T-test	279	40.53	18.64	319	35.14	16.82	t =3.71**
Child population (age <18)	T-test	417	7.47	4.74	476	6.66	4.67	t =2.59**
Old population (age ≥ 60)	T-test	57	70.65	6.1	43	69.76	7.19	t =0.66
Years of residence in the community (for population ≥ 18 years)	T-test	260	24.02	19.41	304	20.57	15.1	t =2.38*
Anthropometric								
Body fat for age ≥ 18	T-test	279	21.95	6.86	316	21.35	7.17	t =1.04
Height-for-age Z-score for age <18	T-test	425	-1.6	1.29	482	-1.69	1.41	t =1.04
Height-for-age Z-score for age ≥ 18	T-test	279	-1.75	0.79	319	-1.85	0.73	t =1.67
Physical stature	T-test	696	131.1	31.19	794	127.3	32.61	t =2.29*
Physical stature for age ≥ 18	T-test	279	157.08	7.93	319	156.77	7.5	t =0.62
Weight-for-age Z-score age <18	T-test	425	-0.7	0.95	483	-0.84	1.07	t =2.02*
Weight-for-age Z-score age ≥ 18	T-test	279	-0.92	0.53	319	-0.94	0.56	t =0.37
Psychological								
Incidence of anger	T-test	305	0.72	1.72	342	0.57	1.23	t =1.28
Incidence of fear	T-test	305	1.06	1.62	342	0.92	1.36	t =1.26
Perception of how well they ate	T-test	305	1.64	0.508	342	1.52	0.528	t =2.83**
Expenditure								
Expenditure on all food by household in the past week	T-test	123	795.29	369.29	121	597.59	258.26	t =4.84**
Expenditure by individual on durable kitchen assets in the last 2 weeks	T-test	305	0.921	7.72	342	0.275	2.67	t =1.45

Note: For the detailed description of the variables used in this table, refer to Table 5 in Appendix 3.

** The difference between the means of the two populations is statistically significant at the 1% significance level

* The difference between the means of the two populations is statistically significant at the 5% significance level

females are insecure. This difference, however, is not that significant. The average age of adults in the secure population was 40.53 years whereas the same average for the insecure population was 35.14 years, i.e. the average age of the insecure adults was almost 5 years less than the average age of secure adults ($t=3.71$). The average ages of children in the two groups, 7.47 years for the secure population and 6.66 for the insecure population, differed by less than a year however this difference was shown to be statistically significant ($t=2.59$). There is hardly any difference in the mean ages of the secure and insecure old people, i.e. 70.65 years for the secure old and 69.76 years for the insecure old, but more of them are secure, unlike the other two age groups. Members of secure households were shown to have lived 4 years longer ($t=2.38$), on average, in the community than members of insecure households, with the average years of residence for the secure adults being 24.02 and 20.57 for insecure adults.

Anthropometric Differences

Testing for differences between the anthropometric measures reveals that except for differences in the average height and the average weight-for-age Z scores (see Table 5, Appendix 3 for description) there are no statistically significant differences in the anthropometrics of the individuals in the two groups.

The average height of food secure individuals, 131.1 cm, was shown to be almost 4cm greater than the average height of insecure individuals, i.e. 127.3 cm. However once age is controlled for, the two averages become almost the same. This can be explained by the higher proportion of children in the insecure population, which brings down the average height of the insecure group. The average weight-for-age Z score of children (i.e. population under the age of 18 years) in the secure population was -0.7 which was 0.14 points higher than the average Z score for children in the insecure population, i.e. -0.84, and the difference was shown to be significant ($t=2.02$).

Differences in Perceptions of Well-being

After controlling for age, the two populations differed significantly in their perceptions of how well they ate. The survey question from which this information was derived asked the subjects to report how satisfied they were with what they ate in the seven days before the day of the interview (Table 5, Appendix 3). Extreme dissatisfaction was recorded as a 0, complete satisfaction as a 2 and responses in between were recorded as 1. The mean satisfaction score for the insecure population was 1.52 which was 0.12 points lower than the mean score for the secure individuals, i.e. 1.64, and the difference in the two averages was also shown to be significant ($t=2.83$). This inspection however, is unable to tell us exactly which aspect of food consumption it was that the subjects reported their satisfaction or dissatisfaction about, i.e. was it the amount, quality or the variety of food consumed? The analysis would have presented a clearer picture if the survey question

had specified which aspect of consumption in particular was being measured. Nonetheless we can gather that the food insecure individuals were less satisfied with their food consumption compared to the food secure individuals.

Differences in Expenditure

The total boliviano value of all food items consumed by the household in the seven days before the day of the interview was a composite of food produced at home, food that was bought from the market as well as hunted meat that was brought into the house over the seven-day time period, multiplied by the respective per unit village prices of those items (Table 5, Appendix 3). This variable was used as the proxy for value of food consumed by the household. Using this composite variable we see that the average weekly expenditure on food by food insecure households was 597.59 bolivianos, which was approximately 200 bolivianos less than the average weekly food expenditure of food secure households, i.e. 795.29 bolivianos. The analysis also shows that this difference in expenditures was significant ($t=4.84$).

The hypothesis that was tested here was whether a composite index such as the FICCI can be used to identify the vulnerable segment of the population and whether there are significant differences between the food insecure and secure segments. From the analysis we can see that there are differences, some of them very significant, between food secure and food insecure households and individuals. The secure population on average has less females and children, is older, has lived longer in the community, is taller, is more satisfied with the amount of food consumed and spends more on food than the insecure population.

9.2. Post-Flood Reduction in Food Consumption

The second hypothesis tested by the study was that households with lower food security scores would reduce their food consumption to cope with the shock of flood. To verify this, the index was tested against the changes in total kilocalorie consumption as well as the changes in kilocalorie consumption of proteins, fats and carbohydrates, before and after the flood (i.e. the difference in food consumption over 2005 and 2006). The results of the tests are summarized in Table 2 on page 26.

Table 2: Changes in the Food Consumption of Tsimane' Households (outcome) over 2005 and 2006 in Relation to the FICCI Scores (explanatory variable) (N=220)

	Change in Food Consumption		Statistical significance of the difference in the mean FICCI scores between (A) and (B)
	Households that decreased consumption (A)	Households that increased consumption (B)	
Food Group			
Proteins			
Average FICCI score	-0.032 (0.094)	0.042 (1.07)	t =0.539
Proportion of households (%)	49.55	50.45	
Carbohydrates			
Average FICCI score	-0.117 (0.083)	0.241 (0.116)	t = 2.53*
Proportion of households (%)	64.86	35.14	
Fats			
Average FICCI score	0.029 (0.088)	0.009 (0.112)	t =0.045
Proportion of households (%)	59.09	40.91	
Total food consumption			
Average FICCI score	-0.066 (0.85)	0.13 (0.12)	t =1.37
Proportion of households (%)	63.64	36.36	

* Difference in the scores is statistically significant at the 5% level of significance
Standard errors are given in parentheses.

Almost 63.64% of the Tsimane' households reduced overall food consumption after the flood and the average Index score for those households was -0.066. Therefore the households that reduced consumption were, on average, food insecure. The most significant reduction was seen in the consumption of carbohydrates for which nearly 65% of the households reported a decline in kilocalorie consumption and those households had a mean FICCI score of -0.117.

This considerable decline can be explained by fact that the main sources of carbohydrates for these households, bread, flour, maize, plantain and rice, are either crops or products of those crops. Since heavy rains and floods generally damage crops, a decline in carbohydrate consumption seems natural. In the case of fat kilocalorie consumption, again more households reduced consumption than increase it, however the test shows that this difference is not very significant. Unlike carbohydrate consumption, households that reduced fat consumption had higher scores than households that increased their consumption of fat kilocalories.

Nearly half of the households reduced their consumption of protein kilocalories and the other half increased it. Households that increased consumption had a higher and positive average FICCI score (0.042) whereas households that reduced protein consumption had a lower and negative average FICCI score (-0.032). The possible reason for protein consumption not declining as drastically as carbohydrate consumption could be that the sources of protein for the Tsimane' are animals and fish, which would not be affected by the flood as severely as crops (maybe if the flood was of a greater intensity, animals would be affected as well).

This analysis supports the second hypothesis; 63.64% of the households reduced their total kilocalorie consumption after the flood and the average FICCI score of the households that reduced consumption, i.e. -0.066, was much lower than the average score for the other 36.36% households that increased food consumption in 2006, i.e. 0.13.

9.3. Other Coping Mechanisms and Institutional Assistance

The third hypothesis of the study was that to cope with the shock, food insecure households rely more on external or institutional assistance whereas the more secure households are more likely to rely on their private coping abilities and the market. The results of the regressions are presented in Table 3 on page 28.

To test this hypothesis, four new dummy variables were created, which are described in Table 5 (Appendix 3). The first one was for coping alone which included relying on oneself and getting assistance from family. The second one was for relying on the market which included selling goods, taking formal credit and relying on wage labor. The third variable, i.e. received help from local institutes, was created for individuals who relied on assistance from local community institutes. The fourth variable, received help from non-Tsimane' institutes, was also created for institutional help but for institutions that are outside the community such as the Red Cross. Separate regressions were run on each of the six variables shown in Table 3, using the index as a continuous variable and

Table 3: Regression of Coping Strategies Adopted in 2006 by Individuals on FICCI (N=604)

Explanatory Variables	\bar{X}	Coping Strategies (outcome)					
		Coped Alone	Relied on Market	Received help from Local Inst	Received help from non-Tsimane' Inst	Some other strategy	Did nothing
FICCI score	0.138	-0.0135 (0.0086)	0.0065 (0.007)	-0.002 (0.02)	0.059** (0.24)	0.042*** (0.015)	0.01 (0.017)
Age	35.92	-0.0005 (0.0005)	-0.00003 (0.0004)	0.0012 (0.001)	-0.0021 (0.001)	-0.0004 (0.001)	-0.001 (0.001)
Sex (1= male, 0= female)	0.483	0.007 (0.015)	-0.003 (0.013)	0.035 (0.036)	-0.053 (0.043)	0.0076 (0.028)	0.03 (0.029)
Knowledge of edible wild plants	10.58	0.0014 (0.0027)	0.003 (0.003)	-0.037*** (0.0069)	0.052*** (0.008)	-0.014*** (0.005)	-0.006 (0.005)
Walking distance to town (San Borja)	3.21	-0.006* (0.003)	0.003 (0.002)	0.016** (0.006)	-0.051*** (0.008)	0.02*** (0.004)	- 0.018*** (0.001)
Years of residence in village	21.33	0.0003 (0.0005)	-0.0001 (0.0005)	0.00003 (0.0013)	0.0004 (0.002)	0.002** (0.001)	0.0017* (0.001)
Household size	7.06	-0.005* (0.003)	0.002 (0.0025)	0.0013 (0.007)	0.024*** (0.008)	-0.007 (0.005)	- 0.016*** (0.006)
Mean FICCI score †		-0.426	0.264	-0.065	0.033	0.163	0.051
Pseudo R square (%)		6.16	2.92	4.83	8.86	5.84	4.64

Note: For the detailed description of the variables used in this table, refer to Table 5 in Appendix 3.

The table shows results of probit regressions where the 6 coping strategies were separately regressed on the FICCI using confounds. The coefficients are reported as marginal change over sample mean for a marginal change in the independent variables.

* The coefficient is statistically significant at the 10% significance level ($p < 0.10$)

** The coefficient is statistically significant at the 5% significance level ($p < 0.05$)

*** The coefficient is statistically significant at the 1% significance level ($p < 0.01$)

† The mean FICCI scores for individuals adopting particular strategies were calculated by testing (t-test) the Index (FICCI) against the 6 individual coping strategies.

controlling for age, sex, traditional knowledge of plants, distance from town of San Borja, years of continuous residence in the community and household size.

The results show that the likelihood of coping alone decreases by 1.35% with a one standard deviation increase in the FICCI score over the sample mean FICC score of 0.138, decreases by 0.05% with a one year increase in age and increases by 0.7% if the adult is male. The likelihood of coping alone is significantly reduced by 0.6% as the distance from town increases one standard deviation above the mean walking distance of 3.21 hours. Household size is another variable that was shown to be significantly correlated with the strategy to cope alone; an increase of one member above the mean family size of 7.06 members reduced the likelihood of the individual coping alone by 0.5%. The average FICCI score of individuals who coped on their own was -0.426, i.e. they were on average food insecure.

The likelihood of relying on the market increased by 0.65% with a one standard deviation increase in the FICCI score above the mean FICCI score of 0.138. The likelihood of adopting this strategy decreased by 0.3% if the subject was male and it increased by 0.2% with a one member increase in the family size above the mean household size of 7.06. The coefficient for the distance from town seems counter intuitive as it shows that with a one standard deviation increase above the mean distance of 3.21 hours, the likelihood of relying on the market increased by 0.3%. However, the individuals who relied on this mechanism had an average FICCI score of 0.264, which was higher than any of the other FICCI score averages given in Table 3, which indicates they had more resources than any of the other groups. This could mean that individuals who had more resources had the means to access markets and hence rely on it as a coping mechanism.

People who received help from local agencies had an average score of -0.065, i.e. they were relatively more secure than the people who coped alone but still insecure. The regressions results show that with an increase in the FICCI score the likelihood of relying on local institutes decreased by 0.2%, increased by 0.35% if the subject was male. The likelihood of getting assistance from local institutes was significantly affected by subject's traditional knowledge, i.e. with a one standard deviation increase in the subject's traditional knowledge above the mean score of 10.58, the likelihood of relying on local institutes decreased by 0.37%. This implies that subjects with more traditional knowledge relied less on local institutional help. A standard deviation increase in the mean walking distance from town significantly increased the likelihood, by 1.6%, of the individual relying more on local agencies. Households that received help from non-Tsimane' agencies had an average FICCI score of 0.033 and the likelihood of relying on this source increased significantly with an increase in the index score; with a one standard deviation increase in the FICCI score above the mean FICCI score, the likelihood of receiving assistance from non-Tsimane' institutes increased by 5.9%. The likelihood of receiving this sort of help decreased by 5.1% with a one standard deviation increase in the walking distance from town above the mean time of 3.21 hours. The household size

also significantly influenced the likelihood of getting assistance from an external institute since a one standard deviation increase in the family size above the average family size increased the likelihood by 2.4%.

Individuals who relied on other coping strategies (which were not specified in the data) were likely to be relatively secure, male, have less traditional knowledge and live closer to town. They would have also lived longer in the community and would have smaller families. Individuals who reported having done nothing to cope with the flood had positive FICCI scores (closer to 0), lived closer to town and had smaller households.

Analyzing these results under the conditions of the third hypothesis, we see that the relatively insecure individuals are more likely to cope alone and not the more secure ones as hypothesized. However there is evidence of the more secure households relying on the market as a coping mechanism. Finally for institutional assistance the results show that local institutes were more likely to assist the more insecure individuals whereas the non-Tsimane' institutes helped the relatively secure ones. However looking at the mean index scores of the population assisted by both the institutions it can be derived that neither one is reaching out to the most insecure. The average FICCI score for individuals who relied on the market to cope was 0.264, i.e. they were the most secure group amongst these groups of individuals whereas the people who relied on no one but themselves had an average FICCI score of -0.426, which was the lowest amongst these groups. Individuals who received help from local institutes and those who received help from non-Tsimane' institutes had average FICCI scores of -0.065 and 0.033 respectively, which are lower than the average for people who relied on the market but are still higher than the average for the people who relied only on themselves. The results for institutional assistance, however, are ambiguous in that some institutes help the insecure whereas some seem to assist the relatively more secure individuals. Nonetheless, what is more obvious is that the most insecure individuals might not be covered by institutional assistance.

9.4. Determinants of Variability in FICCI

The final hypothesis tested by the study was that there are certain attributes of the household head and of the household that create inter-household variability in the food security scores. For the purpose, the education, skills (ability to speak Spanish, write and perform basic mathematical calculations) and parental education variables for the household head and the size and distance of the household from town were regressed on the Index to determine the correlation between these variables and the household's level of food security. The regression results are presented in Table 4 on page 32.

According to the analysis, an additional year of schooling of the household head decreases the level of household food security and the affect is more pronounced if the

Table 4: Regression Analysis of the Determinants of Inter-household Variability in FICCI scores

Dependent Variable: Household Food Security Score		
Household Head	Male	Female
Regressor		
Maximum schooling attained	-0.004 (0.29)	-0.021 (0.05)
Spanish speaking ability	0.009 (0.102)	-0.041 (0.096)
Ability to write	0.046 (0.101)	-0.132 (0.132)
Math proficiency	-0.109 (0.067)	0.044 (0.081)
Subject's knowledge of edible wild plants	0.065** (0.02)	0.074** (0.021)
Distance in hours between the village and the town of San Borja	-0.057** (0.021)	-0.06** (0.022)
Household size	0.077** (0.022)	0.111** (0.022)
Subject's father's education	0.002 (0.002)	-0.003 (0.002)
Subject's mother's education	-0.002 (0.002)	0.0001 (0.003)
N	209	221
R-squared (%)	36.35	26.17

Note: For the detailed description of the variables used in this table, refer to Table 5 in Appendix 3.

The model was estimated using Ordinary Least Square (OLS). The standard errors are given in parentheses under the coefficients and individual coefficients are statistically significant at the *5% level ($p < 0.05$) or the ** 1% level ($p < 0.01$).

household head is female; -0.021 for females compared to -0.004 for males. If the male household head was able to speak Spanish and was able to write, the FICCI score increased whereas the same variables had a negative correlation with the household food security score if the household head was female. The reverse was seen to be the case for math skills, i.e. if the male household head had was more proficient in math his household's score would decline by 0.109 points but if the female household head had higher math skills her household's FICCI score would improve by 0.044. The attribute of the household head that was shown to be most significantly correlated with the Index score was the level of traditional knowledge (as represented by the knowledge of wild

plants) and this was the case for both males and females. The traditional knowledge of the female head had a slightly greater impact on the level of household food security compared to the traditional knowledge of the male head; i.e. with a 1% increase in traditional knowledge of the female head, the household FICCI score would increase by 0.074 standard deviations whereas a 1% increase in the traditional knowledge of the male head would increase the FICCI score by 0.065 standard deviations.

The education level of the household head's (male or female) parents was insignificantly correlated with the level of food security of the household. However it is interesting to note that if the household head was female, her father's education had a negative impact on her household's level of food security and if the household head was male then his mother's education had a negative impact on his household's FICCI score. This could mean that more educated mothers were more concerned about the well-being of their daughters whereas more educated fathers were concerned more about the well-being of their sons, which was later on reflected, at least to some extent, in the level of food security of the families of their offspring.

Both the household attributes tested in the regression, i.e. distance from town and household size, had a significant impact on the household food security score. With an hour's increase in the walking distance from town, the FICCI score for the household decreased by approximately 0.06 points. The household size actually had a positive correlation with the food security score and the magnitude of the coefficient was bigger (0.111 compared to 0.077 for male head) if the household was headed by a female.

Based on this analysis we can conclude that skills such as the ability to speak Spanish, write and math skills have different affects on the household level of food security depending on the gender of the household head. Education on its own (excluding the skills just mentioned) is shown to reduce the level of household food security. However this outcome should be analyzed in conjunction with the coefficients of on parental education, which show that mother's education improves the food security level of her daughter's family and that father's education improves the food security of his son's family. Therefore education of the household head might have a negative correlation with the food security level of the current generation, it has implications for future generations and both men and women need to be educated to ensure that their children receive attention from at least one of the parents.

Overall, the analysis reveals that in the case of male headed households, if the household head had fewer years of formal schooling but could speak Spanish and had the ability to write, had more traditional knowledge, had educated father and lived in a bigger household that was closer to town, the household had a higher food security score. In case of female headed households, if the head had fewer years of schooling but was proficient in math, had more traditional knowledge, had an educated mother and lived in

a bigger household that was closer to town, the household had a higher food security score. The male and female headed households were shown to be quite similar in the analysis with the exception of the affects of individual skills and parental education, which although had different outcomes for male and female heads were statistically insignificant. Therefore gender of the household head does not seem to be a significant driver of inter-household inequality but factors like traditional knowledge, wealth, distance from town and household size are important determinants.

9.5. Limitations and Biases

Firstly, for the purpose of testing the first hypothesis, the sample population has been divided into two distinct groups, i.e. food secure and food insecure. In reality this might not be the case and there might not be such a strict dichotomous division; rather there will be several different categories in between these two extremes, such as moderately secure or moderately insecure or food insecure with hunger or food insecure without hunger and so on. The Index created for the study does allow the user to conduct such an analysis- in fact the Index has been used as a continuous rather than dichotomous variable to test the other three hypotheses. However, for the purpose of the first hypothesis it was considered sufficient to use just two classifications.

Secondly the data used to test for how households coped with shocks required the 2005 data set to be merged with the 2006 module on shocks and coping strategies, since the food security index was created using the 2005 data set. There is no evidence to suggest it but there is a possibility of improper matching of some attributes with subject or household identification numbers. Moreover since data from two different years is being used, some of the subjects that were interviewed in the 2005 survey might have left the community or died and might not be a part of the 2006 round of survey. Therefore there is a possibility of attrition bias. There could also be possible random measurement errors in variables such as the amount of food consumed where the subjects were required to recall the amount of food consumed over the seven days before the day of the interview.

10. Conclusions and Recommendations

This study has developed a composite food security measurement index, the FICCI, which uses six household-level variables that are indicative of access to food, availability of food and nutritional adequacy of food consumed. The index was developed to test four hypotheses.

The first hypothesis was that FICCI is a useful tool for separating the food insecure from the food secure and that there are significant differences in the demographics,

anthropometrics and expenditures of the households that are segregated as such. It was found that the households that were identified as insecure, had younger household members, had more females and had members with smaller physical stature and lower weight-for-age Z scores. Members of insecure households also had a low perception of the adequacy of the food that they consumed and spent less on food on average compared to the members of secure households. Therefore FICCI can be used to differentiate between the secure and insecure households within a community, based on their demographic, anthropometric and expenditure traits.

The second hypothesis tested was whether households with lower food security scores lowered their food consumption in response to the shock of flood. The test results support the hypothesis since the households that reduced their overall kilocalorie consumption in fact had lower FICCI scores than households that increased kilocalorie consumption after the flood. Since there is support for the first hypothesis, the index could be used before the shock to identify households with low food security scores to fortify their resilience against shocks. A more disaggregated analysis might be required at this stage to determine the components that the households fall short on. So for instance if the household is insecure because it does not have access to storage facilities, where crops and seeds can be stored, interventions can be designed to provide such households with access to a collective storage facility perhaps. Similarly for households that are not consuming adequate amounts of food, food stamps or supplemental feeding programs can be introduced, depending on the specific circumstances.

The third hypothesis tested whether the secure individuals relied more on their own coping abilities and whether institutional help was given to the more insecure population. The results show that in fact people with the lowest FICCI scores tried to cope with the shock themselves whereas the more secure the household was the more likely it was to rely on the market and to receive help from non-Tsimane' institutions. Local institutes helped the relatively insecure members of the community, which could suggest that understanding of the local conditions is important to ensure that assistance reaches the vulnerable population. This finding can also be taken to suggest that perhaps more of the responsibility for distribution of aid to the local people should be assigned to local institutions. The results also suggest that the most insecure individuals were not covered by institutional assistance, which could be attributed to the lack of proper identification and targeting mechanisms.

The fourth hypothesis was designed to identify some of the drivers of inter-household differences in food security as reflected in the difference in scores. The analysis finds that the traditional knowledge of the household head bears a positive correlation with the level of household food security. Moreover it was found that bigger households that lived closer to town were more secure. Education of the household head does not seem to have any positive affect on the current generation but it has implications for the food security level of future generations; educated mothers will have daughters with more secure

households and educated fathers will have sons with more secure households. Keeping these results in view, if interventions to promote education are designed and if food security is to be protected or enhanced, then both men and women need to be targeted and the programs should not be designed to substitute traditional knowledge, rather they should complement that knowledge. To reduce distance from the facilities available in town, either transportation needs to be improved or those facilities need to be brought closer to the community or in to the community itself.

Food insecurity is a cause of concern for many regions around the world. The issues of current and future availability of food, access to food, nutritional adequacy of food and risks and uncertainties surrounding access and availability all need to be addressed for the problem of food insecurity to be fully addressed. The spread and depth of this problem makes its measurement a challenging task. Nevertheless food insecurity is a problem that requires immediate solutions since there are severe short and long-term physiological and economic repercussions of not addressing this problem at not only the individual and household level but also at the societal level.

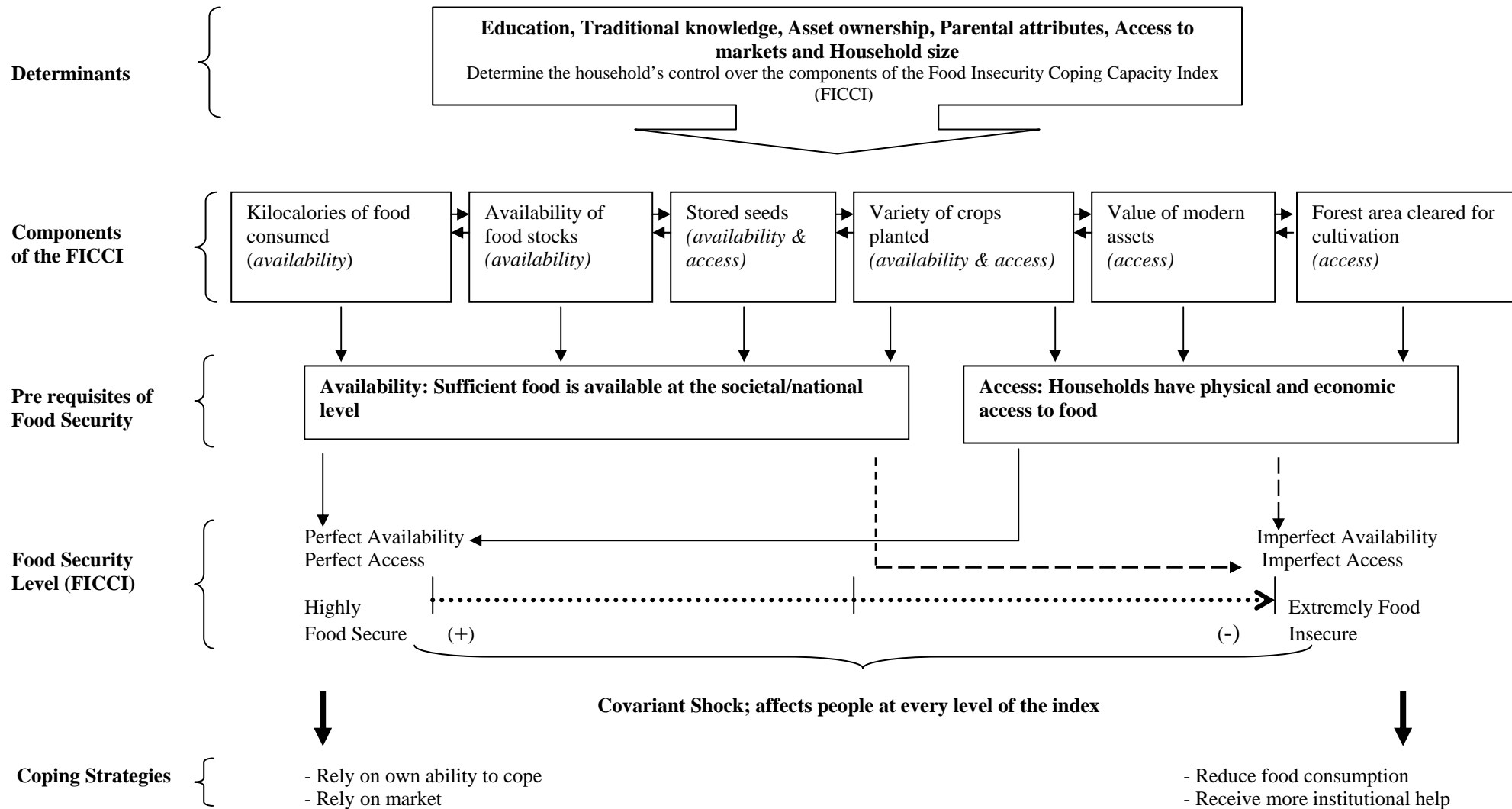
To find appropriate solutions to the problem of food insecurity, it is essential to be able to measure the severity of this problem as well as to determine how it affects different individuals and groups within a society. Unless we are able to measure this phenomenon precisely we cannot expect to find long lasting solutions that are in accordance with the magnitude and complexity of the issue. Moreover, if we cannot measure food insecurity we cannot determine its exact effects on the different segments of the population and thus we cannot differentiate between the at-risk and secure population. Unless we can make this distinction we cannot design targeted, pre or post-crisis, interventions to address the specific needs of the vulnerable group(s). In the absence of specific measure the best we can do is design the one-size-fits-all type of interventions, which are unlikely to address the special needs of the vulnerable. Aid and development agencies and institutions continue to confront the problem of separating the people and households who are most at-risk or who need immediate assistance from the relatively secure ones or who can wait to receive assistance.

The use of a measurement tool such as a food security/insecurity index offers a solution that addresses not only the multi-dimensionality of food security but also the issue of separating the food insecure from the food secure. Such a measurement tool is best designed and tested in a pre-crisis situation since its construction requires identification of appropriate variables and an understanding of the local conditions, which cannot be done in a crisis situation due to the immediate need for assistance. However once the index has been created it can be used to identify the insecure and design interventions that strengthen their resilience against unforeseen events that might adversely affect food security. In a post-crisis situation, the index can be used to direct institutional assistance first and foremost to those who need it the most.

Food insecurity measurement indices offer a solution that attempts to capture the complex interactions between different factors that ultimately determine how food secure or insecure a household is. These factors vary from region to region and their identification requires time and in-depth understanding of the situation. The set of components used in this study is just one of the many different combinations of factors and indicators that can be used to generate quantitative measurement indices; hence there is much room for experimentation and growth in this area. Moreover measures of food security and hunger need not necessarily be quantitative; in some cases qualitative assessment might be more relevant. Once developed, such measures can be used before a shock hits a community, as a crisis prevention mechanism. In the post-shock scenario, for such tools to be useful, they have to be readily available and pre-tested for fitness. The need is to continually study the circumstances surrounding household food security under different environmental, societal and geographic conditions and to create relevant measures so that, whenever needed, there are a variety of tools to choose from to assess food insecurity under different conditions.

Appendix 1

Figure 1: Conceptual Framework: Household Food Security; Determinants, Components and Relation with Coping Strategies



Appendix 2

Conversion of Kilograms of Food into Kilocalories of Food Consumed

Food	% Edible	Energy (Kcal)	Per 100 g edible					
			Proteins		Fat		Carbohydrates	
all fish	47.0	132.0	18.8	75.2	5.7	51.3	0.0	0.0
sardines	100.0	189.0	21.0	84.0	11.0	99.0	0.0	0.0
beef	84.0	273.0	17.5	70.0	22.0	198.0	0.0	0.0
bread	100.0	350.0	6.1	24.4	5.2	46.8	69.7	278.8
charqui	100.0	509.0	60.0	240.0	28.0	252.0	0.0	0.0
chicken	61.0	200.0	20.2	80.8	12.6	113.4	0.0	0.0
corn	35.0	360.0	9.3	37.2	4.0	36.0	73.5	294.0
cow head	82.5	457.0	11.9	47.6	45.0	405.0	0.0	0.0
duck	61.0	340.0	16.2	64.8	30.0	270.0	0.0	0.0
eggs	89.0	163.0	12.4	49.6	11.7	105.3	0.9	3.6
flour	100.0	350.0	11.7	46.8	1.5	13.5	74.3	297.2
pigeon pea	100.0	343.0	21.7	86.8	1.5	13.5	62.8	251.2
lard	100.0	847.0	2.0	8.0	93.0	837.0	0.0	0.0
oil	100.0	884.0	0.0	0.0	100.0	900.0	0.0	0.0
pasta	100.0	367.0	11.0	44.0	1.1	9.9	76.3	305.2
plantain	66.0	113.0	1.2	4.8	0.5	4.5	29.2	116.8
pork	82.5	457.0	11.9	47.6	45.0	405.0	0.0	0.0
rice	100.0	359.0	7.1	28.4	1.1	9.9	78.0	312.0
sugar	100.0	387.0	0.0	0.0	0.0	0.0	100.0	400.0
yuca	80.0	160.0	1.4	5.4	0.3	2.5	38.1	152.4

Source: Bill Leonard; Department of Anthropology, Northwestern University, Evanston, Illinois, USA.

Appendix 3

Table 5: Description of Variables Used in the Analyses

Variable Name	Description/Survey Question	Unit of Measurement
Table 1		
Adult population (age \geq 18)	The number of people in the sample population aged 18 years or more	Number of years
Child population (age $<$ 18)	The number of people in the sample population who are younger than 18 years	Number of years
Old population (age \geq 60)	The number of people in the sample population aged 60 years or more	Number of years
Years of residence in the community (for population \geq 18 years)	How long has the household head been living in the village	Number of years
Body fat for age \geq 18	Body fat assessed from total body density and its estimation from skinfold thicknesses, for subjects 18+ years of age	Millimeters
Height-for-age Z-score for age $<$ 18	These are values for height relative to the height norms (calculated by the National Center for Health Statistics) for individuals from birth up to 18 years of age	Deviation from the pre-calculated norm
Physical stature	Subject's height in centimeters	Centimeters
Weight-for-age Z-score age $<$ 18	These are values for weight relative to the weight norms (calculated by the National Center for Health Statistics) for individuals from birth up to 18 years of age	Deviation from the pre-calculated norm
Incidence of anger	How many times did the subject feel angry in the 7 days before the day of the interview	Number of reported instances
Incidence of fear	How many times did the subject feel afraid in the 7 days before the day of the interview	Number of reported instances
Perception of how well they ate	How well did the subject eat over the 7 days before the day of the interview	0= not well at all, 1=well, 2= extremely well
Expenditure on all food by household in the past week	Kilograms of home-grown wheat, rice, plantain, pigeonpea* village price/kg of wheat, rice, plantain, pigeonpea + meat (bought and hunted)* village price of meat/kg meat+ bought starches and oil *village price of starches and oil	bolivianos
Expenditure by individual on durable kitchen assets in the last 2 weeks	Bolivianos spent by subject on durable kitchen assets during the 14 days before the day of the interview	bolivianos
Table 3		
Variable Name	Description/Survey Question	Unit of Measurement
Knowledge of edible	Cultural competence score in multiple choice	Sliding scale

wild plants	on plants	
Walking distance to town (San Borja)	Hours walking from village to town of San Borja in dry season (12hrs=1day)	Number of hours
Household size	Number of people in the household at the time of the interview	Number of people
Table 4		
Maximum Schooling Attained	Maximum level of schooling achieved by the subject	Reported number of years of school attended
Spanish speaking ability	Does the subject speak Spanish	0=none, 1=some, 2=fluent
Ability to Write	Can the subject write his/her own name	0=can not, 1=with some difficulty, 2=well
Math Proficiency	Can the subject add, subtract, multiply and divide	0=no, 1=add, 2=add & subtract, 3=add, subtract & multiply, 4=all four functions
Total animal, traditional and modern wealth	[(chicken, cows, pigs)*village price of each animal + (canoes, mortars, bows)*village price of each item+(bikes, shotguns, rifles, pots, hooks, knives)*village price of each item]	bolivianos
Subject's father's education	Maximum years of schooling of the subject's father	Reported number of years of school attended
Subject's mother's education	Maximum years of schooling of the subject's mother	Reported number of years of school attended
Coped Alone (1 if individual coped alone, 0 otherwise)	(a) Individual relied on him/herself or (b) asked immediate family for assistance after the flood	Individual coped alone if (a) and (b) or if either (a) or (b)
Relied on Market (1 if individual relied on market, 0 otherwise)	Individual (c) sold forest goods, (d) took formal credit, (e) relied on wage labor	Individual relied on market if all or anyone of (c), (d) or (e) were adopted
Received help from local institute (1 if help was received from local institute, 0 otherwise)	Local institutes included the (f)Tsimane' local government, (g) the local missionaries , (h) the TAPS project team, and (i) hospital in San Borja	Individual relied on local institutes if she/he received help from any or all of (f), (g) , (h) and or (i)
Received help from non-Tsimane' Institute (1 if assistance was provided by an outside institute, 0 otherwise)	Non-Tsimane' institutes included (j) The Red cross and (k) the municipal government	Individual relied on non-Tsimane institutes if help was received from (j) and or (k)
Some other strategy (1 if the individual reported adopting some other strategy, 0 otherwise)	If the Individual reported adopting none of the strategies (a) to (k) but did report doing something to cope with the flood shock then it was recorded as some other strategy	Individual relied on some strategy other than strategies (a) to (k)
Variable Name	Description/Survey Question	Unit of Measurement
Did nothing (1 if the individual reported	If the individual neither adopted anyone of the strategies (a) to (k) nor reported having	

doing nothing to cope with the flood)	adopted some other strategy then the individual then it was recorded as doing nothing	
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