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Dietary Diversity as a Household Food Security Indicator

May 2002

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EXECUTIVE SUMMARY

Household food security is an important measure of well-being. Food security encompasses three dimensions: availability (a measure of food that is, and will be, physically available in the relevant vicinity of a population during a given period); access (a measure of the population's ability to acquire available food during a given period); and utilization (a measure of whether a population will be able to derive sufficient nutrition during a given period). Although it may not encapsulate all dimensions of poverty, the inability of households to obtain access to enough food for a productive healthy life is an important component of their poverty.

Devising an appropriate measure of the access component of food security (household food access) is useful in order to identify the food insecure, assess the severity of their food shortfall, characterize the nature of their insecurity (for example, seasonal versus chronic), monitor changes in circumstances, and assess the impact of interventions. However, obtaining detailed data on household food access– such as 24 hour recall data on food intakes - can be time consuming, expensive, and requires a high level of technical skill both in data collection and analysis.

This paper examines whether a proxy indicator, dietary diversity, defined as the number of unique foods consumed over a given period of time, is a good measure of household food access. It draws on data from ten countries: Bangladesh, Egypt, Ghana, India, Kenya, Malawi, Mali, Mexico, Mozambique, and the Philippines. It uses linear regression techniques to investigate the magnitude of the association between dietary diversity and household food access as well as correlation coefficients, contingency tables and Receiver Operator Curves.

On average, a 1% increase in dietary diversity is associated with a 1% increase in household per capita consumption, a 0.7% increase in household per capita caloric availability, a 0.5% increase in household per capita caloric availability from *staples*, and a 1.4% increase in household per capita caloric availability from *non- staples.* Eliminating the extreme estimates, a 1 per cent increase in dietary diversity is associated with households experiencing between a: 0.65 to 1.11 per cent increase in household per capita consumption; 0.37 to 0.73 per cent increase in household per capita caloric availability; 0.31 to 0.76 per cent increase in caloric availability from staples; and 1.17 to 1.57 per cent increase in caloric availability from non-staples. These associations are found in both rural and urban areas, across seasons, do not depend on the method used to assess these associations, and are equally as strong when using the number of unique food groups consumed as the measure of dietary diversity. Across these ten country data sets, the magnitude of the association between dietary diversity and household per capita caloric availability at the household level increases with the mean level of household per capita caloric availability. Accordingly, dietary diversity would appear to show promise as a means of measuring household food access, monitoring changes and impact, particularly when resources for such measurement are scarce.

1. INTRODUCTION

Household food security is an important dimension of well-being. Food security encompasses three dimensions: availability (a measure of food that is, and will be, physically available in the relevant vicinity of a population during a given period); access (a measure of the population's ability to acquire available food during a given period); and utilization (a measure of whether a population will be able to derive sufficient nutrition during a given period). Although it may not encapsulate all dimensions of poverty, the inability of households to obtain access to enough food for a productive healthy life is an important component of their poverty. In this context, devising an appropriate measure of household food access is useful for several reasons: to identify the food insecure; to characterize the nature of their insecurity (for example, seasonal versus chronic); to monitor changes in their circumstances; and to assess the impact of interventions. However, obtaining detailed data on household food access – such as 24 hour recall data on food intake - can be time consuming, expensive, and requires a high level of technical skill both in data collection and analysis.

The juxtaposition of the value of indicators of food security, together with the difficulties in obtaining detailed information, is the motivation for this paper. It explores whether dietary diversity - the number of different foods or food groups consumed over a given reference period – can act as a proxy indicator of household food access under a variety of circumstances including poor and middle-income countries, rural and urban areas and across seasons. Field experience indicates questions on dietary diversity are relatively straightforward for respondents to answer, are not considered intrusive, and do not impose burdensome demands on time or recall. Asking these questions typically takes less than 10 minutes per respondent. But while dietary diversity is clearly simpler to collect than data on caloric availability from 7 day recall of food acquisition or 24 hour recall of individual food intakes, in order for it to be appropriate as a proxy measure, it is necessary to show that it is strongly correlated with more conventional measures of household food access.

Below we present evidence on this issue from ten countries: Bangladesh, Egypt, Ghana, India, Kenya, Malawi, Mali, Mexico, Mozambique, and the Philippines. These data sets encompass both poor and middle income countries, rural and urban areas, data collected in different seasons, and data on caloric availability obtained using both recall on food acquisition and 24 hour recall on individual food intake. To be confident that our results are not driven by the use of a particular method or variable, we examine associations between dietary diversity (defined as the number of unique foods consumed in the previous seven days) and household per capita consumption; household per capita caloric availability; household per capita caloric availability from *staples*; and household per capita caloric availability from *non-staples*. Additionally, we explore the associations between number of unique food groups consumed in the previous seven days and these variables. We do so using linear regression techniques; we also check for the robustness of

results by calculating three other measures of association: correlation coefficients (Pearson and Spearman); contingency tables; and Receiver Operator Curves (ROC).[1]
On average, a 1% increase in dietary diversity is associated with a 1% increase in household per capita consumption, a 0.7% increase in household per capita caloric availability, a 0.5% increase in household per capita caloric availability from *staples*, and a 1.4% increase in household per capita caloric availability from *non-staples*. Eliminating the extreme estimates, a 1 per cent increase in dietary diversity is associated with households experiencing between a: 0.65 to 1.11 per cent increase in household per capita consumption; 0.37 to 0.73 per cent increase in household per capita caloric availability; 0.31 to 0.76 per cent increase in caloric availability from staples; and 1.17 to 1.57 per cent increase in caloric availability from non-staples. These associations are found in both rural and urban areas, across seasons, do not depend on the method used to assess these associations, and are equally as strong when using the number of unique food groups consumed as the measure of dietary diversity rather than the number of unique foods.

There is also an association between dietary diversity and caloric availability measured at the individual level. Looking across all the country data sets examined, the magnitude of the association between dietary diversity and per capita caloric availability at the household level increases with the mean level of caloric availability. Accordingly, dietary diversity would appear to show promise as a means of measuring food security, monitoring changes and impact, particularly when resources for such measurement are scarce.

[1] The correlation coefficients (Pearson and Spearman), contingency tables, and Receiver Operator Curves results are available in a separate Technical Appendix from the FANTA project website www.fantaproject.org or directly from the FANTA project.

2. BACKGROUND: RATIONALE, METHODS AND DATA

Determining whether dietary diversity meets the criteria of a good indicator of food security requires that we define what we mean by "food security" and what we mean by a "good indicator". We follow the USAID concept of food security, namely that food security is "when all people at all times have both the physical and economic access to sufficient to meet their dietary needs in order to lead a healthy and productive life. (USAID, 1992). There are three dimensions to this definition of food security: availability (a measure of food that is, and will be, physically available in the relevant vicinity of a population during a given period); access (a measure of the population's ability to acquire available food during a given period); and utilization (a measure of whether a population will be able to derive sufficient nutrition during a given period).

The data available to us contain information on the value of household consumption of food and non-food goods (what we will call "consumption"), the amount of food consumed by all household members over the last seven days (what we will call "food acquisition") and, for two data sets, the amount of food consumed by individual household members as measured using intake techniques over a 24 hour period (what we will call "food intake"). We use the data on food acquisition to calculate the amount of calories accessed by the household (what we call "caloric availability"). For two data sets, the Philippines and Bangladesh, we also calculate per capita caloric availability using the 24-hour recall on individual food intakes. Given these data, we assess the usefulness of dietary diversity as an indicator of the "access" dimension to food security by considering the following questions:

- How strong is the correlation between dietary diversity and household consumption, and dietary diversity and caloric availability, the latter also being separated into staples and non-staples?
- Is this correlation observed across a variety of countries?
- Does the strength of this correlation vary seasonally?
- Is this correlation observed in both rural and urban areas?

a) Rationale for focusing on dietary diversity as a food security indicator

Dietary diversity – the number of different foods or food groups consumed over a given reference period - is an attractive indicator for four reasons.[2] First, a more varied diet is a valid outcome in its own right. Second, a more varied diet is associated with a number of improved outcomes in areas such as birthweight (Rao *et. al.*, 2001), child anthropometric status (Allen *et. al.*, 1991; Hatloy, Hallund, Diarra and Oshaug, 2000; Onyango, Koski and Tucker, 1998; Taren and Chen, 1993; and Tarini, Bakari and Delisle, 1999), improved hemoglobin concentrations (Bhargava, Bouis and Scrimshaw, 2001), reduced incidence of hypertension (Miller, Crabtree and Evans,

[2] Earlier studies on this include Hatloy, Torheim and Oshaug (1998), Lorenzana and Sanjur (1999) and Morris (1999).

1992), reduced risk of mortality from cardiovascular disease and cancer (Kant, Schatzkin and Ziegler, 1995). Third, questions on dietary diversity can be asked at the household or individual level, making it possible to examine food security at the household and intra-household levels. Fourth, obtaining these data is relatively straightforward. Our own field experience indicates that training field staff to obtain information on dietary diversity is not complicated, and that respondents find such questions relatively straightforward to answer, not especially intrusive, and not especially burdensome. Asking these questions typically takes less than 10 minutes per respondent.

b) Methods

Broadly speaking, the literature exploring associations between measures of food security uses one of two approaches.

The first focuses on dichotomizing households into two groups: those who are food secure and those who are food insecure. These are used in the construction of c*ontingency tables*, which cross classify indicators. For example, households could be classified by whether per person caloric availability is above or below a certain value (the "cut-off") and cross classified against dietary diversity. Studies that have used this approach include Chung, Haddad, Ramakrishna and Riely (1997) and Habicht, Meyers and Brownie (1982).

A drawback to contingency tables (as well as related approaches such as logits and ROC analysis) is that the cut-off is based on an estimate of caloric requirements. The measurement of these requirements is based on a formula that takes into account the age, sex, physiological status and activity levels of individuals (see Swindale and Ohri-Vachaspati, 1999, for a detailed explanation and examples.) Any arbitrariness in these calculations is carried over to the calculation of the cut-off. In the case of contingency tables, further arbitrariness is introduced via the choice of the cut-off for the proxy indicator. Also, these analyses do not take into account the fact that there are variations in the severity of food insecurity. No distinction is made between misclassifying a household just below the caloric threshold and one far below this cut-off. Put another way, by restricting our analysis to a zero-one (yes-no) variable, we throw away information on the variation in caloric availability and this would seem to be informationally inefficient.[3]

An alternative approach is to construct measures of association treating both the underlying measure of food security and the proxy as continuous variables. Pearsonian and Spearman correlation coefficients are index numbers that show to what extent two variables are linearly related. However, these correlation indices have several limitations. First, an observed correlation could be driven by just one part of the distribution of joint variables. Suppose that for most households, there is little correlation between dietary diversity and caloric availability. But for very rich households the correlation is quite high. As a consequence, the calculated coefficient might just prove to be statistically significant. A second problem is that of false correlation where some other variable is correlated with both measures, producing a false

[3] Brownie, Habicht and Cogill (1986) suggest a method for remedying this limitation. Unfortunately, our data do not satisfy the preconditions they specify if their approach is to be used.

correlation between the two variables that are observed. An alternative approach that overcomes these limitations is linear regression techniques. The dependent variable is the measure of household consumption or caloric availability. Dietary diversity appears as a right-hand side variable; the coefficient on dietary diversity indicates how many additional calories are associated with an increase of one unit of dietary diversity, controlling for confounding factors such as household size, age and education of head and location. If both dietary diversity and the dependent variable are expressed in logarithmic terms, the estimated coefficient is also the elasticity; ie the percentage change in the dependent variable given a one percent change in dietary diversity.

As part of discussions of methodology, it is also useful to consider the construction of the measure of dietary diversity itself. One approach, suggested by Kant *et al* (1991), Hatloy, Torheim and Oshaug (1998) and Swindale and Ohri-Vachaspati (1999), is to count the number of food groups consumed. Kant *et al* and Hatloy, Torheim and Oshaug suggest eight groups. Swindale and Ohri-Vachaspati suggest the twelve groups used to construct the FAO food balance sheets. An alternative approach, suggested by Krebs-Smith *et al.* (1987), Drewnowski *et al.* (1997) and Hatloy, Torheim and Oshaug (1998), is to count each food item separately. There are advantages and disadvantages to both approaches. Knowing, for example, that a household consumes four food groups, as opposed to four different types of cereals, is more indicative of a diverse diet. Conversely, changes in food consumption resulting from higher incomes may be evidenced by improved quality of foods rather than consumption of different food groups.[4] Consequently, the analysis described below uses both food groups and number of unique foods consumed.

c) Data sets

We use ten data sets for our analysis, from Bangladesh, Egypt, Ghana, India, Kenya, Malawi, Mali, Mexico, Mozambique, and the Philippines. All data sets were collected with input from the International Food Policy Research Institute. We pay particular attention to the sample-specific measurements of dietary diversity, consumption, caloric availability and intake.

When presenting such descriptive material, one can easily be overwhelmed by detail. To simplify presentation, Tables 1 and 2 provide a summary of these surveys. Table 1 provides basic information on the survey period, number of observations and a brief description of the survey. Table 2 explains how total consumption, caloric availability and number of unique foods were calculated for each survey.

From each data set, we extracted the following information: a unique household identifier; a set of variables denoting location; a dummy variable for rural/urban; household size; household per capita consumption; household per capita caloric availability from recall food acquisition data

[4] Whether this is captured in the data depends partly on household behaviour and partly on the design of the questionnaire. For example, suppose households choose to consume rice rather than millet as their incomes rise. This will be captured in the data collected provided that both millet and rice are listed in the questionnaire. But suppose that households choose to shift from a lower to higher grade of rice as their incomes rise. A questionnaire only listing “rice” will not capture this change.

and, in the case of the Philippines and Bangladesh surveys, 24 hour recall individual food intakes. In nine surveys, per capita caloric availability was further disaggregated into calories from staples and from non-staples.[5] Prior to analysis, the data were checked for outliers, defined as household daily per capita caloric consumption below 1400 kcal or above 4500 kcal.[6] There were only a trivial number of such outliers in all surveys except for Mozambique. In that survey, respondents were asked to report quantities using physical units that they regarded as being most appropriate. In practice, it proved difficult to convert many of these into metric units. Using the same cut-offs as used in the other surveys would have resulted in a massive loss of sample size. Consequently, for this sample alone, we followed the suggestion of Datt, Simler, Mukherjee and Dava (2000) and dropped 665 observations (8% of the sample) with household daily per capita caloric availability less than 500 kcal and 1037 observations (12% of the sample) with caloric availability above 5000 kcal.

These ten data sets permit a variety of comparisons. The Egypt and Mozambique surveys allow us to see whether dietary diversity is associated with household food access in both rural and urban areas. The Philippines and Bangladesh data sets allow us to examine whether the manner in which data on household food access are obtained affects our findings. The India, Bangladesh and Philippines surveys provide information on household consumption, caloric availability and dietary diversity at different points throughout the crop year.

Table 3 provides some descriptive statistics on these samples. The samples are ordered from those with the lowest to highest level of mean household per capita caloric availability. By this measure, the households in the India sample are least well-off, followed by the Accra, Ghana and Bukindon, Philippines sample. Note that expressed in terms of the number of unique foods consumed, these households appear to enjoy a varied diet, even when compared to the better-off households elsewhere. In part, this may be due to differences in questionnaire design, as there was no limited on the number of possible unique foods that could be consumed. But also note that non-staple foods contribute very little in the way of calories in the Philippines, and also in the two Maharashtra villages in the India sample (see Chung, Haddad, Ramakrishna and Riely, 1996, p. 77).

[5] It was not possible to do this with the Indian data as this level of disaggregation is not found in the version of the data set available to us.
[6] These figures were chosen as they were approximately 50 per cent lower and higher than estimates of daily caloric requirements for an adult equivalent, such as those reported in Swindale and Ohri-Vachaspati (1999).

Table 1. Survey descriptions

Survey	Survey period	Sample size by round	Survey description	Reference document
Bangladesh	June-September 1996 (*Aman rice crop*, lean period); October-December 1996 (*Aman harvest*); February-May 1997 (post harvest); June-September 1997 (*Aman rice crop*, lean period)	955 (June-Sep 1996); 949 (Oct-Dec, 1996); 948 (Feb-May, 1996); 946 (Jun-Sep 1997)	Survey data was collected to assess the impact of new agricultural technologies. Three sites were chosen: Saturia thana in Manikganj district with commercial vegetable production technology, Jessore Sadar thana in Jessore district with group managed fish ponds and Gaffargaon thana in Mymensingh district and Pakundia and Kishoreganj Sadar thanas in Kishoreganj district with individually owned fish ponds. At each site, three different types of households were selected: (a) households that were NGO members and adopted new technology in villages where the technology had been disseminated;(b) households that were NGO members, lived in villages where technology was not yet made available but were likely to adopt the technology when introduced, and (c) a sampling of all other remaining households (non-NGO members and NGO members who had not adopted) in both types of villages.	IFPRI (2000)
Egypt	March – May 1997	1115 (urban); 1311 (rural)	The Egypt Integrated Household Survey (EIHS), a nationwide, multiple-topic household survey administered in 20 governorates (covering both urban and rural localities) using a two-stage stratified selection process that ensured that the data were nationally representative.	Datt, Jolliffe and Sharma (1998)
Ghana (Accra)	January – April 1997	558	The Accra Urban Food and Nutrition Security Study was based on a sampling frame of 879 urban and 33 peri-urban enumeration areas (EAs). EAs were selected using a systematic sample from a random start. 36 households were selected in 16 primary sampling units; the sample is representative of households with children under age 3.	Maxwell, Levin, Armar-Klemesu, Ruel, Morris and Ahiadeke (2000)
India	August – September 1992 (poor food availability in Dokur and Shirapur, moderate availability in Kanzara and surplus in Aurepalle); January-February 1993, (post-rainy season, food surpluses everywhere); June-July 1993 (monsoon, poor food availability in all localities.)	321 (Aug –Sep 1992); 308 (Jan-Feb 1993); 308 (June-July 1993)	Sample is a resurvey of four villages that were part of ICRISAT’s longitudinal village level studies, Kanzara, Shirapur, Aurepalle and Dokur.	Chung, Haddad, Ramakrishna and Riely (1996)
Kenya	December 1985 (pre-harvest,short rains crop); July 1986 (post-harvest, long rains); February-March 1987 (pre-harvest, long rains)	583 (Dec 1985); 593 (July 1986); 587 (Feb-Mar 1987)	Households are located in South Nyanza District, Nyanza Province where a new sugar factory was constructed in the early 1980s. Households surveyed had at least one preschooler, less than 20 ha of land and a resident farmer or were displaced by the creation of the sugar factory or were manual workers at the factory.	Kennedy and Cogill (1987); Kennedy (1989)
Malawi	January – February 1998 (pre-harvest period)	706	Survey data were collected to assess the impact of participation of two rural development projects on income and food security in Kandeu Extension Planning Area (Central Region). Farm households with no more than 10 hectares of land were selected from lists of participants in each project. Non-beneficiary households for the control group were randomly selected for each beneficiary household in the sample using a ‘random walk’ procedure, a variant of the EPI-cluster sampling method.	Carletto (1999)
Mali	August – September 1997 (pre-harvest period); October-November 1997; March-April 1998; August 1998 (pre-harvest period)	272 (Aug – Sep 1997); 255 (Aug 1998)	Survey was conducted in the Zone Lacustre region in order to assess food security in this very poor locality and to test different methodologies for assessing food security. Ten villages near the town of Niafunke participated in a four round household survey as well as participatory rapid appraisal activities. Rounds 1 and 4 used here.	Christiaensen (1999)

Table 1 cont. Survey descriptions

Survey	Survey period	Sample size by round	Survey description	
Mexico	June 1999; November 1999	22229 (June 1999); 23248 (November 1999)	These two "ENCEL" surveys were fielded in 505 rural localities in seven south-central Mexican states, Guerrero, Hidalgo, Michoacan, Puebla, Queratáro, San Luis Potosi and Veracruz. Approximately 60 per cent of surveyed households received cash benefits as part of Mexico's *PROGRESA* social program.	Hoddinott, Skoufias and Washburn (2000)
Mozambique	February 1996 – April 1997	2023 (urban); 4525 (rural)	Data are taken from the *Inquerito Nacional aos Agregados Familiares Sobre As Condicoes de Vida (MIAF)* or National Household Survey on Living Conditions. The survey covered all ten of Mozambique's provinces as well as the city of Maputo and is nationally representative.	Datt, Simler, Mukherjee and Dava (2000)
Philippines	August 1984 (harvest period, maize); December 1984; April 1985 (height of hungry season); August 1985 (harvest period, maize)	448 (Aug 1984); 448 (Dec 1984); 448 (Apr 1985); 448 (Aug 1985)	Data were collected in the southern part of Bukidnon Province, located on the southern island of Mindanao as part of research on the impact of cash crop production on nutrition.	Bouis and Haddad (1990); Bouis and Haddad (1992)

Table 2. Construction of key variables

Survey	Method for calculating consumption	Method for calculating caloric availability	Method for calculating number of unique foods consumed
Bangladesh	Self-reported recall information on food consumption (derived from purchases, own-production, payment in-kind and transfers): (a) cereals and fish - last 3 days; (b) pulses, edible oil, and vegetables – last 7 days (c) spices- 2 weeks (14 days) and (d) animal products, fruits and other foods - last 1 month – all converted into the equivalent of seven day recall data. Non-food items recorded as expenditures incurred in the previous week, month and three months. *In addition*, wife of household head provided 24 hour recall data on the amount of ingredients used to prepare each recipe for meal, the amount served and the amount each household member ate.	Self-reported physical consumption of foods consumed in last month converted to grams, adjusted for processing and converted to kilocalories. *In addition*, 24 hour recall data on individual consumption converted to calories and aggregated over all household members.	Count of number of unique foods consumed in previous month. *In addition*, count of number of unique foods consumed in 24 hours by all household members.
Egypt	Self-reported consumption (derived from purchases, own-production and transfers) of 123 pre-coded food items consumed in last seven days valued at local prices was recorded. Non-food items were reported as expenditures incurred in the previous week, month and three months. Estimates made of imputed value of owner occupied housing and household durable goods.	Self-reported physical consumption of foods consumed in last seven days converted to grams, adjusted for processing and converted to kilocalories.	Count of number of unique foods consumed in previous seven days.
Ghana (Accra)	Self-reported consumption (derived from purchases, own-production and transfers) of 160 pre-coded food items consumed in last seven days valued at local prices was recorded. These were grouped into 14 categories of which four included prepared foods pre-cooked, ready to eat and obtained outside the home. Non-food items were recorded as expenditures incurred over a variety of recall periods.	Self-reported physical consumption of foods consumed in last seven days converted to grams, adjusted for processing and converted to kilocalories.	Count of number of unique foods consumed in previous seven days.
India	Self-reported consumption (derived from purchases, own-production, payment in-kind and transfers) of food items consumed in last seven days. Most common items were pre-coded, but questions were open-ended so households could include any food items acquired. Non-food items were reported using a flexible period of recall.	Self-reported physical consumption of foods consumed in last seven days converted to grams, adjusted for processing and converted to kilocalories.	Count of number of unique foods consumed in previous seven days.
Kenya	In each survey round, self-reported consumption of food items consumed in last seven days. Non-food items were reported using a flexible period of recall.	Self-reported physical consumption of foods consumed in last seven days converted to grams and converted to kilocalories (unclear if adjusted for processing).	Count of number of unique foods consumed in previous seven days.
Malawi	In each survey round, self-reported consumption (derived from purchases, own-production, payment in-kind and transfers) of 62 pre-coded food items consumed in last seven days valued at local prices was recorded. Non-food items were recorded as expenditures incurred in the previous week, month and six months.	Self-reported physical consumption of foods consumed in last seven days converted to grams, adjusted for processing and converted to kilocalories.	Count of number of unique foods consumed in previous seven days.

Table 2 cont. Construction of key variables

Survey	Method for calculating consumption	Method for calculating caloric availability	Method for calculating number of unique foods consumed
Mali	In each survey round, self-reported consumption (derived from purchases, own-production, payment in-kind and transfers) of 72 pre-coded food items consumed in last seven days valued at local prices was recorded. Non-food items were recorded as expenditures incurred in the previous week, month and six months.	Self-reported physical consumption of foods consumed in last seven days converted to grams, adjusted for processing and converted to kilocalories.	Count of number of unique foods consumed in previous seven days.
Mexico	In each survey round, self-reported consumption (derived from purchases, own-production and transfers) of 35 pre-coded food items consumed in last seven days valued at local prices was recorded. Non-food items were recorded as expenditures incurred in the previous week, month and six months.	Self-reported physical consumption of foods consumed in last seven days converted to grams, adjusted for processing and converted to kilocalories.	Count of number of unique foods consumed in previous seven days.
Mozambique	Three interviews were used. In the first interview, self-reported consumption of food items consumed (derived from purchases, own-production and transfers) the previous day was recorded. In the second and third interviews, physical consumption of "major" food items in the previous three days was recorded. Most common items were pre-coded, but questions were open-ended so households could include any food items acquired. Non-food items were reported as expenditures incurred in the previous week, month and three months. Estimates made of imputed value of owner occupied housing and household durable goods.	Self-reported physical consumption of foods consumed over three recall periods summed, converted to grams, adjusted for processing and converted to kilocalories.	Count of number of unique foods consumed in previous seven days.
Philippines	In each survey round, self-reported consumption (derived from purchases, own-production, payment in-kind and transfers) of 50 pre-coded food items consumed in the last month was recorded. Non-food items were reported as expenditures incurred in the previous four months. *In addition*, the wife of the household head provided 24 hour recall data on the amount of ingredients used to prepare each recipe for each meal, the amount served and the amount each household member ate.	Self-reported physical consumption of foods consumed in last month converted to grams, adjusted for processing and converted to kilocalories. *In addition*, 24 hour recall data on individual consumption converted to calories and aggregated over all household members.	Count of number of unique foods consumed in previous month. *In addition*, count of number of unique foods consumed in 24 hours by all household members.

Table 3. Basic descriptive statistics

Country/locality	Number of observations	Mean Household per capita consumption in local currency	Mean Household per capita consumption in PPP dollars	Mean Daily per capita caloric availability from acquisition recall data	Mean Daily per capita caloric availability from *staples* from acquisition recall data	Mean Daily per capita caloric availability from *non-staples* from acquisition recall data	Mean number of unique foods consumed	Maximum number of unique foods consumed
Bangladesh, round 1	955	160	16	2310	1815	495	30	67
Bangladesh, round 2	949	144	14	2225	1788	441	29	57
Bangladesh, round 3	948	171	15	2503	1954	563	32	65
Bangladesh, round 4	946	170	15	2453	1862	599	33	59
Bangladesh, pooled	3798	161	15	2373	1854	524	31	67
Egypt, urban	1115	56	56	3474	1697	1776	28	58
Egypt, rural	1311	31	31	3746	2222	1525	25	56
Egypt, full sample	2426	43	43	3611	1961	1650	27	58
Ghana (Accra)	558	19773	45	1717	1002	715	39	89
India, round 1	321	62	11	1610			37	77
India, round 2	308	47	8	1578			47	78
India, round 3	308	56	9	1539			48	74
India, pooled	937	55	10	1576			44	78
Kenya, round 1	583	60	9	2306	1670	636	21	50
Kenya, round 3	593	63	9	2143	1534	609	19	43
Kenya, round 4	587	71	10	2282	1663	619	20	41
Kenya,pooled	1763	65	9	2243	1622	621	20	50
Malawi	706	336	48	2850	1599	1251	10	22
Mali, round 1	272	2721	14	2982	2656	326	9	20
Mali, round 4	255	2934	14	2480	2203	277	8	18
Mali, pooled	527	2832	14	2739	2437	302	8	20
Mexico, Progresa	22229	54	9	2447	1849	602	17	35
Mexico, Progresa	23248	49	8	2200	1559	642	18	35
Mexico, Progresa	45477	52	9	2321	1699	622	18	35
Mozambique, urban	2023	59557	20	2075	1145	929	15	35
Mozambique, rural	4525	37372	12	2065	1084	981	9	30
Mozambique, All	6548	44226	14	2068	1103	965	11	35
Bukindon, Philippines	448	49	10	1926	1610	325	34	64
Bukindon, Philippines	448	43	9	1794	1504	290	33	61
Bukindon, Philippines	448	47	9	1910	1616	294	33	67
Bukindon, Philippines	448	45	9	1765	1482	283	33	68
Bukindon, Philippines	1792	46	9	1849	1550	298	34	68

Note: Expenditures are on weekly basis.
Source: PPP conversion factors were obtained from WDI 2001 CD-ROM

3. Results

a) Introduction

We now turn to the results of applying the methodologies described in section 2b to the data described in section 2c. We consider, in turn, associations between dietary diversity (number of unique foods consumed) and four indicators of household food access: 1) per capita consumption, 2) per capita caloric availability, 3) per capita caloric availability from staples (cereals and cereal products) and 4) per capita caloric availability from non-staples. We also consider associations between the number of unique food groups consumed and these four characteristics. For the latter work, we divided foods into the following categories: country specific basic staples (eg. maize in Mozambique, rice in Bangladesh); country specific "luxury staples" (eg. macaroni and fino bread in Egypt; breakfast cereal in Mexico); vitamin A rich roots, tubers, vegetables and fruits; beans, soya and other pulses; dairy; fats; sugars; meat, fish and eggs; other roots and tubers; other fruits; other vegetables; and beverages, spices and other products. This section focuses on summarizing these results and providing some explanatory notes.

A challenge in presenting these results is summarizing the many measures of association that have been estimated. Applying the four methods described above to assess the association between dietary diversity as measured by the number of unique foods consumed and the number of unique food groups consumed to household per capita consumption, per capita caloric availability, per capita caloric availability from staples and per capita caloric availability from non-staples using both a common and nationally specific cut-off for caloric adequacy for the 34 data sets available to us (recall that for many surveys, we have more than one round, and in some cases we have caloric availability for the same sample from two methods) produces more than 1300 measures of association.[7]

In light of this, our discussion focuses on the regression coefficients we obtain when exploring the relationship between dietary diversity and these measures of household food access. These coefficients are based on the following regressions:

Log household per capita consumption = $\alpha + \beta \cdot$ (Log of number of unique foods consumed) + "control variables" + disturbance term (1)

Log household per capita caloric availability = $\alpha + \beta \cdot$ (Log of number of unique foods consumed) + "control variables" + disturbance term (2)

Log household per capita caloric availability from staples= $\alpha + \beta \cdot$ (Log of number of unique foods consumed) + "control variables" + disturbance term (3)

Log household per capita caloric availability from non-staples = $\alpha +$ $\beta \cdot$ (Log of number of unique foods consumed) + "control variables"

[7] The complete set of results run to 22 single spaced pages. They are available in a separate Technical Appendix from the FANTA project website www.fantaproject.org or directly from the FANTA project.

+ disturbance term (4)
and
Log household per capita consumption = $\alpha + \beta \cdot$ (Log of number of unique food groups consumed) + "control variables" + disturbance term (5)
Log household per capita caloric availability = $\alpha + \beta \cdot$ (Log of number of unique food groups consumed) + "control variables" + disturbance term (6)
Log household per capita caloric availability from staples= $\alpha + \beta \cdot$ (Log of number of unique food groups consumed) + "control variables" + disturbance term (7)
Log household per capita caloric availability from non-staples = α + $\beta \cdot$ (Log of number of unique food groups consumed) + "control variables" + disturbance term (8)

Our decision to focus on the regression results is based on three considerations. First, using any of the methods we described above yields the same pattern of association between dietary diversity and household food access. So we do not lose information, or mislead in any way, if we examine the regression results in detail. Second, an attraction of these results is that the coefficients are readily interpretable in terms of the strength of association. Because we use a "log-log" specification, the coefficients are also elasticities; a coefficient of 0.696 on dietary diversity for urban Mozambique in equation (2) indicates that a 1 per cent increase in dietary diversity is associated with a 0.696 per cent increase in household per capita caloric availability. An urban Mozambiquan household with dietary diversity 20 per cent below the mean has household per capita caloric availability 14 per cent below the mean.[8] Third, these regressions control for confounding factors such as household size, age and education of head and location. These controls serve two roles. It may be the case that the availability of foods varies by location. Consider two localities, a very poor urban area with access to a wide variety of foods, and a moderately well-off rural area where staples and a handful of non-staple foods are available. A comparison of mean values might show that the poorer urban locality is characterized by greater dietary diversity and lower caloric availability, with the converse holding in the rural locality. In this simple comparison, it would appear that dietary diversity is inversely related to household food access, but such an observation is driven by the availability of different foods. The second role for these controls is to take into account, albeit rather crudely, differences in tastes and preferences. A household with a large number of adults may be more likely to contain individuals with a wider range of tastes; tastes may also vary with age and education. Given these possibilities, an attraction of focusing on the multivariate regressions is that they permit us to explore these associations, controlling for confounding factors such as tastes and physical availability of different foods.[9]

[8] To see this, multiply 20% by 0.696.
[9] Haddad, Sullivan and Kennedy (1994) correctly point out that regression analysis will be unsatisfactory when outliers in the data exert excessive leverage on the parameter estimates. As a check on these results, we re-estimated these regressions used least absolute deviation (LAD) estimators. Because LAD estimators pass through the median, not the mean, they are not susceptible to the influence of outliers. Doing so produces only trivial differences in the results reported here.

These regression results are summarized in Tables 4 through 11. Appendix one provides a visual representation of these findings.

Table 4. Parameter estimates for association of dietary diversity (number of unique foods consumed) with per capita consumption

Survey	Parameter estimate for dietary diversity	Mean per capita caloric availability	Mean dietary diversity	Maximum dietary diversity
India, post-harvest season (round 2)	0.390 (3.41)**	1578	47	78
Mozambique, rural	0.614 (28.68)**	2065	9	30
India, hungry season (round 3)	0.619 (2.72)**	1539	48	74
Mali, hungry season 1998 (round 4)	0.543 (5.44)**	2480	8	18
Malawi	0.634 (10.45)**	2850	10	22
Accra, Ghana	0.654 (10.24)**	1717	39	89
India, early hungry season (round 1)	0.661 (7.35)**	1610	37	77
Mali, hungry season 1997 (round 1)	0.819 (8.44)**	2982	9	20
Egypt, urban	0.829 (9.60)**	3474	28	58
Egypt, rural	0.865 (20.68)**	3746	25	56
Kenya, hungry season (round 4)	0.882 (7.55)**	2282	20	41
Philippines, early hungry season (round 2)	0.953 (14.63)**	1794	33	61
Bangladesh, lean season (round 3)	0.987 (7.52)**	2503	32	65
Philippines, post-harvest season (round 1)	0.990 (13.11)**	1926	34	64
Mozambique, urban	1.002 (21.69)**	2075	15	35
Philippines, hungry season (round 3)	1.059 (13.34)**	1910	33	67
Philippines, post-harvest season (round 4)	1.083 (12.80)**	1765	33	68
Kenya, early hungry season (round 1)	1.111 (16.55)**	2306	21	50
Bangladesh, post-harvest season (round 2)	1.161 (19.68)**	2225	29	57
Bangladesh, lean season (round 1)	1.203 (19.08)**	2310	30	67
Kenya, post-harvest season (round 3)	1.250 (7.55)**	2143	19	43
Mexico, November 1999	1.309 (86.57)**	2200	18	35
Bangladesh, lean season (round 4)	1.326 (10.87)**	2453	33	59
Mexico, June 1999	1.373 (81.80)**	2447	17	35

Notes: * significant at the 5% level; ** significant at the 1% level. Dietary diversity is the number of unique foods consumed. Control variables are log household size, log age of head, education of head and location.

Table 5. Parameter estimates for association of dietary diversity (number of unique foods consumed) with per capita caloric availability using recall data

Survey	Parameter estimate for dietary diversity	Mean per capita caloric availability	Mean dietary diversity	Maximum dietary diversity
India, post-harvest season (round 2)	-0.067 (1.31)	1578	47	78
India, early hungry season (round 1)	0.036 (0.28)	1610	37	77
India, hungry season (round 3)	0.167 (2.20)*	1539	48	74
Mali, hungry season 1998 (round 4)	0.342 (3.71)**	2480	8	18
Philippines, post-harvest season (round 1)	0.367 (6.38)**	1926	34	64
Mozambique, rural	0.369 (16.66)**	2065	9	30
Malawi	0.371 (7.48)**	2850	10	22
Philippines, early hungry season (round 2)	0.465 (8.58)**	1794	33	61
Philippines, post-harvest season (round 4)	0.481 (7.67)**	1765	33	68
Philippines, hungry season (round 3)	0.545 (9.71)**	1910	33	67
Accra, Ghana	0.599 (10.74)**	1717	39	89
Mexico, November 1999	0.605 (39.87)**	2200	18	35
Mali, hungry season 1997 (round 1)	0.665 (6.24)**	2982	9	20
Bangladesh, lean season (round 1)	0.690 (12.87)**	2310	30	67
Mozambique, urban	0.695 (20.72)**	2075	15	35
Egypt, rural	0.707 (18.34)**	3476	25	56
Egypt, urban	0.709 (15.73)**	3746	28	58
Bangladesh, post-harvest season (round 2)	0.728 (8.66)**	2225	29	57
Mexico, June 1999	0.781 (36.63)**	2447	17	35
Kenya, hungry season (round 4)	0.879 (8.62)**	2282	20	41
Kenya, early hungry season (round 1)	1.036 (14.72)**	2306	21	50
Kenya, post-harvest season (round 3)	1.152 (16.13)**	2143	19	43
Bangladesh, lean season (round 4)	1.222 (8.09)**	2453	33	59
Bangladesh, lean season (round 3)	1.321 (6.17)**	2503	32	65

Notes: * significant at the 5% level; ** significant at the 1% level. Dietary diversity is the number of unique foods consumed. Control variables are log household size, log age of head, education of head and location.

Table 6. Parameter estimates for association of dietary diversity (number of unique foods consumed) with per capita caloric availability from staples using recall data

Survey	Parameter estimate for dietary diversity	Mean per capita caloric availability	Mean dietary diversity	Maximum dietary diversity
Mozambique, rural	0.073 (1.82)	2065	9	30
Philippines, post-harvest season (round 1)	0.184 (2.88)**	1926	34	64
Mali, hungry season 1998 (round 4)	0.206 (2.11)**	2480	8	18
Malawi	0.249 (4.27)**	2850	10	22
Philippines, early hungry season (round 2)	0.311 (5.05)**	1794	33	61
Philippines, post-harvest season (round 4)	0.320 (4.58)**	1765	33	68
Egypt, urban	0.369 (7.30)**	3474	28	58
Philippines, hungry season (round 3)	0.413 (6.94)**	1910	33	67
Mexico, November 1999	0.423 (24.80)**	2200	18	35
Bangladesh, lean season (round 1)	0.469 (7.71)**	2310	30	67
Egypt, rural	0.487 (9.87)**	3476	25	56
Mozambique, urban	0.512 (8.75)**	2075	15	35
Mali, hungry season 1997 (round 1)	0.580 (5.01)**	2982	9	20
Bangladesh, post-harvest season (round 2)	0.594 (3.11)**	2225	29	57
Mexico, June 1999	0.634 (28.97)**	2447	17	35
Accra, Ghana	0.654 (10.23)**	1717	39	89
Bangladesh, lean season (round 3)	0.759 (5.89)**	2503	32	65
Bangladesh, lean season (round 4)	0.763 (6.55)**	2453	33	59
Kenya, hungry season (round 4)	0.782 (7.11)**	2282	20	41
Kenya, early hungry season (round 1)	1.027 (11.73)**	2306	21	50
Kenya, post-harvest season (round 3)	1.126 (12.27)**	2143	19	43

Notes: * significant at the 5% level; ** significant at the 1% level. Dietary diversity is the number of unique foods consumed. Control variables are log household size, log age of head, education of head and location.

Table 7. Parameter estimates for association of dietary diversity (number of unique foods consumed) with per capita caloric availability from non-staples using recall data

Survey	Parameter estimate for dietary diversity	Mean per capita caloric availability	Mean dietary diversity	Maximum dietary diversity
Malawi	0.663 (7.74)**	2850	10	22
Accra, Ghana	0.822 (10.86)**	1717	39	89
Mozambique, rural	1.011 (23.40)**	2065	9	30
Mexico, November 1999	1.101 (23.40)**	2200	18	35
Mozambique, urban	1.167 (22.35)**	2075	15	35
Mali, hungry season 1998 (round 4)	1.191 (9.60)**	2480	8	18
Kenya, early hungry season (round 1)	1.291 (11.26)**	2306	21	50
Mali, hungry season 1997 (round 1)	1.308 (8.48)**	2982	9	20
Mexico, June 1999	1.347 (53.86)**	2447	17	35
Egypt, urban	1.373 (9.39)**	3474	28	58
Philippines, post-harvest season (round 4)	1.381 (18.49)**	1765	33	68
Kenya, post harvest season (round 3)	1.416 (16.33)**	2143	19	43
Egypt, rural	1.418 (11.74)**	3476	25	56
Bangladesh, post-harvest season (round 2)	1.469 (27.71)**	2225	29	57
Philippines, post-harvest season (round 1)	1.490 (16.38)**	1926	34	64
Philippines, early hungry season (round 2)	1.552 (15.20)**	1794	33	61
Bangladesh, lean season (round 3)	1.567 (10.84)**	2503	32	65
Philippines, hungry season (round 3)	1.583 (14.26)**	1910	33	67
Kenya, hungry season (round 4)	1.589 (11.48)**	2282	20	41
Bangladesh, lean season (round 1)	1.601 (23.08)**	2310	30	67
Bangladesh, lean season (round 4)	1.613 (28.17)**	2453	33	59

Notes: * significant at the 5% level; ** significant at the 1% level. Dietary diversity is the number of unique foods consumed. Control variables are log household size, log age of head, education of head and location.

Table 8. Parameter estimates for association of dietary diversity (number of food groups consumed) with per capita consumption

Survey	Parameter estimate for food groups	Mean per capita caloric availability	Mean dietary diversity	Maximum dietary diversity
Mali, hungry season 1998 (round 4)	0.485 (2.58)**	2480	8	18
Mozambique, rural	0.618 (22.97)**	2065	9	30
Malawi	0.633 (8.82)**	2850	10	22
Mali, hungry season 1997 (round 1)	0.829 (4.97)**	2982	9	20
Kenya, hungry season (round 4)	0.860 (5.77)**	2282	20	41
Egypt, urban	0.874 (6.30)**	3474	28	58
Mozambique, urban	1.049 (14.55)**	2075	15	35
Accra, Ghana	1.064 (9.80)**	1717	39	89
Egypt, rural	1.077 (13.05)**	3476	25	56
Bangladesh, lean season (round 3)	1.092 (5.41)**	2503	32	65
Bangladesh, post-harvest season (round 2)	1.139 (9.10)**	2225	29	57
Mexico, June 1999	1.225 (61.44)**	2447	17	35
Mexico, November 1999	1.255 (67.67)**	2200	18	35
Kenya, post harvest season (round 3)	1.338 (13.35)**	2143	19	43
Bangladesh, lean season (round 1)	1.376 (11.73)**	2310	30	67
Kenya, early hungry season (round 1)	1.379 (12.09)**	2306	21	50
Bangladesh, lean season (round 4)	1.510 (7.29)**	2453	33	59
Philippines, hungry season (round 3)	1.602 (8.92)**	1910	33	67
Philippines, early hungry season (round 2)	1.703 (12.15)**	1794	33	61
Philippines, post-harvest season (round 1)	1.822 (9.90)**	1926	34	64
Philippines, post-harvest season (round 4)	2.037 (10.66)**	1765	33	68

Notes: * significant at the 5% level; ** significant at the 1% level. Dietary diversity is the number of unique foods consumed. Control variables are log household size, log age of head, education of head and location.

Table 9. Parameter estimates for association of dietary diversity (number of food groups consumed) with per capita caloric availability

	Parameter estimate for food groups	Mean per capita caloric availability	Mean dietary diversity	Maximum dietary diversity
Mozambique, rural	0.351 (12.77)**	2065	9	30
Malawi	0.377 (6.36)**	2850	10	22
Mali, hungry season 1998 (round 4)	0.485 (2.58)**	2480	8	18
Mexico, November 1999	0.551 (29.45)**	2200	18	35
Philippines, post-harvest season (round 1)	0.587 (4.48)**	1926	34	64
Philippines, early hungry season (round 2)	0.715 (5.98)**	1794	33	61
Mexico, June 1999	0.724 (28.99)**	2447	17	35
Mozambique, urban	0.728 (13.92)**	2075	15	35
Philippines, hungry season (round 3)	0.817 (6.52)**	1910	33	67
Mali, hungry season 1997 (round 1)	0.829 (4.98)**	2982	9	20
Bangladesh, lean season (round 1)	0.884 (9.18)**	2310	30	67
Egypt, urban	0.906 (8.84)**	3474	28	58
Kenya, hungry season (round 4)	0.931 (6.48)**	2282	20	41
Accra, Ghana	0.933 (6.08)**	1717	39	89
Bangladesh, post-harvest season (round 2)	0.933 (5.25)**	2225	29	57
Egypt, rural	0.958 (13.11)**	3476	25	56
Philippines, post-harvest season (round 4)	1.023 (6.12)**	1765	33	68
Kenya, early hungry season (round 1)	1.209 (9.54)**	2306	21	50
Kenya, post harvest season (round 3)	1.315 (11.68)**	2143	19	43
Bangladesh, lean season (round 4)	1.763 (5.58)**	2453	33	59
Bangladesh, lean season (round 3)	2.214 (5.54)**	2503	32	65

Notes: * significant at the 5% level; ** significant at the 1% level. Dietary diversity is the number of unique foods consumed. Control variables are log household size, log age of head, education of head and location.

Table 10. Parameter estimates for association of dietary diversity (number of food groups consumed) with per capita caloric availability from staples

Survey	Parameter estimate for food groups	Mean per capita caloric availability	Mean dietary diversity	Maximum dietary diversity
Mozambique, rural	-0.054 (1.05)	2065	9	30
Mali, hungry season 1998 (round 4)	0.129 (1.08)	2480	8	18
Philippines, post-harvest season (round 1)	0.258 (1.73)	1926	34	64
Mexico, November 1999	0.334 (17.01)**	2200	18	35
Egypt, urban	0.340 (3.61)**	3474	28	58
Philippines, early hungry season (round 2)	0.424 (3.28)**	1794	33	61
Mozambique, urban	0.466 (5.22)**	2075	15	35
Mexico, June 1999	0.557 (22.86)**	2447	17	35
Egypt, rural	0.569 (6.63)**	3746	25	56
Philippines, hungry season (round 3)	0.592 (4.68)**	1910	33	67
Bangladesh, lean season (round 1)	0.613 (5.70)**	2310	30	67
Malawi	0.633 (8.82)**	2850	10	22
Accra, Ghana	0.652 (4.20)**	1717	39	89
Mali, hungry season 1997 (round 1)	0.656 (3.70)**	2982	9	20
Kenya, hungry season (round 4)	0.792 (5.19)**	2282	20	41
Bangladesh, post-harvest season (round 2)	0.820 (1.83)	2225	29	57
Philippines, post-harvest season (round 4)	0.864 (3.73)**	1765	33	68
Bangladesh, lean season (round 4)	0.979 (4.28)**	2453	33	59
Kenya, early hungry season (round 1)	1.118 (6.71)**	2306	21	50
Kenya, post harvest season (round 3)	1.255 (9.05)**	2143	19	43
Bangladesh, lean season (round 3)	1.303 (4.58)**	2503	32	65

Notes: * significant at the 5% level; ** significant at the 1% level. Dietary diversity is the number of unique foods consumed. Control variables are log household size, log age of head, education of head and location.

Table 11. Parameter estimates for association of dietary diversity (number of food groups consumed) with per capita caloric availability from non-staples using recall data

Survey	Parameter estimate for food groups	Mean per capita caloric availability	Mean dietary diversity	Maximum dietary diversity
Malawi	0.632 (6.29)**	2850	10	22
Mozambique, rural	1.046 (19.43)**	2065	9	30
Mexico, November 1999	1.174 (49.23)**	2200	18	35
Mozambique, urban	1.317 (16.10)**	2075	15	35
Mali, hungry season 1998 (round 4)	1.396 (6.12)**	2480	8	18
Mexico, June 1999	1.424 (52.05)**	2447	17	35
Accra, Ghana	1.531 (8.12)**	1717	39	89
Mali, hungry season 1997 (round 1)	1.675 (8.83)**	2982	9	20
Bangladesh, post-harvest season (round 2)	1.711 (12.05)**	2225	29	57
Kenya, post harvest season (round 3)	1.726 (12.13)**	2143	19	43
Bangladesh, lean season (round 1)	1.919 (14.41)**	2310	30	67
Kenya, early hungry season (round 1)	1.947 (9.47)**	2306	21	50
Bangladesh, lean season (round 4)	2.010 (13.48)**	2453	33	59
Kenya, hungry season (round 4)	2.120 (9.09)**	2282	20	41
Bangladesh, lean season (round 3)	2.182 (5.81)**	2503	32	65
Egypt, urban	2.220 (7.03)**	3474	28	58
Egypt, rural	2.280 (9.21)**	3746	25	56
Philippines, post-harvest season (round 4)	2.623 (12.81)**	1765	33	68
Philippines, post-harvest season (round 1)	2.645 (11.05)**	1926	34	64
Philippines, hungry season (round 3)	2.778 (9.25)**	1910	33	67
Philippines, early hungry season (round 2)	2.881 (11.34)**	1794	33	61

Notes: * significant at the 5% level; ** significant at the 1% level. Dietary diversity is the number of unique foods consumed. Control variables are log household size, log age of head, education of head and location.

b) Basic findings

Table 4 reports associations between dietary diversity and household per capita consumption, the latter being a measure of access to food - a measure of the population's ability to acquire available food during a given period. The striking feature of Table 4 is that, irrespective of the sample used (and irrespective of the measure of association employed)[10], there are strong associations recorded between dietary diversity and household per capita consumption.

Table 5 reports associations between dietary diversity and household per capita caloric availability, the latter being another measure of household food access. Across the three survey rounds conducted in the poor, semi-arid region of India, there is no systematic association between dietary diversity and household per capita caloric availability. Indeed, sometimes, as in the post-harvest period, the association is negative, though poorly measured. However, in the remaining 19 samples, the relationship is positive and statistically significant, though there are variations in the magnitude of this association.

Table 6 reports associations between dietary diversity and household per capita caloric availability from staples for all samples except India. Generally, the association is positive and statistically significant. Again, there is considerable variation in the magnitude of these associations, ranging from 0.073 in the case of Mozambique to 1.126 in the case of the post harvest period for the Kenya sample.

Table 7 reports associations between dietary diversity and household per capita caloric availability from non-staples for all samples except India. These results are remarkably consistent across all samples (and measures of association[11]); increases in dietary diversity are associated with increases in the number of calories consumed from non-staples. Apart from the Malawi and Accra samples, the magnitude of association is remarkably similar across these diverse samples.

Tables 8 through 11 provide information on these associations where we use the number of unique food groups, rather than the number of unique foods, as the measure with which we compare to measures of household food access. These results are comparable to those reported in Tables 4 through 7 in that they indicate a well measured association between the number of food groups consumed and household per capita consumption and household per capita caloric availability from non-staples. As in the results for the number of unique foods consumed, there are a number of samples where there is no statistically significant association between the number of food groups consumed and per capita caloric availability from staples. Per capita caloric availability from all foods is associated with the number of food groups consumed though there are marked variations across the samples. As the magnitude of this measure of dietary diversity is small when compared to unique foods, the magnitudes of these associations are, not surprisingly, larger than those reported in the earlier tables.

[10,11] See Technical Appendix available from the FANTA project website www.fantaproject.org or directly from the FANTA project.

c) Comparing associations in urban and rural localities

Two of our samples, Egypt and Mozambique, have data collected in both urban and rural areas. Table 12 compares the parameter estimates on associations by location. In Egypt, the richer sample, there is no meaningful difference between the results for rural and urban areas. In Mozambique, the strength of association appears larger in urban localities; in rural areas it is weaker – and in the case of the association with household per capita calories from staples, non-existent. We return to this feature below.

Table 12. Comparing measures of association between rural and urban areas

Parameter estimate on number of unique foods consumed					
Survey	**Location**	**Per capita consumption**	**Per capita caloric availability**	**Per capita caloric availability from staples**	**Per capita caloric availability from non-staples**
Mozambique					
	Rural	0.614 (28.68)**	0.369 (16.66)**	0.073 (1.82)	1.011 (23.40)**
	Urban	1.002 (21.69)**	0.695 (20.72)**	0.512 (8.75)**	1.167 (22.35)**
Egypt					
	Rural	0.865 (20.68)**	0.707 (18.34)**	0.487 (9.87)**	1.418 (11.74)**
	Urban	0.829 (9.60)**	0.709 (15.73)**	0.369 (7.30)**	1.373 (9.39)**

Notes: * significant at the 5% level; ** significant at the 1% level. Dietary diversity is the (log) number of unique foods consumed. Control variables are log household size, log age of head, education of head and location.

d) Comparing associations across seasons

Table 13 compares the parameter estimates on associations by season for four samples, India, Bangladesh, the Philippines and Kenya. There is some suggestion in these data of seasonal variations. In India, Bangladesh and the Philippines, the magnitudes of association are higher for household per capita caloric availability in the hungry seasons than in the post-harvest seasons (compare rounds 2 and 3 for India; rounds 2 and 4 for Bangladesh; and rounds 1 and 3 for the Philippines). This pattern would appear to be driven by differences in associations for staples (compare rounds 2 and 4 for Bangladesh; and rounds 1 and 3 for the Philippines). One explanation for this could lie in seasonal variations in prices. In the post-harvest period, when staples fall in price, it may make sense for households to "stock up" on staples – that is to say, acquiring calories (and body mass) when it is relatively cheap to do so. This argument is consistent with recent work by Dercon and Krishnan (2000) who look at the determinants of adult nutritional status across seasons in rural Ethiopia. They find that body mass rises sharply in the post-harvest period when calories are cheap to acquire. However, this pattern does not hold for all comparisons of post-harvest and hungry seasons. The opposite pattern is found for the Kenyan sample and there are other periods where the magnitudes of these associations are comparable across seasons in both Bangladesh and the Philippines. This ambiguity in findings may reflect the fact that the "hungry" and "post-harvest" seasons are defined relative to the staple crop. Households in these samples grow both staples and other crops and it may be variations in the harvesting of the latter that lead to the absence of a consistent pattern in these estimates.[12]

Table 13. Comparing measures of association across seasons

Parameter estimate on number of unique foods consumed					
Survey	**Location**	**Per capita consumption**	**Per capita caloric availability**	**Per capita caloric availability from staples**	**Per capita caloric availability from non-staples**
India					
	Post-harvest (r2)	0.390 (3.41)**	-0.067 (1.31)		
	Early hungry (r1)	0.661 (7.35)**	0.036 (0.28)		
	Hungry (r3)	0.619 (2.72)**	0.167 (2.20)*		
Bangladesh					
	Post-harvest (r2)	1.161 (19.68)**	0.728 (8.66)**	0.594 (3.11)**	1.469 (27.17)**
	Early hungry (r3)	0.987 (7.52)**	1.321 (6.17)**	0.759 (5.89)**	1.567 (10.84)**
	Hungry (r4)	1.326 (10.87)**	1.222 (8.09)**	0.763 (6.55)**	1.613 (28.17)**
	Hungry (r1)	1.203 (19.08)**	0.690 (12.87)**	0.469 (7.71)**	1.601 (23.08)**
Philippines					
	Post-harvest (r4)	1.083 (12.80)**	0.197 (7.39)**	0.320 (4.58)**	1.177 (25.35)**
	Post-harvest (r1)	0.990 (13.11)**	0.190 (5.48)**	0.184 (2.88)**	1.124 (19.95)**
	Early hungry (r2)	0.953 (14.63)**	0.197 (6.70)**	0.311 (5.05)**	1.183 (20.45)**
	Hungry (r3)	1.059 (13.34)**	0.228 (7.86)**	0.413 (6.94)**	1.583 (14.26)**
Kenya					
	Post-harvest (r3)	1.250 (7.55)**	1.152 (16.13)**	1.126 (12.27)**	1.416 (16.33)**
	Early hungry (r1)	1.111 (16.55)**	1.036 (14.72)**	1.027 (11.73)**	1.291 (11.26)**
	Hungry (r4)	0.882 (7.55)**	0.879 (8.62)**	0.782 (7.11)**	1.589 (11.48)**

Notes: * significant at the 5% level; ** significant at the 1% level. Dietary diversity is the (log) number of unique foods consumed. Control variables are log household size, log age of head, education of head and location.

[12] For example, in many parts of Africa, legumes and vegetables are harvested prior to the maize crop.

e) Comparing associations by data collection method for caloric acquisition

Lastly, for two samples – the Philippines and Bangladesh – data on caloric availability was obtained in two different ways. We have a measure of caloric availability at the household level based on recall information on food acquisition. Additionally, we have information on caloric intake by individuals based on a 24 hour recall module. This allows us to explore whether our results are sensitive to the manner in which data on caloric availability were obtained. These results are reported in Table 14.

Table 14. Comparing measures of association by data collection method for caloric availability

		Parameter estimate on number of unique foods consumed		
Survey	**Location**	**Per capita caloric availability**	**Per capita caloric availability from staples**	**Per capita caloric availability from non-staples**
Philippines				
Round 1	7 day recall	0.367 (6.38)**	0.184 (2.28)**	1.490 (16.38)**
	24 hour recall	0.190 (5.48)**	0.084 (1.24)	1.124 (19.95)**
Round 2	7 day recall	0.465 (8.58)**	0.311 (5.05)**	1.552 (15.20)**
	24 hour recall	0.197 (6.70)**	0.051 (1.60)	1.183 (20.45)**
Round 3	7 day recall	0.545 (9.71)**	0.413 (6.94)**	1.583 (14.26)**
	24 hour recall	0.228 (7.86)**	0.064 (2.05)*	1.191 (26.59)**
Round 4	7 day recall	0.481 (7.67)**	0.320 (4.58)**	1.381 (18.49)**
	24 hour recall	0.197 (7.39)**	0.024 (0.82)	1.177 (25.35)**
Bangladesh				
Round 1	7 day recall	0.690 (12.87)**	0.469 (7.71)**	1.601 (23.08)**
	24 hour recall	0.093 (10.20)**	0.086 (8.62)**	0.150 (11.46)**
Round 2	7 day recall	0.728 (8.66)**	0.594 (3.11)**	1.469 (27.17)**
	24 hour recall	0.067 (7.54)**	0.063 (6.74)**	0.117 (8.90)**
Round 3	7 day recall	1.321 (6.17)**	0.759 (5.89)**	1.567 (10.84)**
	24 hour recall	0.083 (7.53)**	0.064 (6.07)**	0.123 (9.82)**
Round 4	7 day recall	1.222 (8.09)**	0.763 (6.55)**	1.613 (28.17)**
	24 hour recall	0.113 (11.49)**	0.108 (10.88)**	0.155 (12.00)**

Notes: * significant at the 5% level; ** significant at the 1% level. Dietary diversity is the (log) number of unique foods consumed. Control variables are log household size, log age of head, education of head and location.

There is an unambiguous pattern to these results. There is a statistically significant association between dietary diversity and availability of calories from all foods and from non-staples, regardless of whether data were taken from recall of household food acquisition or 24-hour recall of individual intakes. An association also exists between availability of calories from staples based on 24-hour recall of individual food intakes in the Bangladesh sample but not in the Philippines sample. The magnitudes of these associations are considerably smaller than those for caloric availability at the household level.

4. Conclusion

Tables 4 through 14, together with the results contained in the Technical Appendix,[13] contain an enormous number of estimates of association between dietary diversity and measures of household food access. It is helpful to begin by briefly summarizing these results:

- In every sample, there is a well measured, positive, statistically significant association between dietary diversity and household per capita consumption– a wisely used measure of household food access. This result is obtained irrespective of the measures of association used;
- In every sample, there is a well measured, positive, statistically significant association between dietary diversity and household per capita daily caloric availability from *non-staples*. The quantity of calories from non-staples – arguably an indictor of dietary quality - appears to rise with the number of non-staples consumed;
- In the majority of samples, there is a well measured, positive, statistically significant association between dietary diversity and household per capita daily caloric availability from *staples*. However, there are exceptions such as the Philippines in the post-harvest period and rural Mozambique, Malawi and Mali in the 1998 hungry season.
- In the majority of samples, there is a well measured, positive, statistically significant association between dietary diversity and total household per capita caloric availability. But again there are some exceptions where this relationship is either not statistically significant (as in the three India samples) or relatively small in magnitude, again as in the Philippines in the post-harvest period and rural Mozambique, Malawi and Mali in the 1998 hungry season.
- These associations appear to be found in both rural and urban areas.
- These associations are generally found across all seasons. Although there are variations in these magnitudes, there does not appear to be a systematic pattern to these variations.
- The measurement of these associations does not depend on the method used to assess these associations (See Technical Appendix).
- These associations are also found when using the number of unique food groups consumed as the measure of dietary diversity.
- There is an association between dietary diversity and caloric availability as measured by individual intakes.

Are these results plausible? The associations between dietary diversity and household per capita consumption and per capita caloric availability from non-staples are consistent with econometric studies showing that the income elasticity for the demand for non-staple foods is typically considerably higher than that for staples, see Bouis and Novenario-Reese (1997), Alderman and Lindert (1998) and Hoddinott and Skoufias (2000) for recent examples. The mixed evidence on

[13]See Technical Appendix available from the FANTA project website www.fantaproject.org or directly from the FANTA project.

the associations between dietary diversity and per capita caloric availability from all foods requires a little more detailed explanation.

A good starting point is papers by Subramanian and Deaton (1996), Strauss and Thomas (1995) and Hoddinott, Skoufias and Washburn (2000). These provide non-parametric estimates of the relationship between per capita caloric availability and per capita household consumption for rural India, Brazil and rural Mexico respectively. An attraction of this approach is that it allows the functional form of this relationship to be data driven, rather than imposed externally by the analyst. In particular, it is possible to see how the consumption-calorie elasticity – how caloric availability responds to changes in incomes – evolves as one moves from examining the behaviour of poorer to richer households. The households in Strauss and Thomas's Brazil sample are the richest, followed by Hoddinott, Skoufias and Washburn's Mexican households, with Subramanian and Deaton's Indian households being the poorest. Strauss and Thomas find strong non-linearities in the income-calorie relationship, with elasticities of 0.24-0.33 for households with household per capita consumption below the median. Richer households exhibit much lower estimates that fall towards zero. Hoddinott, Skoufias and Washburn find higher elasticities, around 0.4, with these falling towards 0.2 for the richest deciles. Subramanian and Deaton's work indicate elasticities between 0.3 and 0.5, but with less flattening out at higher values of household per capita consumption.

Hoddinott, Skoufias and Washburn rationalize these findings by appealing to earlier work by Behrman (1988) and Behrman and Deolalikar (1987). The essence of the argument is that at the margin, people select foods for reasons beyond their caloric value. Behrman and Deolalikar (1987) suggest that food variety itself may be valued so that as incomes increase, individuals purchase a wider variety of foods even though this may not affect their caloric intakes very much. This desire for variety is derived from the many characteristics, apart from calories, that different foods possess. These include attributes such as food texture, status value, appearance, taste, aroma and preparation. As a result, below a subsistence constraint, households focus primarily on acquiring additional calories. Once this constraint is met, further increases in income causes the household to move off the subsistence constraint with both calories and dietary diversity increasing.

Meta-regression analysis allows us to explore this possibility more formally.[14] In meta-regression analysis, the dependent variable is a summary statistic drawn from *each* sample. The regression coefficients listed in Table 5 are an example of such a statistic. The independent variables are characteristics of the sample. In our case, we want to determine if variations in mean household per capita caloric availability across samples is associated with variations in the magnitude of association between dietary diversity and household per capita caloric availability.
The results of our meta-regression analysis are reported in Table 15. Despite the fact that we have just 24 samples for these regressions, they appear to produce a fairly clear finding. Specification (1) shows that the magnitude of the association between dietary diversity and per capita caloric availability at the household level rises with the mean level of household per capita caloric availability. Evaluated at the means of the coefficient estimates (0.631) and mean per capita

[14] See Stanley (2001) for a more detailed introduction to meta-regression analysis.

caloric availability (2198), a 1% rise in mean per capita caloric availability increases the magnitude of the association by 1.2%. We also explored whether this change was linear or whether it leveled off at high levels of caloric availability. Specification (2) adds an interaction term between mean per capita caloric availability and a dummy variable equaling one if this mean is in the top quartile of the samples available to us. The negative coefficient on the interaction term shows this flattening effect. Judging by the t statistic, this is a well-measured effect and the R2 indicates that the regression accounts for about half of the variation in these coefficients across all samples. The inclusion of a quadratic term shows a similar effect (results not reported). Lastly, as a check on functional form, we re-estimate the model using the log of mean per capita caloric availability. This produces similar results; a rise in 1% in mean per capita caloric availability increases the magnitude of the association by 1.3%. Note that these results are robust to the inclusion of variables denoting size of sample, mean dietary diversity in sample, maximum dietary diversity in sample and indicator variables denoting that sample is urban and observed in post-harvest period.

Table 15. Meta-regression analysis of the parameter estimates of association between dietary diversity (number of unique foods consumed) with per capita caloric availability under three specifications

	(1)	(2)	(3)
Mean caloric availability	0.000302 (2.22)*	0.000897 (5.01)**	-
Mean caloric availability X Dummy variable =1 if mean caloric availability >2500	-	-0.000355 (4.49)**	-
Log of sample mean caloric availability	-	-	0.825 (2.61)*
F statistic	4.92*	14.61**	6.83*
Adjusted R2	0.19	0.58	0.19
Number of samples	24	24	24

Notes: * significant at the 5% level; ** significant at the 1% level. Dependent variable is the parameter estimate on dietary diversity as reported in Table 3.2. Results are robust to the inclusion of quadratic on mean caloric availability, size of sample, mean dietary diversity in sample, maximum dietary diversity in sample and indicator variables denoting that sample is urban and observed in post-harvest period.

To conclude, we find that as a general rule, changes in dietary diversity – as defined as the number of unique foods consumed – are a good indicator of changes in household per capita consumption and household per capita caloric availability, all measures of the access component of household food security. Changes in dietary diversity are associated with changes in the per capita availability of calories from staples and non-staples, with the magnitude of this association being higher in the case of the latter. This association is observed in both rural and urban locations and in different seasons. It is also observed when dietary diversity is measured as the number of unique food groups consumed. These results are not dependent on the methods used to assess association. We find that dietary diversity is also associated with individual caloric intakes recalled over the previous 24 hours but that the magnitude of this association is considerably smaller.

These findings indicate that households with low levels of dietary diversity are likely to have low levels of consumption per person and low caloric availability. Further, increases in dietary diversity are associated with increases in consumption, caloric availability and calories from staples and non-staples. As such, dietary diversity can play a role in identifying the food insecure, in monitoring changes in circumstances as well as assessing the impact of interventions. Based on the reasonably large number of data sets available to us, we can also suggest the magnitudes of these changes. Eliminating the ‘extreme estimates’ – those found in the bottom and top quartiles of the parameter estimates – a 1 per cent increase in dietary diversity is associated with households experiencing between a: 0.65 to 1.11 per cent increase in household per capita consumption; 0.37 to 0.73 per cent increase in household per capita caloric availability; 0.31 to 0.76 per cent increase in caloric availability from staples; and 1.17 to 1.57 per cent increase in caloric availability from non-staples. The meta-regression results indicate that for caloric availability, differences in these estimates are related to the mean level of caloric availability. Lower estimates are more appropriate in populations with relatively low levels of caloric availability; higher estimates are more appropriate in populations with higher levels of caloric availability.

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APPENDIX

Associations between dietary diversity and food security
and between unique food groups and dietary diversity

FIGURES 1-8

Figure 1: Elasticities of association between dietary diversity and per capita consumption

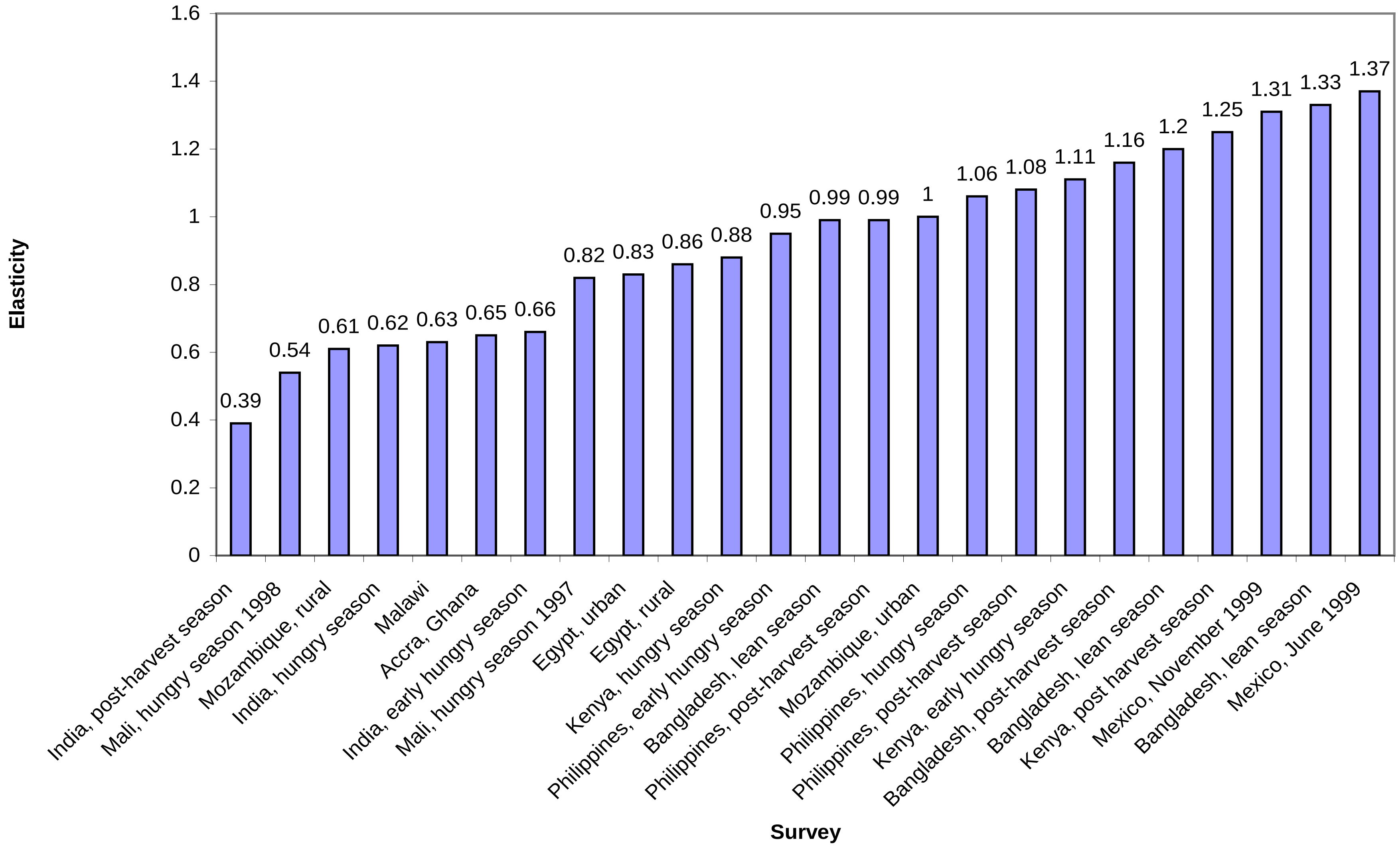

Figure 2: Elasticities of association between dietary diversity and per capita caloric availability

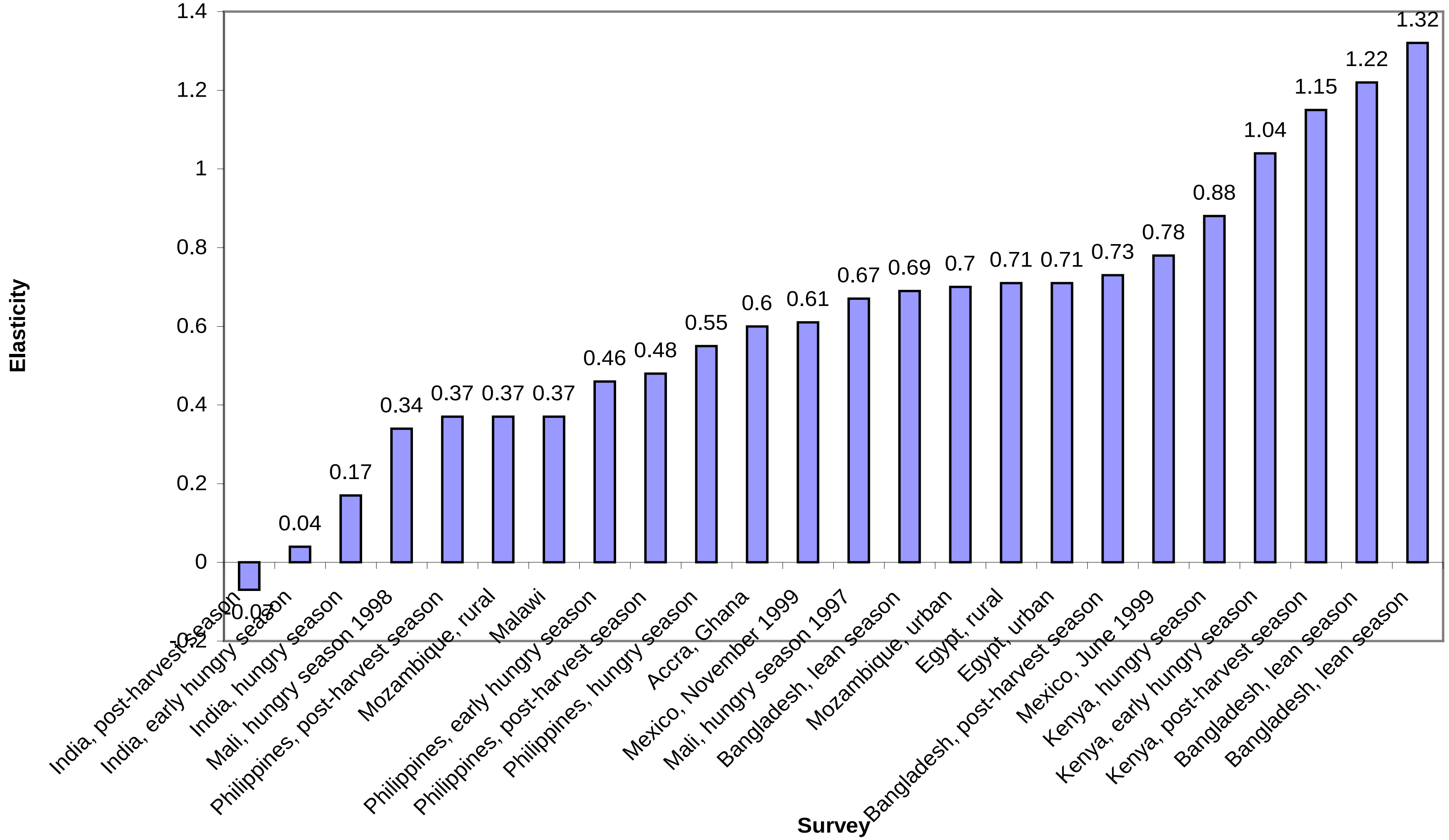

Figure 3: Elasticities of association between dietary diversity and per capita caloric acquisition of staples

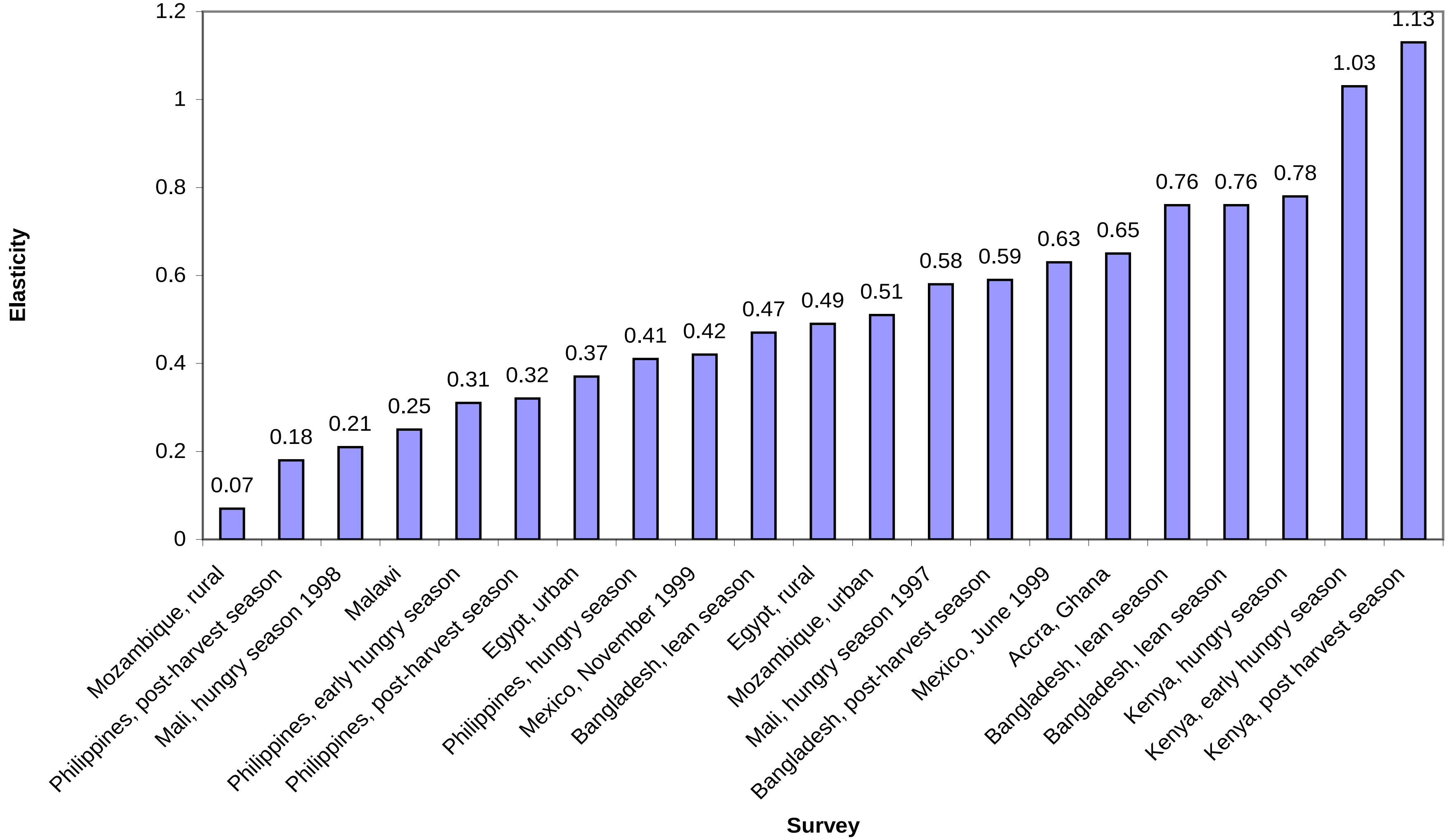

Figure 4: Elasticities of association between dietary diversity and per capita consumption of non-staples

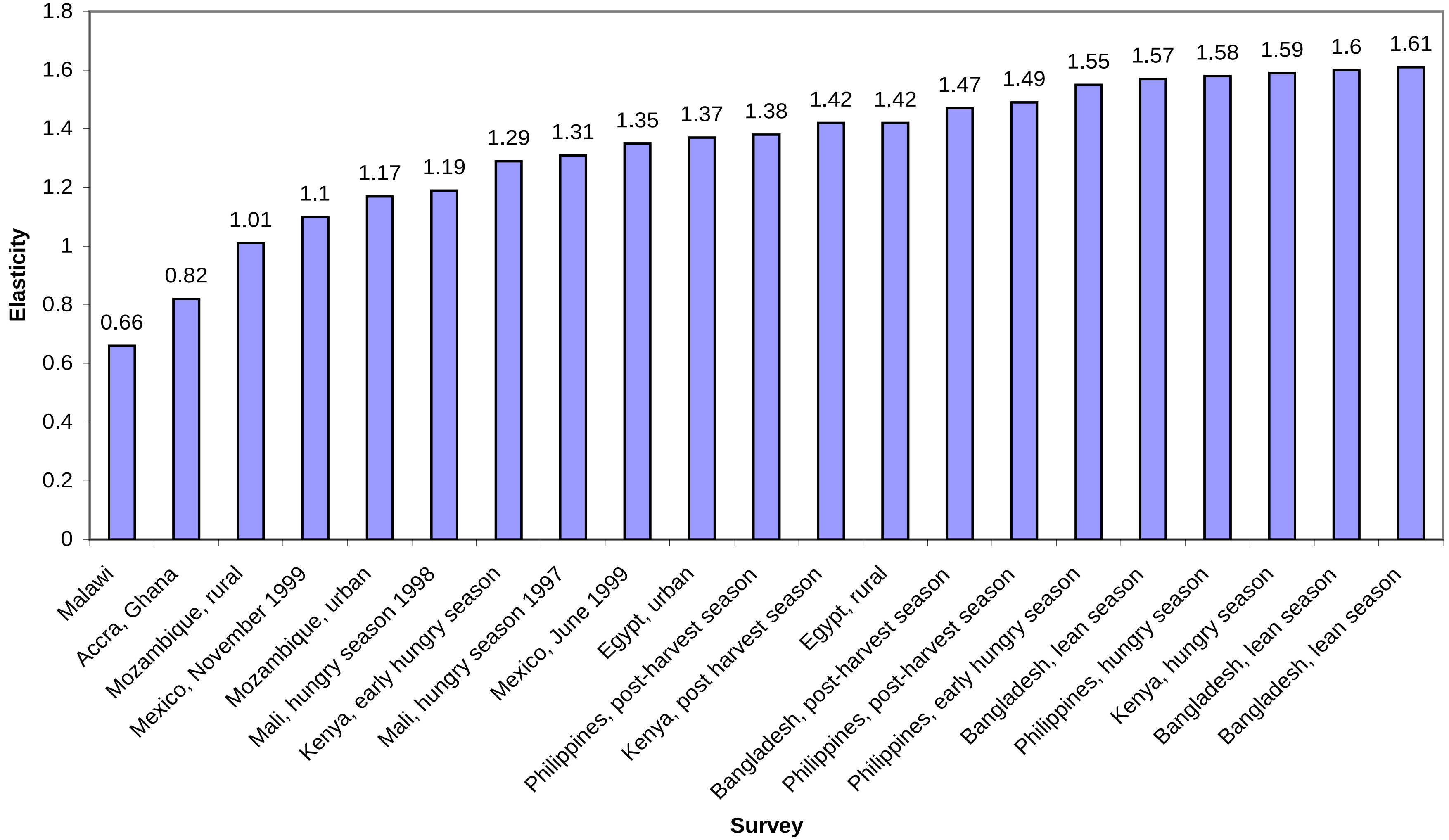

Figure 5: Elasticities of association between food groups and per capita consumption

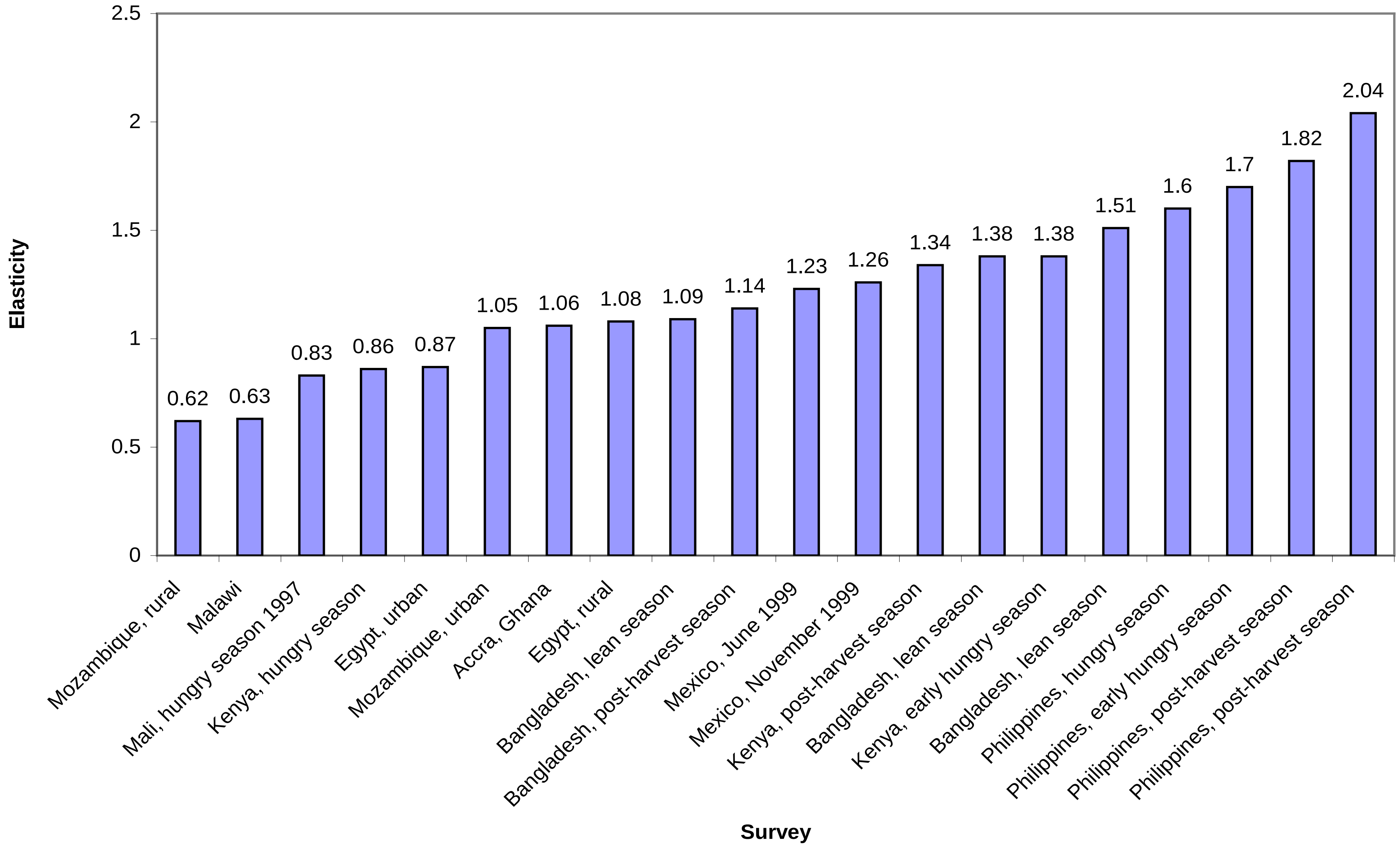

Figure 6: Elasticities of association between food groups and per capita caloric acquisition

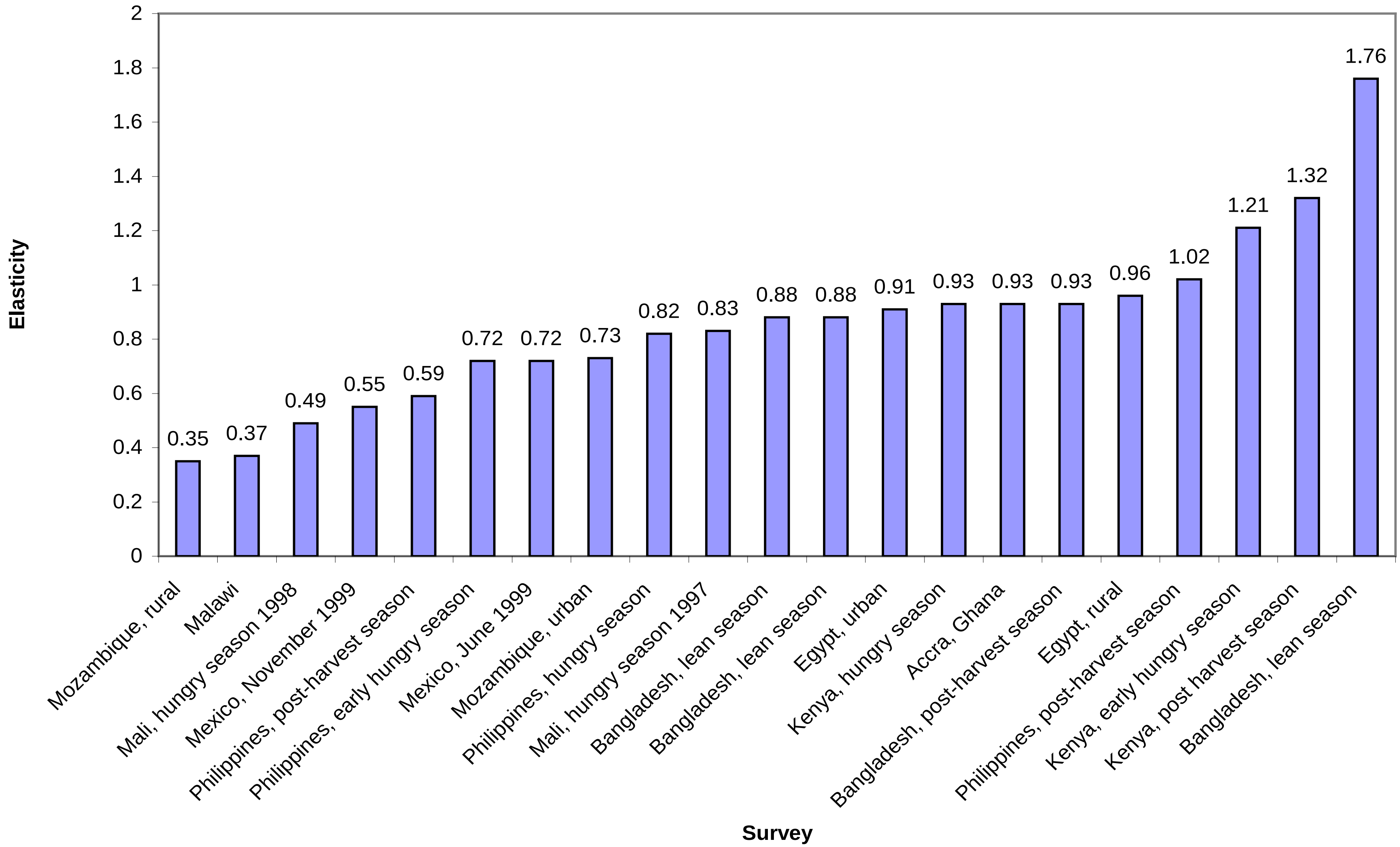

Figure 7: Elasticities of association between food groups and per capita caloric availability from staples

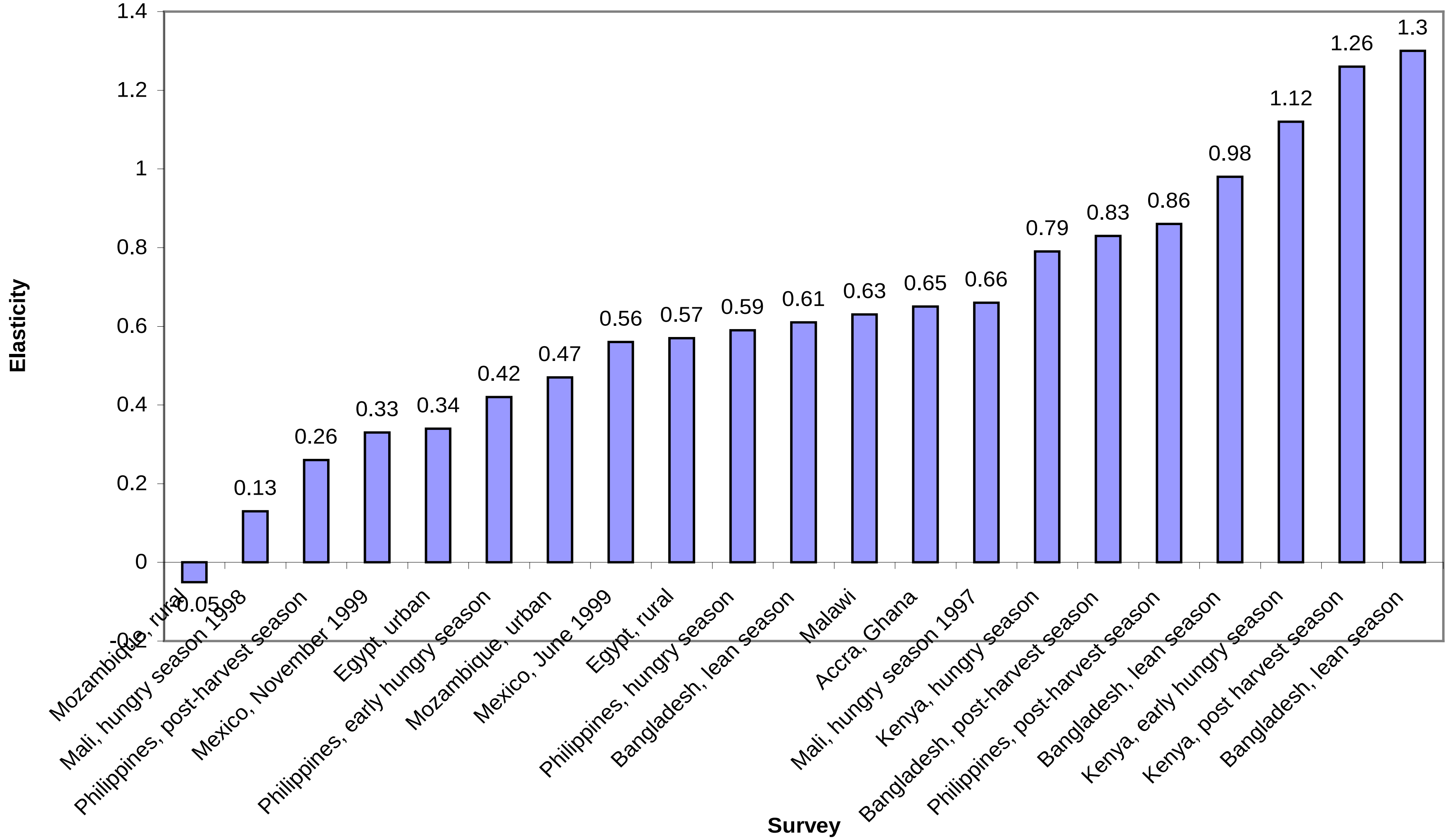

Figure 8: Elasticities of association between food groups and per capita caloric availability from non-staples