Chapter 2 INDICATORS FOR EXAMINING LINKS BETWEEN AGRICULTURE, FOOD SECURITY, AND NUTRITION

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ABSTRACT: HOW CAN THE NUTRITION IMPACT OF AGRICULTURE PROGRAMS BE ASSESSED?
Depending on context, data may need to be collected on production practices for food, livestock, and cash crops; post–farm gate value chain and other market-based activities; commodity prices; household food security; women's empowerment; dietary quality and quantity, and nutritional status. This chapter provides a primer[3] on commonly used indicators for these processes and outcomes: diet and nutritional status; household food security; gender, household decision making, and empowerment; agricultural production, productivity, and diversification; and food markets and prices. The importance of dietary quality as a key intermediary between agriculture and nutrition is emphasized throughout this chapter. Individual dietary quality is best measured by dietary diversity as dietary diversity indicators have been repeatedly validated as predictive of nutritional adequacy. Individual dietary quality is a key outcome to measure the success of most agricultural programs and policies, if an impact on population well-being is desired. However, in many countries the surveys which collect data on individual dietary patterns (and other nutrition indicators) are not the same as those which collect information on agricultural production. While justifiable from a sectoral perspective, this "data disconnect" poses a challenge to analyzing agriculture–nutrition links.

ASSESSING DIETARY AND NUTRITIONAL STATUS

Agriculture produces food, food comprises diets, and diets determine nutritional status. Diet (quality and quantity of food consumed) and nutrition (weight and height) outcomes are measured at the individual level, as they relate to what an individual consumes and the physical process of absorbing and utilizing nutrients within the body. These types of metrics are appropriate for assessing the utilization dimension of food security (see Chapter 1) in which individual nutrition practices can be detected.

DIETARY RECALL AND INDIVIDUAL DIETARY DIVERSITY SCORES

Twenty-four-hour food recall surveys collect detailed information on the precise foods[4] and amounts eaten by an individual over the past day. Food composition tables are then used to assess the nutrients in these foods, providing an estimate of an individual's dietary quality and the quantity of nutrients consumed (Jones et al. 2013).

Eating a variety of foods helps ensure adequate intake of essential nutrients and promotes good health. Accordingly, individual dietary diversity measures are used as indicators of dietary quality. Dietary diversity scores for an individual are computed from information on the number of specific food groups from which the individual consumed food over a recent short period of time. These metrics have been repeatedly validated as having a robust and consistent positive statistical association with adequacy in individual micronutrient consumption. In other words, the higher the dietary diversity score for an individual, the more likely that individual has a diet that meets his or her vitamin and mineral requirements (Ruel, Harris, and Cunningham 2013).

The populations from which indicators of individual dietary diversity are most commonly collected are women of reproductive age, via the Women's Dietary Diversity Score (WDDS), and children under two years of age, via the Infant and Young Child Dietary Diversity Score (IYCDDS) (Leroy et al. 2015).

ANTHROPOMETRY

Anthropometry assesses the physical growth status of an individual relative to an international reference population. In other words, it measures the impact of an individual's diet on his or her weight and height. Thus, anthropometric statistics are typically reported as indexes based on standard deviations from the mean of this reference population, or Z-scores. In children, two of the most commonly used anthropometric indexes are height-for-age (HAZ) and weight-for-height (WHZ) (WHO 2008).

Children whose height-for-age is less than two standard deviations below the median height of individuals of the same age in the reference population (HAZ<-2.0) are considered stunted in their growth and suffering from chronic (long-term) undernutrition. In contrast, children with low weight-for-height (WHZ<-2.0) are assumed to be wasted and suffering from acute (recent and severe) undernutrition. Stunting prevalence can be high even in situations of relative food security, depending on the quality of diets consumed and the prevalence of infectious disease. Wasting in children is often seasonal due to food shortages and disease and carries a higher risk of death.

In addition to these indicators, mid-upper arm circumference or MUAC, is also used to assess the nutritional status of children and, in some cases, adults. Body mass index (BMI), which is computed as the weight of an individual in kilograms divided by the height of the individual in meters squared (kg/m^2), is a more commonly used anthropometric indicator for adults and is used to detect both under- and overnutrition.

Demographic and Health Surveys (DHSs) are considered among the best sources of anthropometric data in many countries, including for Malawi. Five nationally representative DHSs have been carried out in Malawi—in 1992, 2000, 2004, 2010, and 2015.

ASSESSING HOUSEHOLD FOOD SECURITY

Household food security measures provide estimates of families' access to food. Access, in this context, is both physical and economic, including foods that a household grows for its own consumption and foods that a household purchases outside the home. Household access to food is typically used as an indicator of income and household calorie availability or lack thereof (Hoddinott and Yohannes 2002; Swindale and Bilinsky 2006).

While some of the most commonly used household food security indicators look only at household access to different food groups, others go further, estimating per capita calorie and micronutrient availability based on international recommendations for individual requirements. However, if these estimates are based on household-level data that do not capture how food is divided between household members, they should not be considered representative of individual-level diets.

HOUSEHOLD DIETARY DIVERSITY SCORE

As it is strongly associated with household calorie access and socioeconomic status, household-level dietary diversity is considered a proxy indicator for food access. It is used to measure the quantity and type of foods eaten by a household as a whole, thus providing information on what dietary options are available to individual household members, albeit without unpacking how those options may be exercised, since the allocation of food to individual members is not addressed during data collection (Hoddinott and Yohannes 2002; Kennedy et al. 2010). Household-level dietary diversity cannot be used to assess individual-level dietary intake or quality.

The most commonly used indicator of household dietary diversity is the Household Dietary Diversity Score (HDDS). HDDSs are calculated by summing equally weighted response data on the consumption of 12 food groups by the family over a given recall period. These food groups are cereal grain staples, roots and tubers, vegetables, fruits, meat, eggs, fish, pulses and nuts, dairy products, oils and fats, sugar, and condiments. Higher numbers of food groups consumed and, hence, higher HDDS scores are associated with higher household access to calories (Hoddinott and Yohannes 2002; Kennedy et al. 2010). For Malawi, HDDSs can be calculated using food consumption data collected for Malawi's Second and Third Integrated Household Surveys (IHSs).

MICRONUTRIENT-SENSITIVE HDDS AND HOUSEHOLD MICRONUTRIENT ACCESS

The Micronutrient-sensitive Household Dietary Diversity Score (MsHDDS) was created by IFPRI to increase understanding of which micronutrients are available to households through the foods that families reported eating (Verduzco-Gallo, Ecker, and Pauw 2014). To date, the MsHDDS has only been applied in Malawi, using food consumption recall data from IHS2 and IHS3.

Based on the same idea as a conventional HDDS, the Malawi MsHDDS further subdivides the food groups used to calculate the final score: the vegetable group is divided into dark green leafy vegetables, vitamin A–rich (red/orange/yellow) vegetables, and other vegetables; the group of fruits is divided into vitamin A–rich fruits and other fruits; and the group of meat is divided into red meat and white meat (mainly poultry). A total of 16 different food groups are used for the MsHDDS, rather than the 12 groups used for the HDDS.

An additional indicator, household micronutrient access, can then be estimated. This indicator—based on per capita estimates of micronutrient intake—provides more detail on which micronutrients are available to household members than is provided by the MsHDDS alone, which only provides a simple count of food groups eaten. The per capita intake estimates are compared to age- and sex-specific nutritional requirements (using World Health Organization standards) to estimate the prevalence of shortfalls in micronutrients accessed by the household (Ecker and Qaim 2011).

As with the HDDS, lack of information about intrahousehold food allocation is the primary reason why the MsHDDS and related estimates of per capita micronutrient consumption should be viewed as a measure of household access to diverse foods and adequate micronutrients rather than of individual nutrient intake. Furthermore, while there are clear theoretical associations between these indicators and individual dietary quality,[5] these associations have not been empirically validated.

Nonetheless, the MsHDDS adds a useful nutrition lens to a common food security indicator, and the Household Micronutrient Access indicator provides a rare example of nationally representative food-based micronutrient access estimates. The fact that these indicators can be constructed using household consumption and expenditure data increases their value (see section below on Addressing the "Data Disconnect").

FOOD CONSUMPTION SCORE

Developed by the World Food Programme (WFP), the Food Consumption Score (FCS) is a composite score comprising data on food groups and the frequency of consumption of those food groups. The typical recall period is usually 7 days (as opposed to the HDDS, which may be either 7 days or 24 hours) and data are collected on fewer food groups—8 food groups, rather than 12. Each food group is weighted according to its nutritional value (for example, sugar and oil receive a weight of 0.05, while meat, milk, and fish receive a weight of 4.00), and the questionnaire collects information on how often each of the food groups was consumed by one or more family members over the past week. The FCS is intended to monitor changes in food security status across large geographic areas, such as regions or countries, and is positively associated with per capita calorie consumption (Jones et al. 2013; Lovon and Mathiassen 2014). Using household survey data, WFP periodically computes FCS for Malawi as part of its food security monitoring efforts, presenting aggregate results at national and district levels.

HOUSEHOLD FOOD INSECURITY ACCESS SCALE AND COPING STRATEGIES INDEX

The Household Food Insecurity Access Scale (HFIAS) is based on the assumption that there is a set of predictable reactions to the experience of food insecurity that can be summarized and quantified (Carletto, Zezza, and Banerjee 2013). Based on the administration of nine questions to a household respondent, this measure has been incorporated into household surveys around the world and has been validated in Latin America and Africa south of the Sahara for reliability and validity in local contexts (Knueppel, Demment, and Kaiser 2010; Melgar-Quiñónez et al. 2006). However, other validation studies suggest that this indicator's cross-cultural comparability may be weak, due largely to cultural and language issues that complicate interpretation of results across contexts (Swindale and Bilinsky 2006). In response to this criticism, the Household Hunger Scale (HHS) was created and has been cross-culturally validated, although its design only captures severe cases of food insecurity (Ballard et al. 2011). The harmonized Latin American and Caribbean Food Security Scale (ELCSA) and the recently launched Food Insecurity Experience Scale (FIES) are examples of similar, experience-based food security scales (Cafiero et al. 2014). In Malawi, the FIES is currently included in IHS and in a nationally representative annual survey administered by the Gallup World Poll.

The Coping Strategies Index (CSI), developed by WFP, also takes an experiential approach to food security analysis, assuming that there are several behavioral coping strategies used by households to manage food shortages. The CSI is composed of a weighted average of the frequency and severity of a menu of these coping strategy behaviors, developed and assessed based on location-specific assessments and appraisal methods (Carletto, Zezza, and Banerjee 2013). The CSI is periodically reported for Malawi by WFP.

Unlike household dietary diversity indicators, the food insecurity scales and the CSI have been validated to predict food vulnerability (Carletto, Zezza, and Banerjee 2013). That is, these indicators can predict impending food insecurity, as opposed to providing only an immediate snapshot of what foods households were accessing at the time of the survey.

ASSESSING GENDER, HOUSEHOLD DECISION MAKING, AND EMPOWERMENT

As women are more likely than men to influence the nutrition outcomes of family members due to their roles as primary caretakers and mothers, agricultural interventions that include an emphasis on women's empowerment generally have proven to be more effective at improving nutrition than approaches that do not (Hawkes and Ruel 2007). Moreover, women's nutritional status and control over assets are important for improving agricultural productivity and investment (FAO 2011, Meinzen-Dick et al. 2011). As such, measuring women's empowerment and decision-making power is considered an essential requirement for understanding the linkages between agriculture, food security, and nutrition (Quisumbing et al. 2014; van den Bold, Quisumbing, and Gillespie 2013).

Women's empowerment is best viewed as a process and thus is often assessed in terms of improvements in decision-making power over time. Proxies for decision-making power include women's income, education, and assets (Malapit and Quisumbing 2014). Assets can include physical assets, such as jewelry and livestock, or social assets, such as group membership. Direct indicators of empowerment and decision-making power include how the earnings of the woman and her husband are spent; how much the woman earns relative to her husband; whether she owns or co-owns land or a house; and who makes decisions concerning the woman's healthcare, major purchases, and visits to family (Heckert and Fabic 2013). In the context of nationally representative surveys, these questions are primarily asked to one woman in each household.

The Women's Empowerment in Agriculture Index (WEAI) collates multiple dimensions of women's empowerment as they relate to agricultural production and human development outcomes, including nutrition (IFPRI 2012). The WEAI is a composite empowerment score, comprising standardized questions posed to the primary male and female decision makers in the household across the following domains: input into agricultural production decisions; autonomy in production; ownership of assets; purchases, sales, or transfers of assets; access to and decisions on credit;

control over the use of income; group membership, public speaking, and other leadership activities; existence of leisure time; and workload. To date, WEAI interviews provide one of the most comprehensive data sources for assessing women's empowerment and how it relates to agriculture, food security, and nutrition outcomes. The WEAI was developed by IFPRI and is currently used in projects of the Feed the Future initiative of the US government in Malawi and elsewhere.

ASSESSING AGRICULTURAL PRODUCTION, PRODUCTIVITY, AND DIVERSIFICATION

Unlike nutrition and food security indicators—many of which have been rigorously validated—metrics for assessing agricultural production, productivity, and diversification are often best considered as theoretical proxies. As such, the discussion below differs somewhat from the sections above. More detail is provided on data sources and the theoretical underpinnings of these indicators, while less is provided on validation and construction.

AGRICULTURAL PRODUCTION: CROPS

The most commonly used agricultural indicators are those pertaining to production of crops or livestock. Because of the cereal-centric nature of agriculture and food preferences in Malawi and many other countries, crop production estimates typically receive more attention than livestock production estimates. Crop yields are usually defined as output per unit of land—typically metric tons per hectare. Estimates can be aggregated to district or national levels, or assessed at the household or farm level.

The most common approach is to rely on local government agricultural extension workers—typically from the Ministry of Agriculture or similar agency—to provide estimates of local crop yields. These local production statistics are then aggregated up to the district or national level. In Malawi, the Agricultural Production Estimates Survey (APES) of the Ministry of Agriculture, Irrigation, and Water Development (MoAIWD) produces three rounds of crop estimates annually. While estimates from extension officers are perhaps the easiest way to collect yield data, they are also considered highly subject to measurement error, given that they usually rely on informal interviews with farmers and local communities (Jayne and Rashid 2010, 2). Ministerial crop estimates also tend to be vulnerable to upward or downward revision for political reasons.

Alternatively, detailed, nationally representative data on cropland allocation, crop production, and crop sales can be captured through household surveys, such as Malawi's IHS, or the less frequent National Census of Agriculture and Livestock (NACAL), last conducted in 2006/2007. In Malawi, these surveys are implemented by the National Statistical Office (NSO) and may be more accurate than the annual crop estimates, both because of the more accurate methods used and because the likelihood of political interference is lower.

AGRICULTURAL PRODUCTION: LIVESTOCK

Both crop forecast surveys and household surveys often collect data on livestock ownership. In some cases, data collected by household surveys may be quite detailed, capturing information on current livestock ownership and stock changes due to new births, purchases, sales, theft, or consumption over a 12-month period. Specific indicators include whether a family owns any livestock, which and how many species they own, and the type or amount of animal products, e.g., milk, eggs, meat, honey, and the like, produced by the household.

One convenient way of quantifying ownership of a wide range of different livestock types in a standardized manner is to convert numbers to equivalent tropical livestock units (TLUs). For example, relative to a cow of 250 kg (with TLU = 1.0), a sheep or goat weighing 30 kg will have a TLU = 0.2. The ratio is based on the concept of metabolic weight (that is, energy expenditure per unit of body weight per unit of time) and the fact that smaller animals produce more heat and consume more food per unit of body size.[6] This conversion can be done in Malawi with both the NACAL and the IHS datasets.

CROP DIVERSIFICATION

The term agricultural diversification broadly relates to the concept of allocating resources (inputs) across an increasing number of agriculture-related activities. The concept can be applied at the farm, district, or country level. Crop diversification, more narrowly, refers to the idea of not only increasing the number of crops (or varieties) that are grown, but also to how equitably land is allocated across those crops. Crop diversification is seen as an approach toward broad-based agricultural development and an important risk-management strategy for farm households, especially in a country like Malawi that relies heavily on a limited range of rainfed food crops, yet faces significant weather challenges in the short run (Devereux 2007). From a nutrition perspective, studies in Kenya, Malawi, Uganda, and Rwanda have found that agricultural systems with greater agrobiodiversity are associated with greater dietary diversity at village, farm, and household levels (Herforth 2010; Remans et al. 2011; Jones et al. 2013; Romeo et al. 2016).

The most commonly used indicator of crude crop diversity is a simple crop count, that is, how many crops or varieties are being grown. However, several indexes, including the Herfindahl–Hirschman Index (HHI) and the Simpson Index of Diversification (SID), are often used with or instead of these simple counts to assess not only the number of crops grown, but also the share of land allocated to each (Minot et al. 2006; Joshi et al. 2003). The SID, for example, equals zero under complete specialization, indicating that all land is allocated to one crop. Theoretically, it approaches one under increased diversification, indicating that a very large number of crops are being grown under equitable land allocation. In Malawi, crop counts and diversification indexes can be calculated using APES, NACAL, and IHS datasets at differing levels of aggregation.

AGRICULTURAL PRODUCTIVITY

The rate of production for given inputs is described as productivity. In a context like Malawi's, where land is scarce and productive inputs such as fertilizer are expensive, productivity per unit of land, labor, fertilizer, or other inputs into agricultural production is often discussed. Raising productivity through adoption of improved farming techniques or technological innovation—such as small-scale irrigation or sustainable-intensification approaches—is seen as an important strategy for improving food availability. Increased productivity may also be associated with increased farm profits and household income, which, in the presence of reliable food markets, can improve access to food. Indicators of productivity generally are derived using the same agricultural production data sources as above—in Malawi these are IHS, APES, and NACAL.

ASSESSING MARKET ACCESS, MARKET PARTICIPATION, FOOD PRICES, AND SEASONALITY

MARKET ACCESS AND PARTICIPATION

The degree to which households participate in or have access to markets is relevant to food security and nutrition outcomes. Households may engage either as sellers of their own produce, buyers of food available in local markets or trading centers, or both. Market access is often assessed in terms of a household's physical proximity to markets. Specific indicators include distance, traveling time, or cost of transportation to improved roads or to trading centers. Participation simply refers to whether a household engages in market transactions, including barter.

Household surveys often collect detailed information about market access and participation. In Malawi, the IHS agricultural questionnaire captures information about the quantity and value of crop sales (i.e., by producers), including the place of sale (farm gate or local market) as well as the distance and cost of transport to that place of sale. The latter often reflects a combination of distance and quality of road networks. Utilizing such information, Jayne et al. (2010), for example, find that among smallholder maize producers in Malawi, around 55 percent only buy maize at markets; 9 percent only sell maize; 8 percent engage as both buyers and sellers of maize;

and 28 percent of maize producers are autarkic, meaning they do not participate in markets at all. This suggests that almost three-quarters of maize farmers have physical access to and actively participate in markets. However, for the remaining autarkic households, the choice not to participate does not necessarily imply a lack of physical access, and for this reason information about distance and transport costs to markets is useful for better understanding their choice.

Also on the consumption side, which may include farm and nonfarm households, the IHS contains useful information about market access and participation. When reporting on food consumption, households report the quantities of food obtained from own production, gifts, or market purchases; for the latter category, actual expenses are also reported. This permits the calculation of unit food prices and their distribution across different regions, which alongside consumption data can be used in the analysis of costs of living, poverty, and food access and availability (see, for example, Chapter 4). The extent to which households procure food from the market is an indication of their access to markets; however, as is the case with farm households choosing not to participate in markets, households reporting zero food purchases do not necessarily lack physical access to markets, but may simply choose not to participate, perhaps because they obtain sufficient quantities of food from other sources. For example, IHS data show that around 36 percent of maize consumed in rural areas is purchased, while in urban areas this share is 68 percent. For the relatively large share of households—especially in rural areas—that are not dependent on markets for their maize needs, it is necessary to also consider information about distance or transport costs to markets before drawing conclusions about market access. In this regard, the IHS community questionnaire, administered to village or neighborhood representatives, asks several questions about the distance and frequency of visits to local markets, as well as the availability of staple foods in markets compared with five years before.

FOOD PRICES AND SEASONALITY

Food price volatility is most commonly measured by the coefficient of variation (CV) in prices, a standardized indicator of the degree to which a commodity's price in a particular market diverges from the mean regional or global price of that commodity. In this sense, the CV can be said to measure the price transmission of a particular commodity from international to domestic markets.

In addition to whether local food prices transmit or reflect regional and global prices, national and subnational market characteristics are also relevant to households' access to food. These include the cost of transporting food to markets, usually measured by road infrastructure and fuel costs; the ratio of buyers and sellers to producers; whether markets are connected or isolated from each other in terms of geographical access and in terms of price alignment; and the presence or absence of government policies that intervene in the market, such as setting price ceilings or floors for specific foods or implementing export bans on particular commodities.

In contexts like that of Malawi, where high transport costs and few buyers and sellers relative to the number of producers cause markets to be thin, prices are volatile. This volatility often results in unpredictable and highly seasonal food prices, which have significant implications for food security. Indicators of seasonality in food prices are typically constructed using household-level food consumption and food price data. In Malawi, price data are collected throughout the country on a weekly basis by the government, under the Agricultural Market Information System (AMIS).

In cases where seasonality has an adverse effect, the relationship between food consumption and price levels will be inverse. This reflects a typical cycle of selling at a time when prices in the market are low but household cash needs are high, such as just after the harvest, then buying at times of high prices when household food stocks dwindle and the next harvest has not yet arrived.[7] This vicious circle has been well documented in Malawi (Kaminski, Christiaensen, and Gilbert 2014; Jayne et al. 2010).

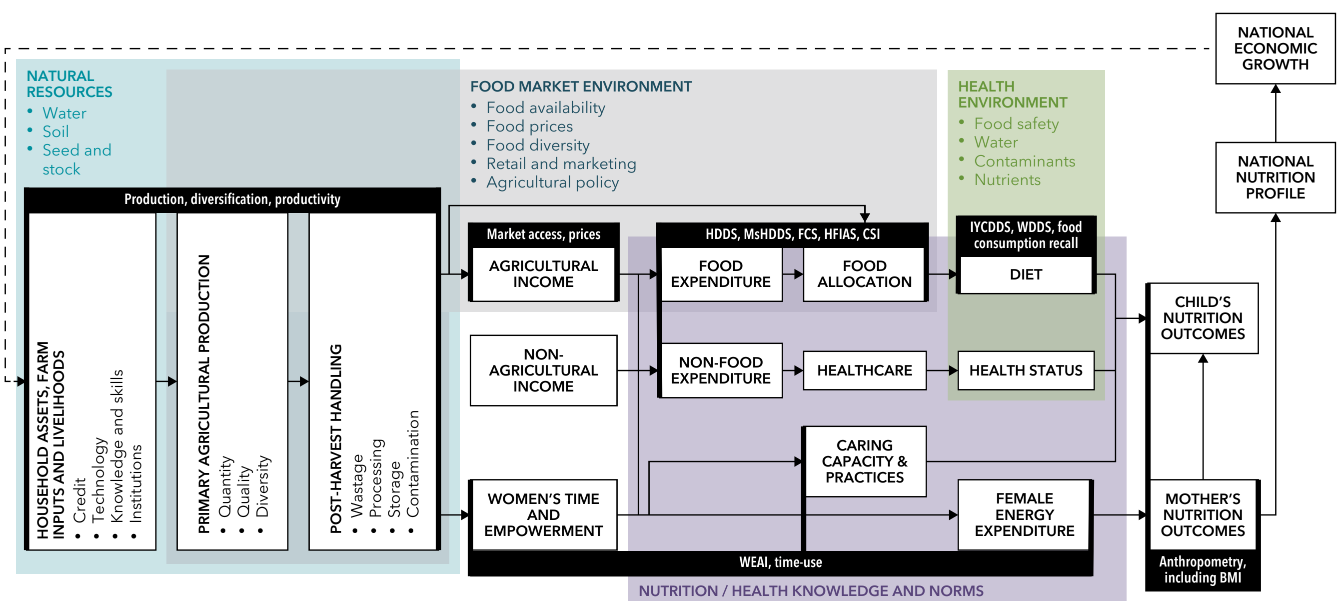
ADDRESSING THE "DATA DISCONNECT"– OPPORTUNITIES FOR MALAWI

Figure 3 overlays indicators reviewed in this chapter onto the conceptual framework described in Chapter 1, providing a visual representation of the range of metrics needed to investigate the association between agriculture and nutrition.

Among the datasets reviewed in this chapter, those which provide information on individual diets are the most informative for assessing how food-related factors affect individual nutritional status—in Figure 3, these are the Infant and Young Child Dietary Diversity Score (IYCDDS), Women's Dietary Diversity Score (WDDS), and food consumption recall datasets associated with the Diet component of the conceptual pathways between agriculture and nutrition. As discussed earlier, household-level indicators stop short of estimating individual dietary or nutrition outcomes, thus preventing assessment of the final frontier of utilization. In contrast, anthropometric indicators provide excellent estimates of how individuals are utilizing nutrients. However, these metrics do not distinguish between what proportion of undernutrition is caused by health considerations, such as infection, and what is caused by problems related to food accessibility and related constraints to dietary intake. As it is food that is most directly affected by agriculture,[8] individual diets are a key outcome to measure the success of most agricultural programs and policies, if an impact on population well-being is desired (Herforth and Harris 2014). Especially important is the issue of dietary quality—meaning diets that include safe and hygienic foods from as many food groups as possible, providing a variety of nutrients in addition to calories. A focus on dietary quality is often missing in food security work, but is the key concept linking agriculture and food systems with nutrition outcomes.

The IYCDDS and WDDS are currently considered the best options for accurately measuring individual dietary quality in a non-invasive, inexpensive, and efficient way (Leroy et al. 2015). Both indicators include cutoffs and use a standardized questionnaire (although adaptation to local contexts is required for the

FIGURE 3 INDICATORS FOR EXPLORING CONCEPTUAL PATHWAYS BETWEEN AGRICULTURE AND NUTRITION



Source: Herforth and Harris (2014), revised by authors.

Note: BMI = Body Mass Index; CSI = Coping Strategies Index; FCS = Food Consumption Score; HDDS = Household Dietary Diversity Score; HFIAS = Household Food Insecurity Access Scale; IYCDDS = Infant and Young Child Dietary Diversity Score; MsHDDS = Micronutrient-sensitive Household Dietary Diversity Score; WDDS = Women's Dietary Diversity Score; WEAI = Women's Empowerment in Agriculture Index.

latter), facilitating intercountry implementation and comparability of results. Dietary recall is also a good option for assessing dietary quality, but such surveys are more time consuming and costly. Anthropometric outcomes are best considered when examining health and sanitation dimensions, in addition to agriculture.

In many countries, the analytical imperative to collect individual dietary quality information is constrained by what is referred to as the agriculture and nutrition data disconnect (Gillespie, Harris, and Kadiyala 2012). This fracture occurs because of long-standing divides between agriculture and health in commonly collected nationally representative data sources. In Malawi, as in many other countries, agricultural data are usually not available in the same datasets as individual diet, women's empowerment, and nutrition outcome data. As such, agriculture–nutrition analyses are often hamstrung by lack of appropriate, integrated data resources. While justifiable from a sectoral perspective, the disconnect results in there generally being limited reliable data that provide information on diet and nutrition outcomes as well as on agricultural production practices, market access, food prices, women's empowerment, and all the other indicator areas required to trace the full trajectory of a causal pathway from agriculture to nutrition outcomes for individuals.

That said, there are instruments that hold considerable potential for the systematic collection of data on standardized livelihood or agricultural production practices, food security, and, in some cases, nutrition (Carletto et al. 2013). In Malawi, many of these instruments already exist. Table 1 provides an overview of the country's key large-scale data sources that provide such complementary data in a systematic manner. An

TABLE 1 DATA SOURCES ACROSS NUTRITION PATHWAYS: OPTIONS IN MALAWI

	Domain					
Data source	Food systems and markets	Agriculture	Food security (availability & access)	Women's empowerment	Individual diets	Individual nutrition outcomes
Demographic and Health Survey (DHS)	–	–	–	Empowerment Decision making	WDDS, IYCDDS Dietary recall	Anthropometry
Integrated Household Survey (IHS)	Seasonality Market access Food prices	Crop & livestock production Crop diversification	HDDS MsHDDS HH Micro-nutrient Access	–	–	Anthropometry
Women's Empowerment in Agriculture Index (WEAI)	–	–	Household Hunger Scale	Empowerment Decision making	WDDS	Anthropometry (women)
Agricultural Production Estimates Survey (APES)	–	Crop production	–	–	–	–
Agricultural Market Information System (AMIS)	Market integration Seasonality Food prices	–	–	–	–	–
National Census of Agriculture and Livestock (NACAL)	Market access	Crop & livestock production Tropical livestock units	–	–	–	–

Source: Authors' compilation.

Note: HDDS = household dietary diversity score; HH = household; IYCDDS - infant and young child dietary diversity score; MsHDDS = micronutrient-sensitive household dietary diversity score. WDDS = women's dietary diversity score example of how data from multiple survey sources in Malawi can be incorporated into a single analysis for nutrition program planning purposes is shown in the Appendix to this chapter.

Of all the data sources listed in Table 1, the data-collection instrument with the highest potential for assessing agriculture–nutrition linkages in Malawi is the Integrated Household Survey series. This survey series covers multiple sectors. The IHS3 of 2010–2011, for example, collected information on household food consumption, crops grown using rainfed and *dimba* wetland cultivation, crop sales, livestock ownership and sales, child anthropometry, and food prices. The advantage of data from the IHS surveys over the Agricultural Production Estimates Survey (APES) and DHS data is that, for example, agricultural production data obtained through the IHS are easily merged with detailed household consumption data (including from own produce or purchased foods) and child nutrition indicators. The fact that the unit of analysis is household-level is important. While the Appendix to this chapter presents an approach to incorporating into a single analysis information obtained from different survey samples by undertaking rank correlation analyses at the survey strata level (typically, district-level), this is clearly a second-best solution. If an integrated, multi-topic, representative household survey dataset is available, this generally will be the preferred dataset to use for planning programs that seek to improve nutritional outcomes. The Malawi IHS series is an important resource for these purposes.

Although the IHS covers an impressively high number of relevant indicators, it still fails to collect data on individual diets, the key intermediary between agriculture and nutrition. Furthermore, the quality of IHS anthropometrics has been called into question, as figures obtained from analysis of the IHS3 differ significantly from those in the 2010 DHS—the DHS being the traditional source of estimates of nutrition indicators for the population of Malawi (Verduzco-Gallo, Ecker, and Pauw 2014).

While substantial retrofitting of the IHS is not practical, the addition of a simple measure of individual diet—such as the WDDS, which is especially valuable given its focus on women—and improvements to the quality of the anthropometric measurements would make the IHS a powerful tool for unpacking how agriculture in Malawi links to food security and nutrition outcomes. Such dietary diversity indicators can be constructed based on an easy-to-administer questionnaire that can be completed quickly by enumerators and at relatively low cost (Leroy et al. 2015). The inclusion of this type of module in the questionnaire for Malawi's IHS surveys could facilitate more thoughtful and robust research on the agriculture–nutrition nexus in the country.

APPENDIX—AGRICULTURAL CORRELATES OF AGGREGATE NUTRITIONAL OUTCOMES IN MALAWI: A DISTRICT-LEVEL RANK ANALYSIS

Todd Benson

Obtaining empirical evidence on the relative importance of agriculture for the nutritional status of individuals is difficult. Most datasets that shed light on nutrition outcomes provide limited information on agricultural livelihoods. Here we take advantage of the fact that the 2010 Demographic and Health Survey (DHS) for Malawi (NSO and ICF Macro 2011) used comparable survey strata to that of the Third Integrated Household Survey (IHS3) (NSO 2012a), a survey conducted in 2010–2011 that collected extensive information on agricultural production. While the surveys sampled different households and individuals, the results of both are representative at the district level. Using a nonparametric rank correlation approach, we use district-level results from the surveys to examine whether any associations exist between the prevalence of stunted children (low height-for-age Z-scores [HAZ]) and of thin women (Body Mass Index below 18.5 kg/m2) in the districts of Malawi (Figure 1) and selected district aggregate characteristics of agricultural production. We then extend our analysis to examine other possible nonagricultural determinants of nutritional status.

Our dataset consists of 27 cases, corresponding to the 27 districts of Malawi covered by the two surveys. This small set of cases limits the sorts of statistical analyses we can use. Moreover, our analysis is based on aggregate statistics. As nutritional status is a characteristic of individuals, information on how nutritional status varies within the population is lost when one uses aggregate statistics. Similar information is also lost on the distribution of the factors examined as potential determinants of those nutritional outcomes. As no assumptions can be made about the distribution of these variables within the population, we must use a nonparametric approach to gain insights from these district-level statistics.

Here we use a rank correlation analysis. This quantifies the degree of similarity between the rankings of two variables across cases to assess whether any significant relationship exists between the variables. We examine whether the ranking of nutritional outcomes by district is similar to the ranking of any agricultural factors by district, either positively or negatively. Where association in the ranking is seen, this indicates the potential existence of a causal relationship between the agriculture and nutrition variables and may merit further study. Where the absolute value of the Kendall's statistic for rank correlations is between 0.10 and 0.30, we consider this association worthy of note, while associations with a coefficient above 0.30 are judged to merit even closer examination.

Potentially important agricultural and nonagricultural determinants of nutrition outcomes were identified for the analysis. Primarily using data from the two surveys, we compute district-level statistics for 10 potential agricultural determinants and about 20 potential nonagricultural determinants. The nonagricultural determinants are categorized into four groups—diet, gender, health, and welfare.

The rank correlation analysis results for the agricultural factors are shown in Appendix Table 1. Relatively limited associations are seen, suggesting that direct relationships between agricultural activities and nutritional outcomes in Malawi are relatively weak. Moreover, the strongest associations run counter to expectations—for example, more district residents engaging in cropping activities is associated with a greater prevalence of thin women. Of the other agriculture–nutrition associations considered, a few are encouraging, such as for livestock and tobacco. Greater average agricultural sales in a district are also associated with improved nutritional outcomes. However, unfavorable or no associations are observed for several other district-level agricultural factors, including for irrigation intensity, district maize yield levels, horticultural production, and the number of crops grown or sold by district households.

APPENDIX TABLE 1 STRENGTH OF RANK CORRELATIONS BETWEEN POTENTIAL AGRICULTURAL DETERMINANTS OF NUTRITION OUTCOMES AND THOSE OUTCOMES, RANK CORRELATION COEFFICIENT, DISTRICT-LEVEL AGGREGATE DATA, MALAWI, 2010

Variable	Stunted children	Thin women
Households engaged in crop production, %	0.13	**0.36**
Landholding size, ha/household	ns	ns
Livestock ownership, Tropical Livestock Units per household	−0.14	ns
Irrigation prevalence, % of households	0.14	ns
Maize yield, kg/ha	ns	ns
Tobacco production prevalence, % of households	−0.15	−0.11
Horticulture production prevalence, % of households	ns	ns
Number of crops grown per household	ns	ns
Number of agricultural products sold per household	ns	ns
Per capita gross agricultural sales, MK thousands	−0.12	−0.13

Source: Authors' analysis of Malawi Demographic and Health Survey (NSO and ICF Macro 2011) and Third Integrated Household Survey (NSO 2012a) datasets.

Note: Kendall's rank correlation coefficients with an absolute value less than 0.10 are judged to indicate an insignificant association between the variables and are not reported. Coefficients with an absolute value greater than 0.30 are associations that are judged to merit closer examination, and are shown in boldface. MK = Malawi kwachas; ns = not significant.

These contrary or insignificant associations signal that the relationship between all dimensions of strengthened agricultural livelihoods and nutritional outcomes in Malawi will not always be positive or benign.

Appendix Table 2 extends the analysis to examine associations between district-level nutritional outcomes and potential nonagricultural determinants of those outcomes. For factors related to food access, districts with higher calorie consumption per capita and greater dietary diversity show lower levels of child stunting and thin women, while those in which a higher proportion of surveyed households reported inadequate food consumption tend to have higher levels of malnutrition.

The strongest positive associations with nutritional outcomes are for the gender variables. Higher average educational attainment levels for women are strongly associated with lower district averages for the nutritional indicators considered—a strongly beneficial relationship (Appendix Figure 1). Moreover, larger average differences between men and women in their educational attainment are associated with worse average nutritional outcomes at the district level. Similarly, women's participation in decision making within the household demonstrates that greater women's empowerment in these decisions is associated with the reduced prevalence of stunted children and of thin women. In districts in which women are more often excluded from such decisions, average malnutrition levels are higher.

Health factors do not provide as strong associations with those outcomes as do the diet and gender variables considered, and the nature of some associations is counter to expectations. For example, better access to safe water is associated with lower child stunting levels, as expected, but also with a higher prevalence of thin women. In contrast, the associations related to welfare are consistent with

APPENDIX TABLE 2 STRENGTH OF RANK CORRELATIONS BETWEEN NUTRITION OUTCOMES AND POTENTIAL AGRICULTURAL DETERMINANTS OF NUTRITION OUTCOMES (RANK-CORRELATION COEFFICIENT, DISTRICT-LEVEL AGGREGATE DATA, MALAWI, 2010)

Variable type	Variable	Stunted children	Thin women
Food access	Calorie consumption per capita/day	−0.12	**−0.30**
	Dietary diversity index (HDDS–12 food groups)	−0.16	**−0.36**
	Households reporting inadequate food past month, %	0.18	ns
Gender; empowerment of women	Female head of household, % HHs	0.17	**0.32**
	Married head of household, % HHs	−0.19	**−0.30**
	Highest level of schooling—women aged 15–49, median years	−0.17	−0.27
	Difference between men and women in years of schooling completed	0.13	0.19
	Married women who decide on purchases for daily needs, %	**−0.32**	−0.21
	Married women who do not participate in household decisions, %	0.17	0.13
Health and public health	Drinking water—improved source, % population	−0.23	0.17
	Improved household sanitation facilities, % population	ns	−0.11
	Member had an illness in previous 2 weeks, % HHs	0.10	ns
Welfare	Per capita annual household nonfarm income, MK thousands	−0.21	−0.18
	Per capita annual total real expenditure, MK thousands	−0.13	**−0.31**
	Individual poverty head count, % below the poverty line	0.15	0.29

Source: Authors' analysis of Third Integrated Household Survey (NSO 2012a) and Malawi Demographic and Health Survey (NSO and ICF Macro 2011) datasets and spatial data from Malawi.

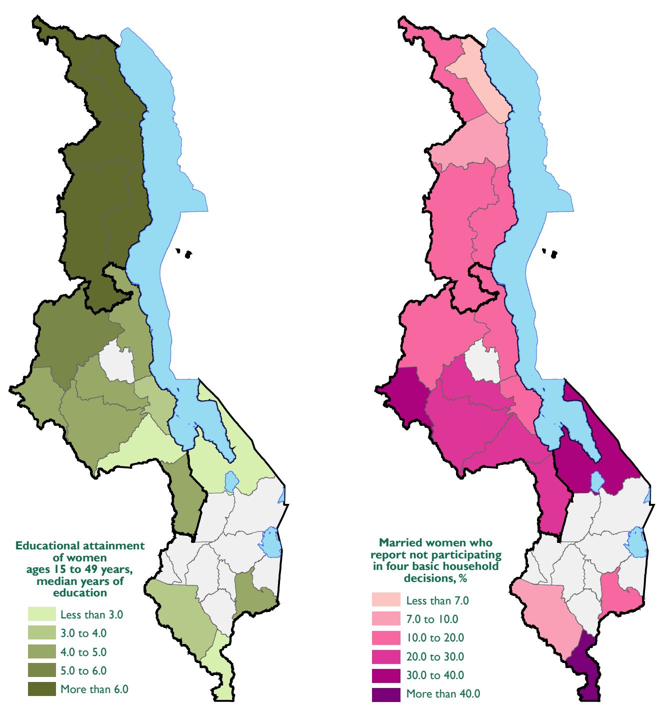
Note: Kendall's rank correlation coefficients with absolute value less than 0.10 are judged to indicate an insignificant association between the variables and are not reported. Coefficients with an absolute value greater than 0.30 are associations judged to merit closer examination and are shown in boldface. Negative associations (green bars) indicate improvements in nutritional status associated with the determinant under consideration, while positive values (red bars) indicate deterioration. ns = not significant. MK = Malawi kwacha.

expectations—higher levels of nonfarm income and expenditures are associated with lower levels of malnutrition, while higher poverty levels are associated with increases in those levels.

This analysis was done to gain additional understanding of how agricultural factors may contribute to nutritional outcomes. However, relatively limited associations are seen, suggesting that direct relationships between agricultural activities and nutritional outcomes in Malawi are relatively weak. Moreover, the nature of several of the associations examined runs contrary to expectations, suggesting more complex relationships between strengthened agricultural livelihoods and nutritional outcomes in Malawi than we might expect. When we extend the analysis, nonagricultural potential determinants of nutritional status show somewhat stronger associations—particularly for gender factors.

The broader insight obtained from this study is that the pathways through which agriculture can lead to nutritional improvement in Malawi are indirect. A broader range of equally necessary determinants of improved nutrition must be in place if significant reductions in malnutrition are to be achieved. In considering these results, however, this analysis must be treated as exploratory. More detailed examinations of any associations of interest using individual- and household-level data are required. Nonetheless, the district-level analysis presented here demonstrates that there are methods that can be used with somewhat coarse and seemingly incompatible data on nutrition status and its potential determinants to skirt around the agriculture and nutrition data disconnect discussed in Chapter 2 and build a better understanding of how agricultural activities can serve to improve nutrition in Malawi.

APPENDIX FIGURE 1 WOMEN AGED 15 TO 49 YEARS, MEDIAN HIGHEST LEVEL OF SCHOOLING ATTAINED AND PROPORTION REPORTING NOT PARTICIPATING IN HOUSEHOLD DECISIONS, BY DISTRICT, MALAWI, 2010



Source: Maps by M. Kedir Jemal, IFPRI, of DHS results.