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by

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Joanna Ryan and Murray Leibbrandt

Abstract

It is well established that household food security is a complex phenomenon with numerous indicators and outcomes, the measurement of which is yet to be adequately captured by a single measure. We propose the adoption of the methodology of multidimensional poverty measurement in calculating an index of multidimensional food insecurity. This framework has gained increasing popularity, particularly with the introduction of the Multidimensional Poverty Index (MPI). The assertion is that, like poverty, food insecurity is a multidimensional phenomenon, requiring the inclusion of multiple aspects of deprivation in its measurement. Nationally representative data from South Africa is used to construct a Multidimensional Food Insecurity Index (MFII), based on the methodology of the MPI. The MFII is used to develop a detailed profile of individual food insecurity in South Africa. Nationally, close to half of the population are considered multidimensionally food insecure, with the greatest contributors to food insecurity being dietary diversity and subjective food consumption adequacy. The Western Cape and Gauteng enjoy the lowest levels of multidimensional food insecurity, while Limpopo and KwaZulu-Natal suffer the highest levels. How food security is measured can have an important impact on how policies are developed and implemented in order to deal with the problem. As such, measurement methodologies can be very practically relevant to research.

1. Introduction

> *"Food security exists, at the individual, household, national, regional, and global levels when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for a healthy and active life"* (FAO, 2001).

The definition of food security cited above enjoys widespread agreement. Yet there is no singular measure of food security that has been accepted as the 'gold' standard when it comes to measuring household food security. Dissatisfaction with existing food security measures is not new, and multiple measures are used in the literature, each capturing various aspects of food insecurity (Headey & Ecker, 2013). Internationally there has been a shift in the thinking about food security from a 'first generation' focus on aggregate food availability (supply side), to a 'second generation' emphasis on individual and household food security (demand side), and finally toward a 'third generation' that locates food security in a broader framework of individual behaviour and perceptions (Barrett, 2002). These changes are reflected in the South African context where there have been two major shifts in the focus on food security: firstly from the national to the household level; and secondly from the use of objective measures to subjective perceptions (Hart, 2009).

It is well established that food security is too complex a phenomenon to be captured by a single indicator and needs to be treated as a multidimensional concept[1] but that it is very hard to give recognition to such multidimensionality in measurement. This discussion tracks a very similar discussion in the literature on measuring poverty. There too there has been a strong movement for the adoption of a multidimensional approach to poverty, with a number of authors recognising the variety of deprivations experienced by those in poverty and the need for an overarching framework to incorporate these[2]. In an effort to address this gap in food security measurement, the assumption here is that the complex nature and measurement of food insecurity is analogous to that of poverty, to the extent that it can be argued that food insecurity is a special case, or manifestation, of poverty. It is thus a natural extension to apply the methods of capturing the multiple dimensions of poverty in a single index to the measurement of food security.

This paper proposes a new multidimensional index for measuring food insecurity, based on the method developed by Alkire & Foster (2009). The Alkire-Foster method is a general framework for the measurement of poverty as a multidimensional concept. Many of the key decisions are left to the user, including the variables or dimensions used, the cut-offs, and the weights which can be varied to fit the purpose of the measure (Alkire & Foster, 2011). The Multidimensional Food Insecurity Index (MFII) exploits this 'general framework' in its construction, using food security specific dimensions, cut-offs and weights. One specific measure that has been developed using the framework, the Multidimensional Poverty Index (MPI), is particularly relevant and is used as the foundation for the measurement of multidimensional food insecurity. The result is an aggregate measure of food insecurity that reflects the prevalence of food insecurity, as well as the joint distribution of deprivation.

In working towards a more comprehensive understanding of what it means to be food insecure, a multidimensional food insecurity index can lead to better policy-making, as is argued in the poverty context (Finn *et al*, 2013). The properties of the MFII that enable the identification of major

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[1] For example Maxwell *et al* , 1999; Hart, 2009; Coates *et al*, 2007; Coates et al, 2006; Battersby, 2012.
[2] See Sen, 2000; Alkire & Foster, 2009 & 2011; Bourguignon & Chakravarty, 2003; Duclos *et al*, 2006; Atkinson, 2003.

contributors to household and individual food insecurity, and the ability to examine the depth and breadth of the problem, allows for the development of more targeted policies to address the most pressing problems. While much of this paper is a contribution to the theory of food security measurement, particularly in the multidimensional framework, the results are also important for applied food security analysis. The index is used to develop a detailed food insecurity profile of South Africa, which highlights the indicators and sub-populations of greatest concern.

In terms of structure, each section of the paper begins with a discussion of the Alkire-Foster method and some technical details, followed by the application in the food security context. Section 2 introduces the Alkire-Foster framework and the choice of dimensions and indicators. The selected variables for the MFII are discussed in some detail, as are the within indicator cut-offs. The Alkire-Foster aggregation procedure, including cross-indicator cut-offs and weights, is then outlined, followed by the application to the MFII. The decomposition properties of the Alkire-Foster framework are discussed, before a detailed profile of multidimensional food insecurity in South Africa is presented. Robustness checks are presented in Section 3, followed by a policy discussion and conclusion in Section 4.

2. Developing the Multidimensional Food Insecurity Index

While South Africa is considered to be food secure at the national level, many households suffer from chronic and transitory food insecurity as measured by numerous indicators[3] (National Department of Agriculture, 2003; HSRC, 2004). The 1995 Income and Expenditure Survey found an urban food poverty rate of 27% compared to a rural rate of 54% (Rose & Charlton, 2002). The National Food Consumption Survey of 1999 found levels of urban food insecurity of 42%, compared to 62% in rural areas. Using a 24 hour recall period the South African Social Attitudes Survey (SASAS) found that 38.3% of South Africans have poor food security (Labadarios *et al*, 2011). These varying levels of food insecurity between surveys can be attributed to the survey tools and proxies that have been used to measure food insecurity.

Aside from the problem of inconsistent measurement of food insecurity across these measures, each of these tools has weaknesses in assessing the depth or severity of food insecurity. For example, Valente (2009) makes use of a question concerning the prevalence of hunger in the household as a measure of food insecurity. However, food insecurity is not synonymous with hunger. Hunger is the extreme end of food insecurity, and as such this measure may miss out on food insecure households that do not fall into hunger (Battersby, 2012). On the other hand the SASAS study made use of dietary diversity as a proxy for food insecurity (Labadarios *et al*, 2011). While this dietary diversity approach has been widely used and has its strengths, it does not make any reference to the adequacy of the quantity of food consumed, either objectively or subjectively. Income and expenditure as measures of food security may also obscure the true extent of food insecurity as prices vary across urban and rural locations, as well as across provinces. Furthermore the amount spent, even only on food, gives no indication of the nutrient quality and diversity of the consumption bundle.

For these reasons it is widely recognised that studies making use of single measures are likely to miss the complexity of the experience that characterises food insecure households and individuals. While

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[3] For discussion on household level food security see Hart, 2009; Hendriks, 2005; Aliber, 2009; and Jacobs, 2009.

the need for a measure that incorporates the multiple experiences of food insecurity is undisputed, the method of doing so has not been so obvious. One promising avenue is to employ the Alkire-Foster methodology of multidimensional poverty measurement. The methodology of multidimensional poverty measurement forms the basis for the development of the multidimensional food insecurity measure. While this is not a paper about poverty measurement, a discussion of this original methodology will lay the foundation for the creation of the Multidimensional Food Insecurity Index.[4] As such, in each section, a conceptual discussion of the Alkire-Foster and MPI methodology precedes the application to the development of the MFII.

2.1 Dimensions, Indicators and Cut-offs of the Index

As noted by Alkire & Foster (2011) the aim of the development of the MPI was two-fold in terms of practical and theoretical goals. From the practical perspective, the purpose was to construct a measure that could be used with continuous and cardinal data. A theoretical goal was to re-examine the identification step – who is poor. The outcome is a measure that first identifies who is poor in each dimension, and then aggregates to obtain group measures that reflect the multiple deprivations experienced by the poor.

Sen (1976) highlights two distinct problems that have to be faced when measuring poverty:

    i)   Identifying the poor among the total population, and
    ii)   Constructing an index of poverty using the available information on the poor.

The first problem involves the choice of a criterion of poverty - a cut-off point that determines poverty, such as a poverty line. The second involves the process of developing an index once the poor have been identified. As noted by Sen at the time (1976), much had been done to address the first problem, while little advancement had been made in respect to the second problem. A number of authors have since recognised the need to consider poverty as multidimensional when addressing the second problem of constructing the index. For example Bourguignon & Chakravarty (2003) argue that poverty should be regarded as the failure to reach 'minimally acceptable' levels of different monetary and non-monetary attributes necessary for a subsistence standard of living, highlighting the multidimensional nature of the phenomenon.

Prior to the multidimensional poverty measurement developed by Alkire & Foster (2009) other methods aimed at accounting for the multidimensional nature of poverty did incorporate multiple dimensions. These aggregate indices however add up the dimensions and then apply an aggregate cut-off to determine who is poor. This has the end result of converting the multiple dimensions of poverty into a unidimensional measure, ensuing in a loss of information on deprivations in specific indicators (Alkire & Foster, 2009). Conversely, the Alkire-Foster method defines a poverty level within each indicator before aggregating across dimensions. In this way the contribution of each indicator to overall poverty is preserved.

The method proposed makes use of a *dual cut-off* in identifying the poor. First there is a *within dimension* cut-off identifying those who are deprived in each indicator, then there is the *across dimension* cut-off identifying those who are deprived in a minimum number of indicators in order to be identified as being multidimensionally poor. The cross-dimensional cut-off extends the traditional *union* and *intersection* approaches of identification, resulting in measures that have a number of key

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[4] For the full details of the multidimensional poverty measures and the MPI see Alkire & Foster 2009 & 2011. The 2011 paper provides useful detail and explanations, once the 2009 paper has been studied carefully.

properties for analysis (Alkire & Foster, 2009). The union and the intersection approaches are two common criteria for identification of the poor, each with their own limitations. In the union approach a person is said to be multidimensionally poor if they are deprived in at least one indicator. This however could lead to the majority of the population being identified as poor even when they are not. This is especially true if there are many dimensions and some of which could be caused by factors other than being poor. As such, the union method can result in overstating the problem, and is not always suitable in the identification of the poor. The intersection approach on the other hand only identifies individuals as being poor if they are deprived in all indicators. While this method is appropriate in identifying those in extreme poverty, it will exclude those who are deprived in a number of indicators, but not necessarily on every indicator. As such this approach is likely to understate the true extent of poverty (Alkire & Foster, 2009).

The dual cut-off method has a number of desirable properties as outlined by Alkire and Foster (2009): Firstly it is 'poverty focused', in that an increase in the achievement level of a non-poor person leaves its value unchanged as only the poor are included in the measure. Secondly it is 'deprivation focused', in that an individual's poverty status is not affected by changes in the levels of non-deprived achievements. Thirdly, cardinalisations of ordinal variables yield identical conclusions regarding whether a person is deprived in that dimension and whether or not they are identified as poor[5]. The implication of this is that the method can be meaningfully applied to data with lower level measurements properties, such as ordinal data. This greatly extends the usefulness of the approach.

The three dimensions of the MFII are guided by the 'domains' of food security as identified by Coates et al (2006)[6]. Domains are defined as the most core experiences of food insecurity that are common across countries and cultures. As identified in a cross-country food security literature review (Coates et al, 2006), they are:

1. Anxiety and uncertainty about the household food supply
2. Insufficient quality (including variety and preferences of the type of food)
3. Inadequate quantity (including the physical consequences)

Additionally, these domains capture the identifiable 'elements' of the FAO definition of food security stated in the introduction[7] (Maxwell *et al*, 2013). The different experiences of food insecurity captured by these domains are also reflected in Maxwell et al (2013), where indicators of food security are classified into recognisable categories: Dietary diversity and food frequency, spending on food, consumption behaviours, experiential measures, and self-assessment measures. Furthermore, the domains consider both subjective and objective measures of food insecurity, an important consideration as highlighted by Barrett (2010).

Thus, the three domains outlined by Coates et al (2006) are widely accepted. As such they form a solid basis for three widely accepted dimensions of food security to be included in the index. As shown in Figure 1 below, each of the three domains has two intuitive indicators that can be used to represent it:

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[5] Cardinalisations are found by applying a monotonic transformation to the ordinal variable and its cut-off, transforming it into a cardinal variable.

[6] There is a fourth dimension measuring 'social unacceptability' in terms of consumption or procurement. This domain is often excluded from studies because these questions are too sensitive to be asked outright and as such there is no data (Coates et al, 2006). This is the case in the NIDS data where such questions have not been asked, and thus this domain is omitted.

[7] "Food security exists, at the individual, household, national, regional, and global levels when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for a healthy and active life"(FAO, 2001).

Figure 1: Structure of the Multidimensional Food Insecurity Index
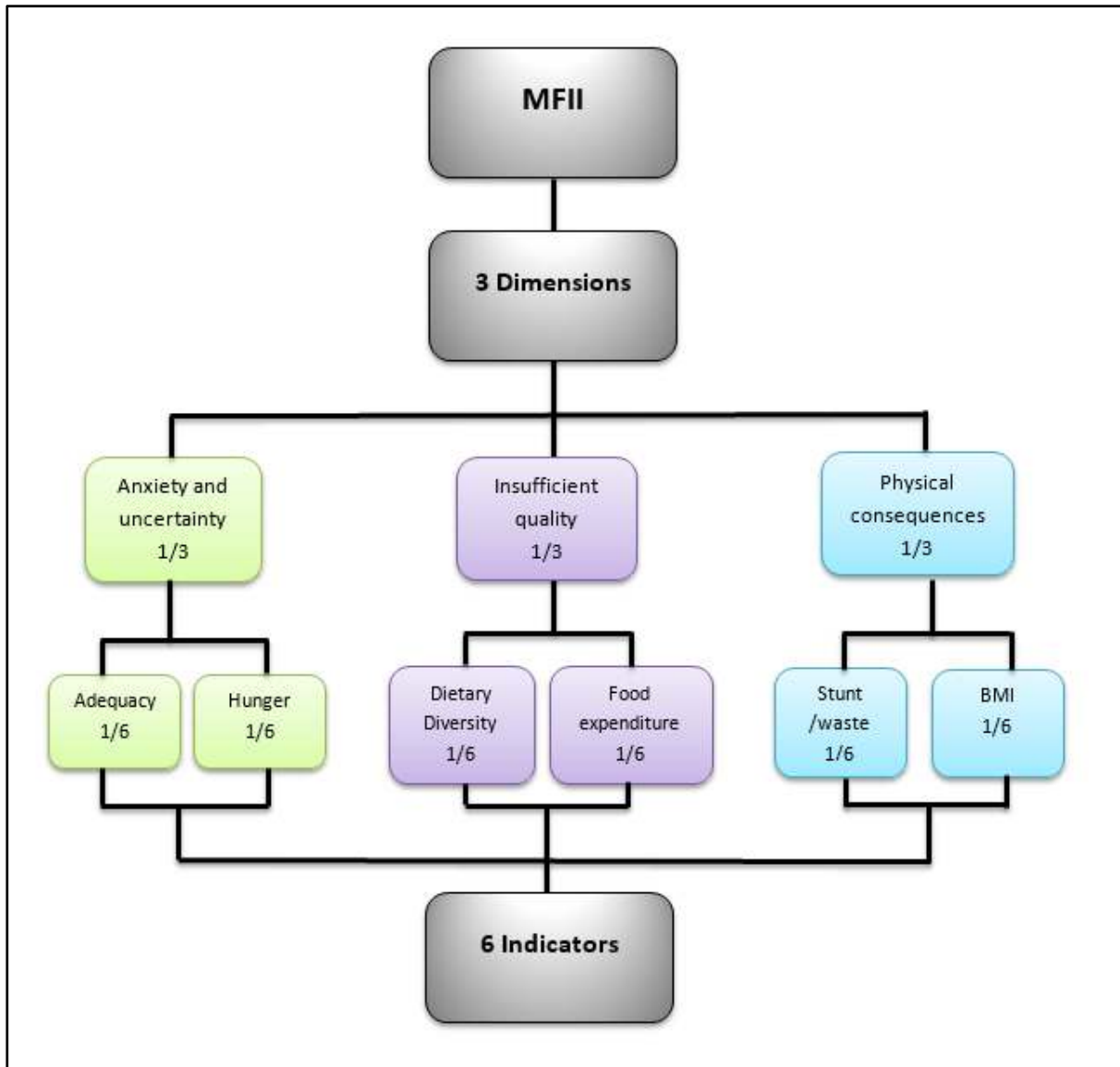
These indicators are commonly used as stand-alone measures of food insecurity, and in recognition of the multidimensionality of food insecurity, subjective and objective indicators are also discussed jointly. Barrett (2010) highlights the importance of anthropometric and perception of hunger measures that are captured in household surveys. The value of survey data that captures objective dietary, economic, and health indicators as well as subjective measures of adequacy, risk exposure and sociocultural acceptability is also noted. Valente (2009) makes use of subjective self-reported hunger as a measure of food insecurity, and more generally subjective measurements such as perceptions and experiences of hunger broaden the understanding of the multiple factors involved in food security (Hart, 2009).

Previously, measuring per capita caloric intake or the adequacy of household food availability over time have been suggested as the main 'benchmark' measures for food security at the household level, and anthropometric measures at the individual level (Maxwell et al, 1996; Maxwell, Coates & Vaitla, 2013). Undernourishment, as measured by anthropometric indicators, is also used to

measure and distinguish short and long term food security. Aspects of child malnutrition, such as stunting and wasting, as well as subjective measures of food insecurity are referred to in an Human Sciences Research Council position paper measuring food security in South Africa (de Klerk *et al*, 2004).

Together with anthropometrics, dietary diversity and food expenditure are popular objective measures of food insecurity. The Household Food Insecurity Access Scale (HFIAS) and the Household Dietary Diversity Score (HDDS) are surveys that capture various objective components of the concept of food security. The HFIAS measures the access component of food insecurity, while the HDDS measures dietary diversity in terms of the number of food groups consumed in a day (Coates *et al*, 2007; Swindale & Bilinsky, 2006). In estimating the prevalence of food insecurity in South Africa, Rose & Charlton (2001 & 2002) employ a quantitative, objective measure termed 'food poverty' which assesses whether the amount spent by a household on food was adequate to purchase a low cost food plan. The MFII manages to incorporate all of these diverse objective and subjective measures.

2.1.2 Data

The National Income Dynamics Study (NIDS) is the first nationally representative panel study in South Africa to document the changes over a number of years in the income, expenditures, assets, access to services, education, health and other dimensions of wellbeing of some 7 305 households (Southern Africa Labour and Development Research Unit, 2014). The first wave of this intensive effort to track and follow the life changes of about 28 000 people was conducted by the Southern African Labour and Development Research Unit SALDRU (Leibbrandt *et al*, 2009). While the second and third waves of the panel are publically available, the approach in this paper is cross-sectional with the data coming from the first wave which was conducted in 2008. Version 5.2 of the Wave 1 data includes provincial and geographic type (urban or rural) data based on the 2011 census. These 2011 variables are used in the analysis as they are closer to the survey year. Later waves of the data are unfortunately not suitable for this analysis as they do not contain a number of the key variables used in the construction of the index.

The baseline questionnaires include information on all members of the household: those who were resident at the time of the interview, as well as those that were non-resident, with residents at the time providing the base sample of individuals who will be followed over time (Leibbrandt *et al*, 2009). The target population for NIDS is private households and residents in workers' hostels, convents, and monasteries in all nine provinces. Other collective living quarters, such as prisons and old age homes, were excluded. The survey includes information on households as well as individuals in the household. Certain groups were underrepresented in the sample and thus it is appropriate to use post stratification weights in the analysis to provide a nationally representative analysis (Southern Africa Labour and Development Research Unit, 2014).

2.1.3 The Indicators

The general methodological framework of the adjusted headcount ratio can be applied to any dimensions, with the choice being guided by the question of interest. As discussed, the dimensions, or domains, adopted for the MFII are those defined by Coates *et al* (2006). The indicators of which the domains are comprised are those that measure and capture the concepts covered by the domain: BMI and child stunting and wasting are measures of the physical consequences of food insecurity; self-reported hunger and perceptions of food adequacy are measures of anxiety and uncertainty about food supply; and dietary diversity and the proportion of food expenditure capture the quality of the food consumed. These measures themselves are common indicators of food insecurity, and the cut-offs within each indicator are guided by the literature.

Dietary Diversity

Dietary diversity, or the number of unique foods consumed over a given period of time, is considered a promising measure or indicator of food security, and has previously been considered the "best performing" (Headey *et al*, 1994; Hoddinott & Yohannes, 2002; Swindale & Bilinsky, 2006). In order to define unique foods, the Household Dietary Diversity Score indicator guide identifies twelve food groups, derived from the United Nations Food and Agriculture Organisation's Food Composition Table for Use in Africa[8] (Swindale & Bilinsky, 2006). Knowing, for example, that a household consumed an average of four different food groups in the past 30 days implies some diversity in the macro and micro-nutrients being consumed. Consumption of different food items is less meaningful in that all four items might be from the same food group, for example cereals (Swindale & Bilinsky, 2006). Following this reasoning, the food items listed in the NIDS data were grouped into twelve food groups, based on the FAO table:

1. Cereals and Grain Products
2. Starchy Roots, Tubers, and Fruits
3. Grain Legumes and Legume products
4. Vegetables and Vegetable Products
5. Fruits and Nuts
6. Sugars and Syrups
7. Meats, Poultry, and Insects
8. Eggs
9. Fish and Shellfish
10. Milk and Milk Products
11. Oils and Fats
12. Miscellaneous (including beverages)

The recall period of the food consumption variables in NIDS is the previous 30 days. This lengthy recall period can result in less accurate information due to imperfect recall, however it can also increase the confidence with which a household can be classified as food insecure (Swindale & Bilinsky, 2006). The longer measurement period allows for greater diversity in consumption as opposed to consumption over, say, a 24 hour period[9]. The likelihood of committing a Type II error and classifying households as food insecure when they are not (based on diversity) is thus reduced.

An increase in the average number of different food groups consumed provides a quantifiable measure of improved household food access. There is however no explicit number of different food groups that serves as a cut-off point in differentiating food secure from food insecure households. One suggestion in the HDDS guide is to take the average diversity of the upper tercile of household diversity scores (Swindale & Bilinsky, 2006). An alternative measure, which in a sense can be considered as a less strict measure resulting in a greater count of deprivation, would be to use the average dietary diversity as a cut-off point, with households who score below average identified as food insecure. The advantage of both of these methods is that the target has been shown to be achievable by the sample population (Swindale & Bilinsky, 2006). This does however result in the measure being a relative one rather than an absolute one (Maxwell *et al*, 1999). In the first instance the second option of using the average diversity as the cut-off has been chosen, largely as a

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[8] This set of food groups is derived from the U.N. Food and Agriculture Organization (Food and Agricultural Organization. Food Composition Table for Africa. Rome, Italy, 1970. As viewed at www.fao.org/docrep/003/X6877E/X6877E00.htm.

[9] 24 hours is the suggested recall period in the HDDS manual (Swindale & Bilinsky, 2006), while the HFIAS utilises a 4 week recall period (Coates, Swindale and Bilinsky, 2007)

consequence of the average dietary diversity score being high at more than 9 out of a possible 12. As mentioned this high average could in part be as a result of the 30 day recall period.

In the NIDS data 12 households report positive expenditure on food items, while not having consumed any of the 12 food groups. On further inspection 9 of these households reported consumption of food hampers, but the contents of these hampers is not known. 3 of the households that report positive food expenditure report no consumption of any of the food items listed. All 12 of these households are excluded from the sample as the required information is missing.

Food expenditure

Food expenditure has been used fairly extensively as an indicator of food security, with the general classification being that households that spend a high proportion of their total expenditure on food are more vulnerable to food insecurity than those that spend a lower proportion (Maxwell, 1999; Jonnson & Toole, 1991). The rationale is that households that spend a large proportion on food are more susceptible to changes in food prices, as well as changes in income, than households who spend a small proportion. Of the income and expenditure measures, food expenditure per capita has been shown to more accurately identify food insecure households than total expenditure per capita, or household income (Haddad *et al*, 1994).

While commonly used as a proxy for food security, food expenditure may not speak to consumption differences. This would depend on what kind of food is available in the market at what prices. For example a household that does not receive a regular income (so cannot plan spending) and does not have storage capacity or access to a supermarket may spend considerably more on less diverse and nutritious food than a household with regular income, storage capacity and access to a supermarket. Furthermore, this indicator may not capture food that is received as gifts or produced by the household (Battersby, 2012).

Nevertheless, food expenditure is a useful factor in an index. The variable constructed using the data captures the total food expenditure of the household in the last 30 days, and is taken as a proportion of total household expenditure over the same period. As suggested by Maxwell *et al* (1999) a high food expenditure proportion is regarded as 60% and above, and these households are classified as food insecure[10]. The index utilises the inverse of this, the proportion of non-food expenditure, as the indicator. This is for ease of interpretation in that a decrease in the indicator equates to greater deprivation in terms the proportion of income spent on food.

Anthropometrics

There are a number of anthropometric measures used as an indication of an adequately nutritious diet. These measures vary between young children, older children and adolescents, and adults. Commonly used measures for young children between the ages of 0 and 5 are z-scores for height for age, and weight for height. These compare the measurements for the child to standard measurements of a reference population of children. A child is classified as undernourished if their z-score is more than 2 standard deviations below the median z-score. Stunting is reflected by low height-for-age, and is associated with a number of long-term factors such as chronic insufficient protein and energy intake, sustained poor feeding practices, frequent infections, and certain micronutrient deficiencies[11]. Stunting does not change rapidly, and it may be irreversible in children older than two years (Cogill, 2003). Wasting is reflected by low weight-for-height and is a short-term

[10] An alternative uses the mean food share figure for the lowest expenditure quintile as the cut-off (Maxwell et al, 1999).
[11] Particularly iron and zinc

measure of malnutrition as wasting can change rapidly with changes in diet and disease prevalence. Causes include inadequate food intake, poor feeding practices, disease and infection, or mostly a combination of these (Cogill, 2003). Z-scores are a strong indicator of long and short term food insecurity. Stunting is used as an indicator for chronic malnutrition and is a bigger problem in South Africa than acute malnutrition, as measured by wasting (Faber & Wenhold, 2007). At the national level, stunting affects almost one out of five children (Labadarios *et al*, 2008). As part of the NIDS Wave 1 questionnaire weight and height measurements were taken for all children, and these were used to generate weight-for-height and height-for-age z-scores for children aged 0 to 5. Children are classified as undernourished if their stunting or wasting z-score is more than 2 standard deviations below the reference group using the WHO international child growth standards (WHO, 2006).

For older children between the ages 6 and 19 BMI-for-age scores are used as an indicator of adequate nutrition. The BMI of adults remains relatively constant unless there is weight gain or loss, and as such it is possible to use the same thresholds for the classification of individuals as underweight, overweight, or obese regardless of the age and sex of the adult. The BMI of children however changes as they mature, and these patterns differ between boys and girls (Dinsdale *et al*, 2011). Stratification by age and gender is thus required for this age group in order to correctly classify individuals based on their BMI (de Onis *et al*, 2007). BMI is calculated as height/weight squared, which is then compared to a reference population of children of the same age and gender[12]. Children who have a BMI less than 2 standard deviations below the median BMI for the reference group are classified as underweight (Dinsdale *et al*, 2011). The classification of adults is less complex, with one threshold applied to all individuals over the age of 20. A BMI below 18.5 is identified as underweight (Ardington & Case, 2009).

From these measurements households that contain at least one child or adult who is classified as undernourished or underweight will be identified as food insecure. This follows the methodology of Finn *et al*, (2013) who classify those identified as underweight with respect to BMI as 'nutritionally deprived' on the MPI for South Africa. This decision is potentially contentious as there are other possible reasons for low z-scores or being underweight, such as diseases causing malabsorption of nutrients (Hendriks, 2015). A sensitivity check is included as part of the robustness tests that extends this cut-off to a minimum of 2 adults or children in a household.

A further point worth discussing regarding anthropometrics and food insecurity is the food insecurity-obesity paradox. There has been considerable debate about the link between food insecurity and obesity with some studies finding that adults, especially women, from low income families were more likely to be overweight than those from wealthier households (Townsend et al, 2001). One review of the literature finds that while there is a positive relationship between obesity and food insecurity observed for women, there are not consistent findings for men or children. Furthermore, several factors (marital status, stressors and food stamp participation) are revealed to alter the association (Franklin, Jones, Love, Puckett, Macklin & White-Means, 2012). Food insecurity obesity can be caused by disordered eating patterns, and due to the high proportion of household income that is spent on food in poor households, prices can have a strong effect on what food a household purchases (Caballero, 2005). In South Africa evidence indicates that women are more obese than men, and that while wealthier men are more likely to be obese, women have similar obesity patterns regardless of socioeconomic status (Alaba & Chola, 2014). Further, large percentages of racial differences in obesity can be explained by socio-economic status and background variables (Averett, Stacey & Wang, 2014). High dietary energy and fat intake is likely to be a major contributing factor to the high prevalence of obesity in South African populations, with

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[12] Using the 2007 WHO reference charts for boys and girls available at http://www.who.int/growthref/en/

low levels of physical activity and education also playing a role (Steyn, Fourie & Temple, 2006). This reflects the global causes of increasing obesity being an increased intake of energy-dense foods that are high in fat, and an increase in physical inactivity (WHO, 2015). Further studies indicate that as countries become increasingly urbanised, undernutrition and obesity can exist side by side within the same country, community or household (Malik, Willett & Hu, 2012).

Obesity is a noisy indicator of food insecurity and it is not clear that it is necessarily an indicator of food deprivation, with access to food and dietary intake being only one of the causes. However, in returning to the definition of food insecurity in the introduction[13], it is plausible that a lack of access to suitably nutritious food is contributing to obesity, which in turn impedes a healthy and active lifestyle. The link speaks largely to dietary quality, and while both dietary diversity and the proportion of household expenditure spent on food are accounted for in the index, it is useful to consider obesity. As such, the link between obesity and food insecurity is considered in the robustness checks where the presence of obese, in addition to underweight, individuals is considered as an indicator of household food insecurity.

Self-reported measures of hunger and food adequacy

There are two hunger related questions in the NIDS data that ask how often did any child, and then adult, go to bed hungry because there was not enough food. At the national level 51.6% of households report experiences of hunger, with approximately 33% being at risk of hunger (Labadarios *et al*, 2008).There is a further question concerning household food consumption over the past month, and the adequacy of this consumption in meeting the needs of the household. These two self-reported measures speak to the first domain of food insecurity and provide insight into household perceptions of food security (Coates, 2004).

There are two shortcomings to bear in mind when considering these measures: Firstly, as highlighted by Battersby (2012) and discussed above, food insecurity should not be equated with hunger as this will miss many food insecure households who do not experience this extreme form of food insecurity. Secondly in many low-income areas there is very limited dietary diversity, which has long-term health consequences, but which households themselves may not consider to be inadequate. However, given that these self-reported measures will not be implemented as stand-alone measures, but rather will be combined with other factors as part of the index, these concerns are at least in part mitigated.

2.1.4 Deprivation by Indicator Findings

Having outlined the relevant indicators and cut-offs used to determine food insecurity, the next step is to examine the deprivation experienced in each indicator. As suggested by Coates (2013) food security dimensions should be reported on in their disaggregated form prior to an aggregated measure of all dimensions being explored. The findings of the proportion of the deprived in each province are presented with the indicators grouped in the three domains[14]. A correlation matrix of the deprivation on each indicator can be found in the Appendix.

Figure 2 illustrates the proportion of the population in each province who are deprived for each indicator. In terms of the subjective indicators, Gauteng and the Western Cape enjoy the lowest

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[13] *Food security exists, at the individual, household, national, regional, and global levels when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for a healthy and active life*

[14] The white areas in the figures that contain no data are Lesotho and Swaziland and as such are excluded from the analysis.

levels of self-reported hunger, while Limpopo and KwaZulu-Natal have the greatest proportion of people deprived on this indicator. KwaZulu-Natal also has the highest levels of deprivation in consumption adequacy, with Mpumalanga suffering the last, followed by the Western Cape.

As in indicated in Figure 3, KwaZulu-Natal and the Eastern Cape report the highest levels of deprivation in both dietary diversity and the proportion of expenditure spent on food. The Western Cape and Gauteng suffer the lowest deprivation in dietary diversity, while Mpumalanga and Gauteng indicate the lowest levels of deprivation in the proportion of expenditure spent on food.

Figure 2: Provincial Deprivations by Indicator: Anxiety and Uncertainty
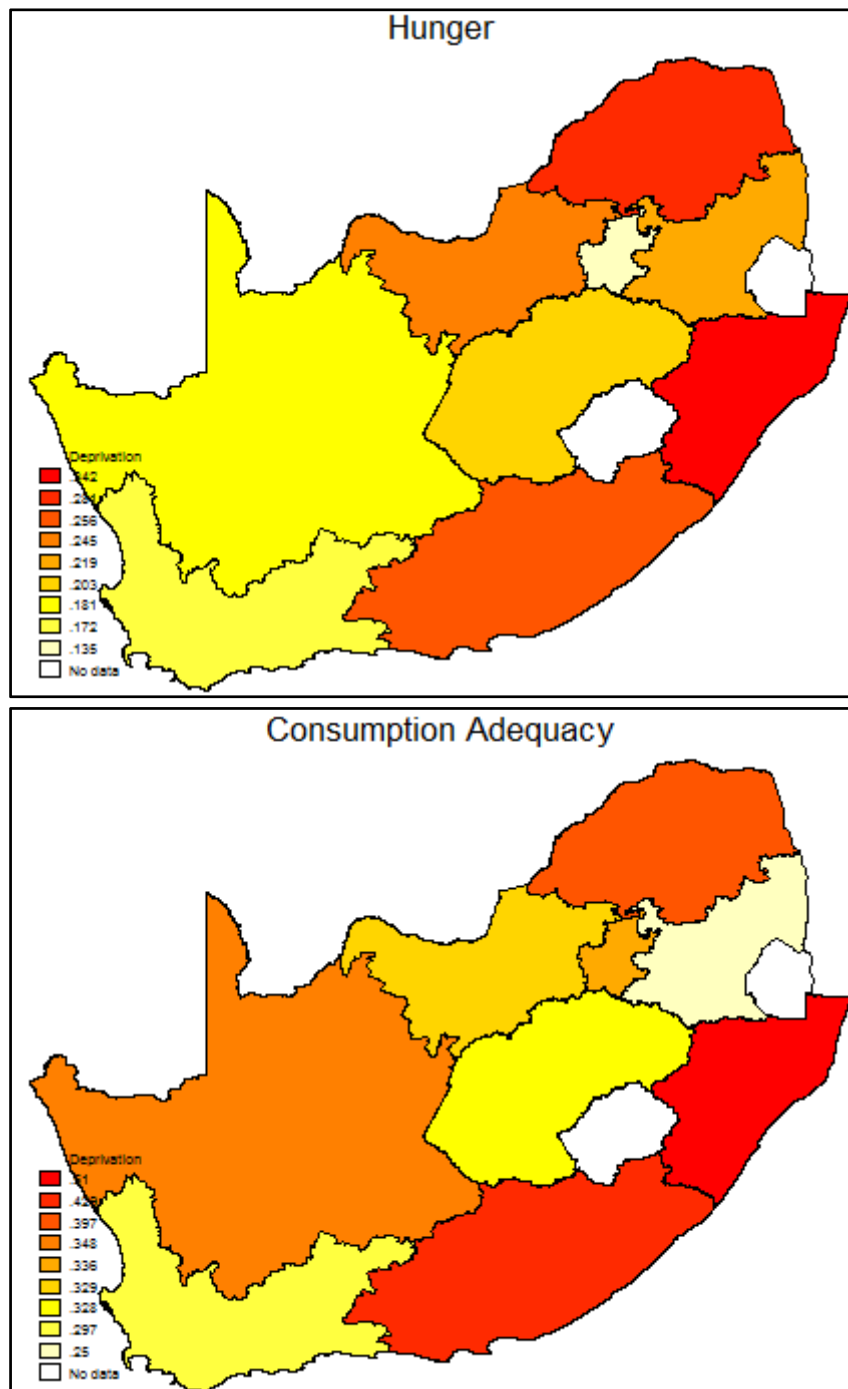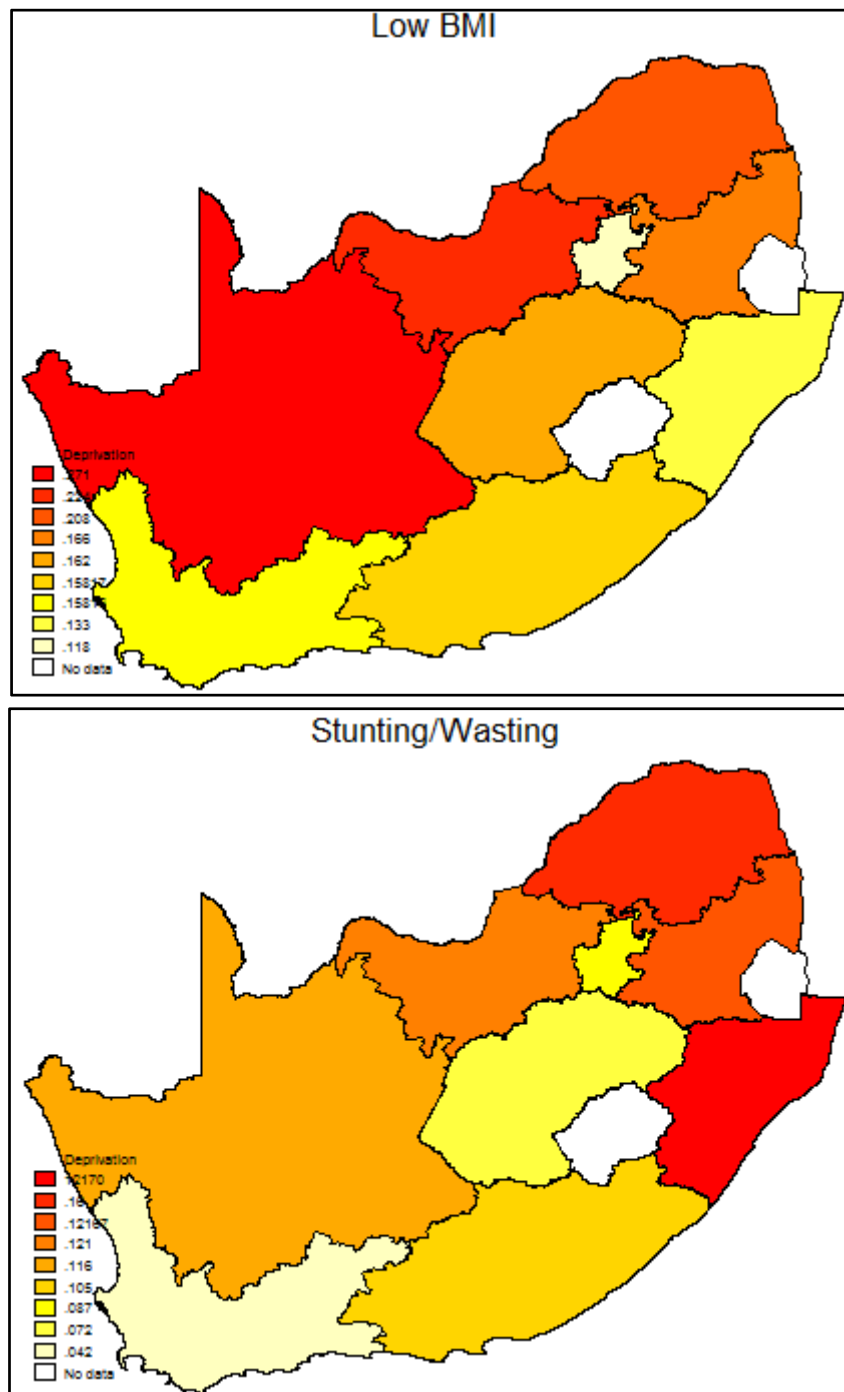

Source: Authors' own calculations using weighted NIDS Wave 1 data (2008)

Figure 3: Provincial Deprivations by Indicator: Insufficient Quality
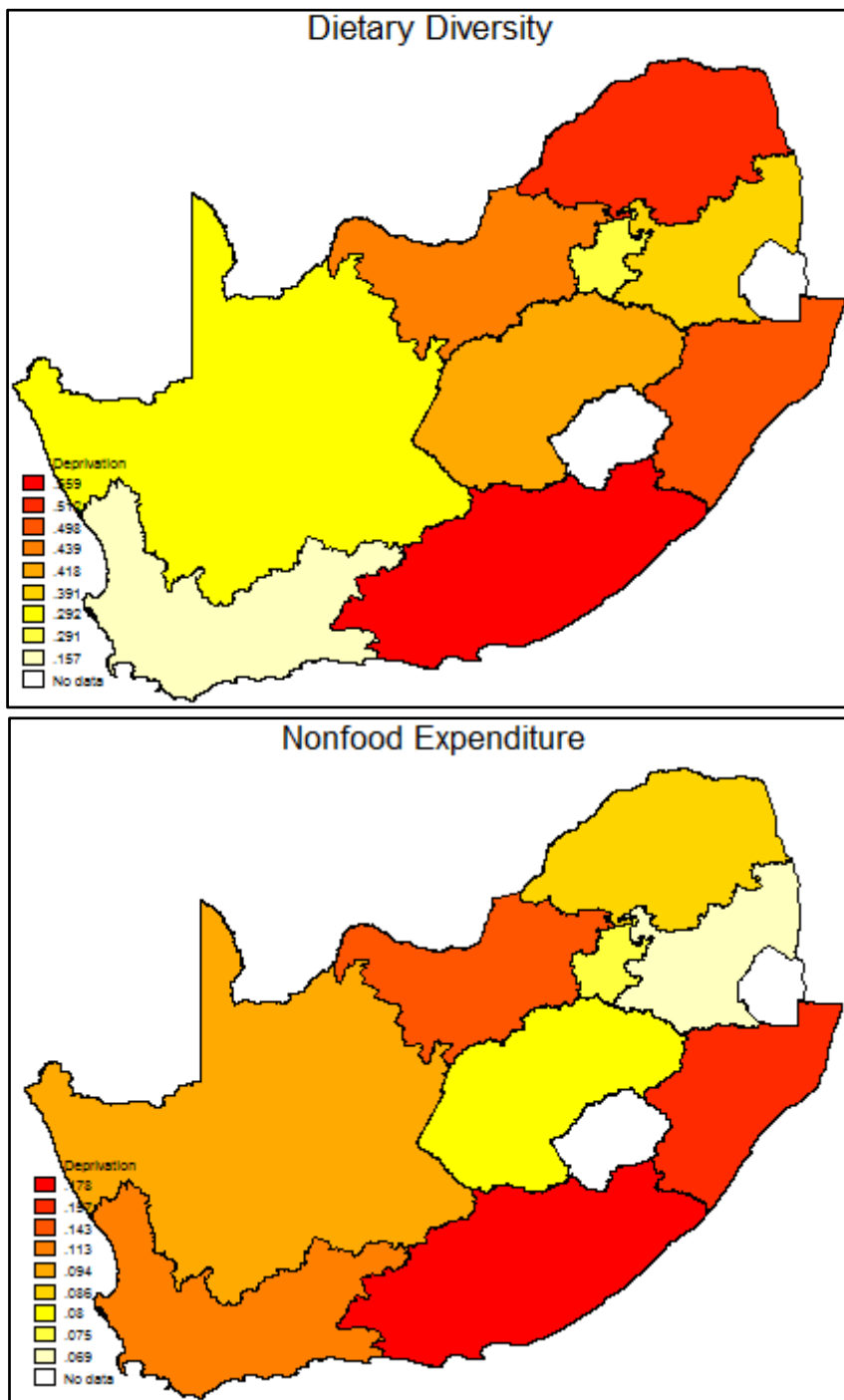
Source: Authors' own calculations using weighted NIDS Wave 1 data (2008)

Figure 4: Provincial Deprivations by Indicator: Physical Consequences

Source: Authors' own calculations using weighted NIDS Wave 1 data (2008)

Figure 4 presents provincial breakdowns of anthropometric indicators of deprivation in terms of low BMI and stunting or wasting. Low BMI is the greatest in the Northern Cape and North West, with Gauteng and KwaZulu-Natal experiencing the least deprivation. Stunting or wasting in children is most prevalent in KwaZulu-Natal and Limpopo, while the Western Cape and the Free State suffer the least.

The relative deprivations for each indicator are somewhat mixed, but on the whole the Western Cape and Gauteng seem to suffer the least, while KwaZulu-Natal and Limpopo have the highest levels of deprivation.

2.2 Aggregation of the Indicators into an Index

The *adjusted headcount ratio,* the key measurement variable, is derived by first identifying the percentage of the population that is poor, *H*. That is the number of poor identified using the dual cut-off approach. The *adjusted headcount ratio* is analogous to the income *headcount ratio*, and while it is easy to calculate and understand it is considered a partial measure - a measure that provides basic information on a single measure of poverty. It gives no indication of the breadth of poverty. When considering multidimensional poverty, the problem is that should a poor person become deprived in an additional indicator *H* will remain the same. This violates what is termed 'dimensional monotonicity' which states that if a person becomes deprived in an additional indicator then overall poverty should increase (Alkire & Foster, 2009). To account for this, another partial measure is included to provide information on the breadth of deprivation, or the number of deprivations, experienced. This is known as the *average deprivation share*, *A*, and indicates the fraction of possible indicators in which the average poor person experiences deprivation. This conveys relevant information about the multiple dimensions in which poverty is experienced. In the food security context for example, if an individual is deemed deprived in at least two indicators, say dietary diversity and hunger, this individual is then counted as being deprived (*H*). The same is true of an individual who is deprived in four of the six indicators. However, the intensity of deprivation (*A*) of the second person is double that of the first.

The adjusted headcount ratio, M_0, is thus given by multiplying the headcount ratio by the average deprivation share (Alkire & Foster, 2009):

$$M_0 = H * A$$

M_0 is sensitive to the frequency and the breadth of multidimensional poverty. Should either the proportion of poor people, *H*, increase or the average number of dimensions in which the poor are deprived, *A*, increase the adjusted headcount ratio will increase. The adjusted headcount ratio, or M_0, is one of a number of multidimensional poverty measures that can be developed following this methodology. Within the general Alkire-Foster framework, the adjusted headcount ratio can be calculated using any dimensions, weights and cut-offs, as determined by the question of interest.

In the general poverty literature the MPI is a special case of the adjusted headcount ratio, in that it makes use of specific indicators, cut-offs and weights. The three dimensions are health, education and living standard, with a number of indicators for each. The indicators are nutrition, child mortality, years of schooling, school attendance, cooking fuel, sanitation, water and electricity, floor and assets. Each dimension and each indicator within the dimensions is equally weighted. The within dimensions cut-offs are guided by the literature, and the cross-dimensional cut-off is set at 2/6[15]. These specific choices make the MPI one of many possible applications of the Alkire-Foster multidimensional methodology to poverty. A different index might use different indicators, weights and/or cut-offs. It is exactly this generalisable framework that makes the methodology applicable in the food security context, where the dimensions and indicators chosen are specific to the measurement of food insecurity.

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[15] For the details of the MPI dimensions, weights, and cut-offs see Alkire and Santos (2010)

It is worth highlighting the methodological point that the 'censoring' step is key to the identification process. This censoring means that the aggregate measure only includes deprivation information of the poor, and not those who may be deprived in a single dimension but are not identified as poor. This is important because information on the deprivations of the non-poor should not affect any measure that is focused on the poor (Alkire & Foster, 2011).

The choice of the dimensions, weights, and cut-offs are key aspects of the index and require further discussion. The dimensions chosen, and the cut-offs within each, are largely guided by the literature where a general motivation and interpretation can be found for each indicator of interest. Selecting these can also be determined by the availability of data to some extent (Alkire & Santos, 2010). In contrast, the cross-dimensional cut-off is less directed by the literature and can rely on a number of points. For example the minimum deprivation count required to be considered poor in a specific context, where the cut-off could be set to the minimal level of one if deprivation on any one dimension is considered a gross violation. Alternatively it might be guided by specific policy goals and priorities, where changing the cut-off can allow for the analysis of a smaller group with multiple deprivations, or a wider group with fewer. It is advised that any choice of cut-off is tested for robustness (Alkire & Foster, 2009).

By defining a measurement based on deprivation counts and simple averages, an equal weight is implicitly assigned to each dimension of the MPI (Alkire & Foster, 2009). The interpretation of the indicators is also made easier by assigning equal, or at least not very different, degrees of importance to the different indicators (Atkinson *et al*, 2002). While this is appropriate when the dimensions have been chosen to be of equal importance, it is no longer applicable when there is reason to believe that some indicators are more important, or bear more weight, than others. The choice of equal weights does not go uncontested, however it is noted by Foster & Sen (1997) that the selection of weights is a judgemental exercise only resolved through reasoned evaluation. While they should enjoy reasonable acceptance, it is important that the dimensional weights used are open to criticism. The issue of weights will be considered in more detail in the Robustness section.

Considering that there is no a priori reason to believe otherwise, and for ease of interpretation, each dimension of the MFII is equally weighted, and each indicator within the dimensions is also equally weighted. There does not appear to be any indication in the literature that the weights should be anything different, but as suggested for the weights in the MPI context these will be varied as part of the robustness checks[16]. Each indicator has its own cut-off point which determines whether a household or individual is food insecure in that measure. These cut-offs are guided by the literature and have been discussed in detail. The second cut-off, the cross-dimensional cut-off, stipulates that a person is identified as food insecure if they are deprived in at least one third, or 2 of the 6, weighted indicators. This again is based on the MPI method, and will be varied as part of the robustness tests.

2.3 Using the Decomposition Properties of the Index for Food Insecurity Analysis in South Africa

Part of the value of such multidimensional measures is the unique properties which allow for a detailed analysis of the problem. These include the decomposability of the index, and the ability to calculate the percentage contribution of each indicator to the overall measure. The property of

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[16] This will include a brief discussion on the relative importance of subjective versus objective measures of food insecurity.

decomposability requires overall poverty to be the weighted average of subgroup poverty levels, where weights are subgroup population shares, and ensure that poverty is evaluated relative to the population size so as to allow for meaningful comparisons across different sized populations (Alkire & Foster, 2009). A common example of this is the urban and rural subgroups of a population, where the contribution of each group to overall poverty can be computed as follows:

$$Contribution\ of\ urban\ areas\ to\ MPI = \frac{\frac{n_u}{n} MPI_u}{MPI_{Total}} * 100$$

Where n_u/n is the population share residing in urban areas. If the contribution of a specific subgroup largely exceeds its population share this indicates that some subgroups bear a disproportionate share of poverty (Alkire *et al*, 2011).

Another key property of the Alkire-Foster framework is that once the index has been calculated, it can be decomposed to reveal the composition of the deprivation experienced by the poor**.**
The contribution of each indicator to total poverty is calculated as follows:

$$Contribution\ of\ Indicator\ I = 100 * \left(\frac{w_i * CH_i}{MPI}\right)$$

Where w_i is the weight of indicator i, CH_i is the censored headcount of indicator i. This is the number of MPI poor who are deprived in indicator i, divided by the total population. When the contribution to poverty of a certain indicator largely exceeds its weight, this suggests that that poor are more deprived in this indicator than the others (Alkire *et al*, 2011).

These properties of decomposability by subgroup and decomposability into indicator contributions facilitate in-depth analysis into the causes of food insecurity within specific groups of the population. As outlined above for the MPI, the MFII reflects both the proportion of individuals that are multi-dimensionally food insecure, denoted *H,* and the average intensity, *A,* of that food insecurity. That is, *A* is the average proportion of indicators in which food insecure individuals are deprived. The MFII is calculated by multiplying the incidence of food insecurity by the average intensity across food insecure individuals (*H*A*). The strength of this MFII measure is that it allows for a rich interrogation of which dimensions and indicators are driving food insecurity. As such it is possible to identify not only how many people are food insecure, but the severity and dimensions in which the deprivation is occurring. Furthermore, the measure can be decomposed by subgroup to investigate themes such as race or socioeconomic differences; geographic applications such as provincial, and urban/rural food insecurity differences; and policy evaluations such as the impact that social grants are having on food security.

Table 1 provides a summary of multidimensional food insecurity in South Africa as a whole, and the subpopulations of urban and rural areas, and for the nine provincial subpopulations.

Table 1: Multidimensional Food Insecurity Measures for South Africa

Sample	Incidence (H)	Intensity (A)	MFII	% Vulnerable	% Severe
South Africa	0.482	0.400	0.193	25.77	28.51
Rural	0.591	0.443	0.262	24.12	33.50
Urban	0.399	0.338	0.135	27.01	24.71
Western Cape	0.418	0.263	0.110	21.37	32.56
Eastern Cape	0.570	0.416	0.236	25.02	31.77
Northern Cape	0.483	0.377	0.168	28.41	26.98
Free State	0.502	0.357	0.179	23.31	32.34
KwaZulu-Natal	0.569	0.450	0.256	22.88	33.08
North West	0.490	0.423	0.207	29.73	26.47
Gauteng	0.349	0.345	0.120	33.04	16.76
Mpumalanga	0.436	0.374	0.163	24.66	24.22
Limpopo	0.561	0.434	0.243	21.25	37.82

Authors' own calculations using weighted NIDS Wave 1 data 2008. MFII is the Multidimensional Food Insecurity Index score. % Vulnerable refers to the percentage of the population that are vulnerable to food insecurity, being deprived in 1 indicator. % Severe refers to the percentage of the population that suffer severe food insecurity, being deprived in 3 or more indicators.
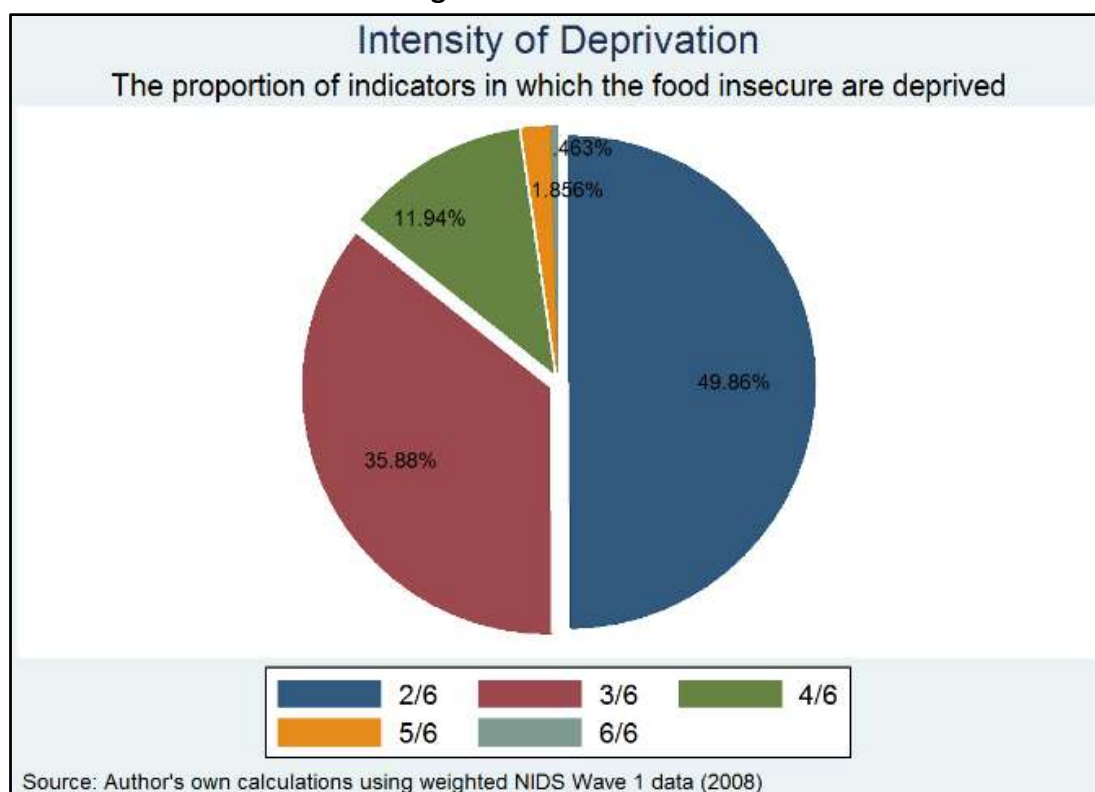
The incidence of food insecurity in South Africa is 0.482, indicating that close to half of the population is considered multidimensionally food insecure. Of a population of roughly 54 million, approximately 26 million are food insecure[17]. The intensity of deprivation, the average proportion of weighted indicators in which the MFII food insecure are deprived, is 0.4. Of those who are deemed food insecure, the average proportion of indicators in which they are deprived is 0.4. The MFII score for South Africa, which accounts for both the depth and the severity of food insecurity, is 0.193. At this stage the incidence and intensity of food insecurity may be separately more informative than the MFII score as there are no MFII's for other countries, or different time periods for South Africa, with which to benchmark or compare this score. Decomposing the measure into various geographic subpopulations, and the contributions of the indicators, does however provide a more nuanced picture of the state of food insecurity in South Africa.

An additional capability of the MFII is to identify those who are vulnerable to food insecurity. It is common in the multidimensional poverty literature to define the "vulnerable" as those who are deprived in 20% to 33.2% of weighted indicators (Finn *et al*, 2013). Considering that the cut-off for food insecurity classification is 33.3%, these are individuals who are close to the cut-off of 1/3 dimensions, but are not classified as food insecure. Following this convention, column 4 indicates that 25.77% of South Africans are vulnerable to food insecurity. The MFII also allows for the identification of individuals suffering severe food insecurity. Severe food insecurity is defined as being deprived in 50% or more of the weighted indicators. Column 5 reveals that 28.51% of South Africans are severely food insecure.

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[17] Population figures from Statistics South Africa (2014) and applied to the MFII incidence

The intensity of the deprivation experienced by the food insecure can also be explored using the MFII. Decomposing the MFII by indicator reveals the dimensions in which deprivation is most concentrated. Each slice of the pie in Figure 5 illustrates the proportion of the food insecure in South Africa who fall in each level of intensity, increasing from 2/6 to 6/6. From the figure it is clear that the majority, almost half of those who are food insecure, are deprived in two of the six indicators, followed by three of the six. Very few are deprived in five or all of the six indicators. It is important to note that these figures are not nationally representative, as they only reflect the indicators for those classified as MFII food insecure. It appears that for the majority of those who are multidimensionally food insecure in South Africa, the intensity is moderate rather than severe.
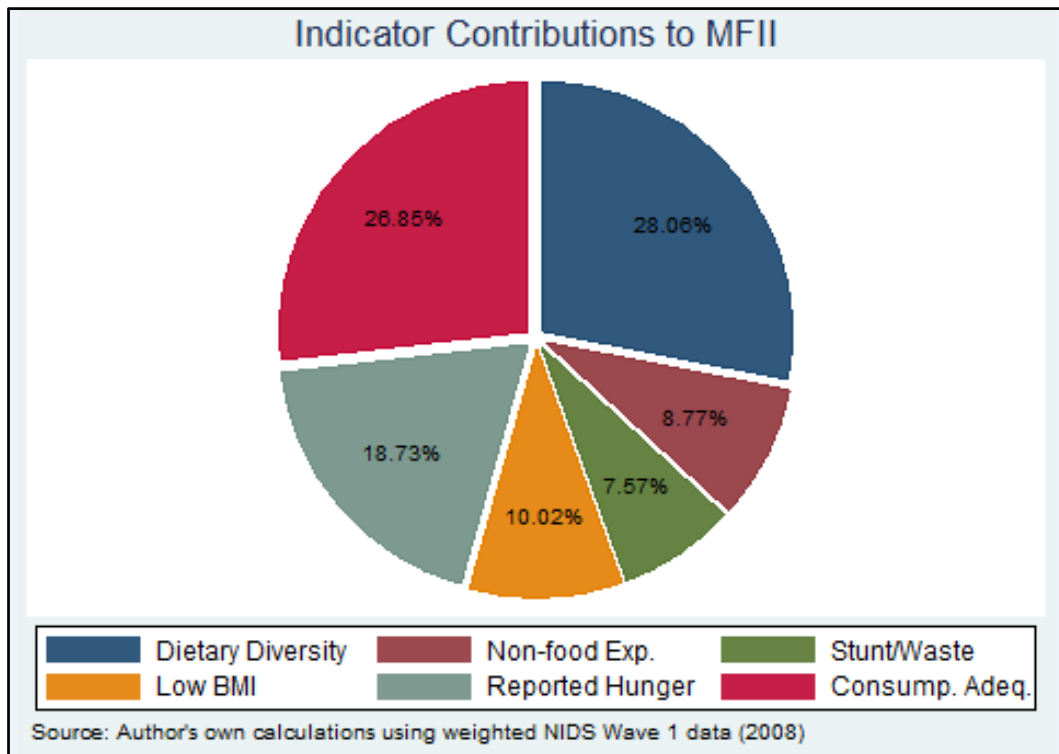
Figure 5: National MFII

Intensity of Deprivation
The proportion of indicators in which the food insecure are deprived

463%
1.856%
11.94%
49.86%
35.88%

2/6   3/6   4/6
5/6   6/6

Source: Author's own calculations using weighted NIDS Wave 1 data (2008)

A further step in unpacking multidimensional food insecurity is to analyse the contributions of each indicator to the overall MFII measure. Figure 6 indicates that the two largest contributors to multidimensional food insecurity in South Africa are poor dietary diversity and the subjective perception of consumption adequacy. These are followed by self-reported hunger. Low BMI, stunting and wasting, and non-food expenditure make up smaller proportions. The prominence of the subjective measures of food insecurity, self-reported consumption adequacy and self-reported hunger, in the top three contributors is worth noting. While dietary diversity, an objective measures, is the largest contributor, these subjective measures are certainly prominent. This emphasises the importance of examining and understanding the differences between subjective and objective measures, their relative importance, and what they mean for the measurement of food insecurity[18].

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[18] The methodology allows for varying the emphasis placed on subjective versus objective measures as dictated by the question of interest

Figure 6: National MFII

Indicator Contributions to MFII

26.85% · 28.06% · 8.77% · 7.57% · 10.02% · 18.73%

Legend:
- Dietary Diversity
- Non-food Exp.
- Stunt/Waste
- Low BMI
- Reported Hunger
- Consump. Adeq.

Source: Author's own calculations using weighted NIDS Wave 1 data (2008)

Contributions to the MFII for South Africa can also be calculated for geographic areas. Figures 7 and 8 show the contributions of each province to the national MFII score, and the contributions of urban and rural areas. KwaZulu-Natal is the greatest contributor, accounting for more than a quarter of the national MFII figure at over 25%. The Northern Cape contributes the least to overall food insecurity at only 2.18%. The contribution of rural areas to national food insecurity is just over half, nearly 53%, with that of urban areas being just under half at about 47%.

Figure 7: Provincial Contributors to the National MFII
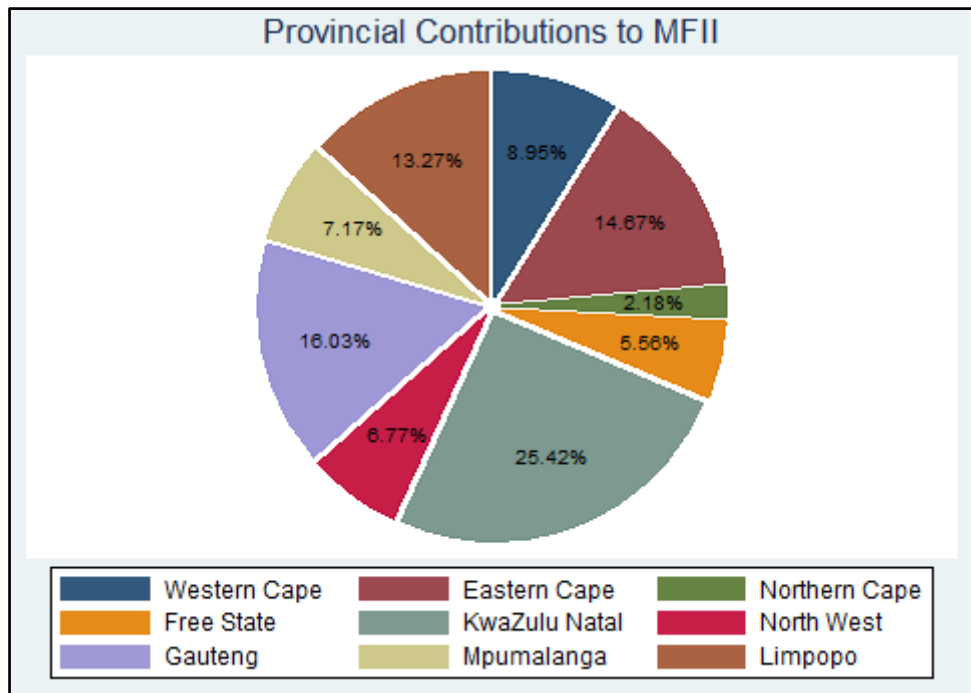
Source: Authors' own calculations using weighted NIDS Wave 1 data (2008)

Figure 8: Urban and Rural Contributors to the National MFII
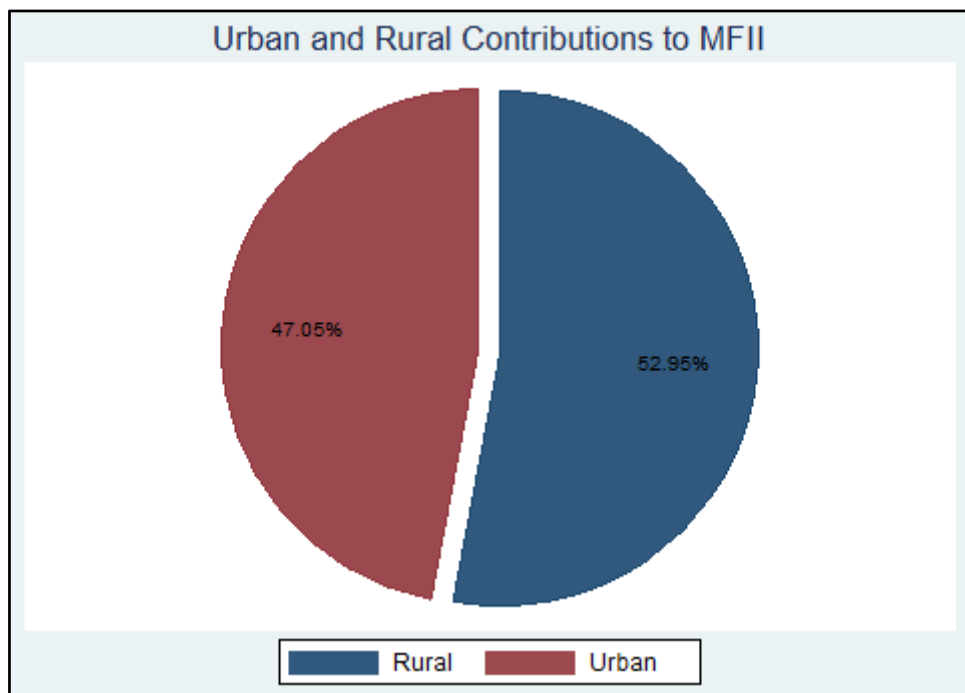
Source: Authors' own calculations using weighted NIDS Wave 1 data (2008)

Rural and Urban Subpopulations

Rural areas contain over one and a half times more MFII food insecure people than urban areas, with incidences of 0.605 and 0.395 respectively. Furthermore, the intensity of food insecurity experienced in rural areas is greater than that in urban areas at 0.443 and 0.340 respectively. Those

in acute poverty are mostly concentrated in rural areas. This is also reflected in the proportion of food insecure who are severely so, at 34.41%. These finding are not surprising, and confirm other relative measures of food insecurity in South Africa highlighted in the introduction. The strength of the MFII, however, is that it allows for detailed interrogation of which dimensions are contributing the most to food insecurity in each area.

Provincial Subpopulations

Figure 9 illustrates the MFII scores for the nine provinces, and allows for easy identification of those provinces with the highest levels of food insecurity. Those suffering the highest multidimensional food insecurity are KwaZulu-Natal (0.256) and Limpopo (0.243). These provinces are largely rural, and this is consistent with the findings for the rural/urban subpopulations. There are however other provinces that are also largely rural but with lower MFII scores, indicating that there are other factors at play in determining food insecurity. The Western Cape enjoys the lowest levels of multidimensional food insecurity (0.110), followed by Gauteng (0.120).

A natural question to explore is the relationship between the two component indices of the MFII, namely the incidence and the intensity. There is a uniform relationship across provinces where the provinces with higher MFII's tend to have higher intensity as well as incidence of food insecurity. This may seem obvious, but it is possible for a subpopulation or province to have a low intensity, yet end up with a high MFII due to a very high incidence (or vice versa). This would be an important distinction, particularly in policy development. While the Western Cape enjoys the lowest MFII score, 0.110, the province has the third highest proportion of severe food insecurity, following Limpopo and KwaZulu-Natal. Gauteng enjoys the second lowest MFII score, with the lowest incidence (0.349) and second lowest intensity (0.345). This province also has the lowest proportion of people suffering severe food insecurity, 16.76%. These differences can be explored further by examining which factors are the largest contributors to food insecurity.

Figure 9: Provincial Food Insecurity

Source: Author's own calculations using weighted NIDS Wave 1 data (2008)
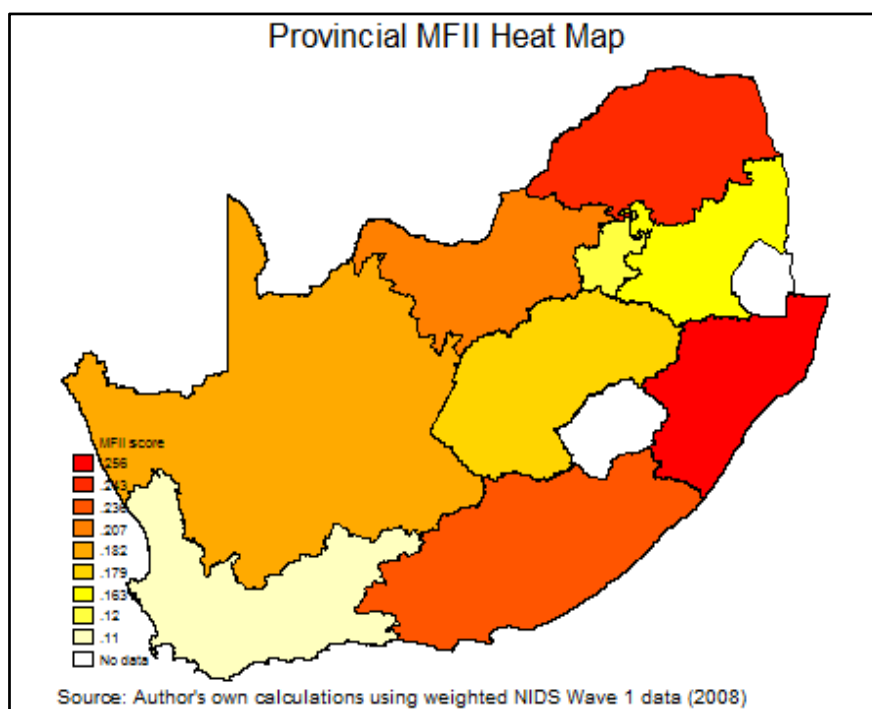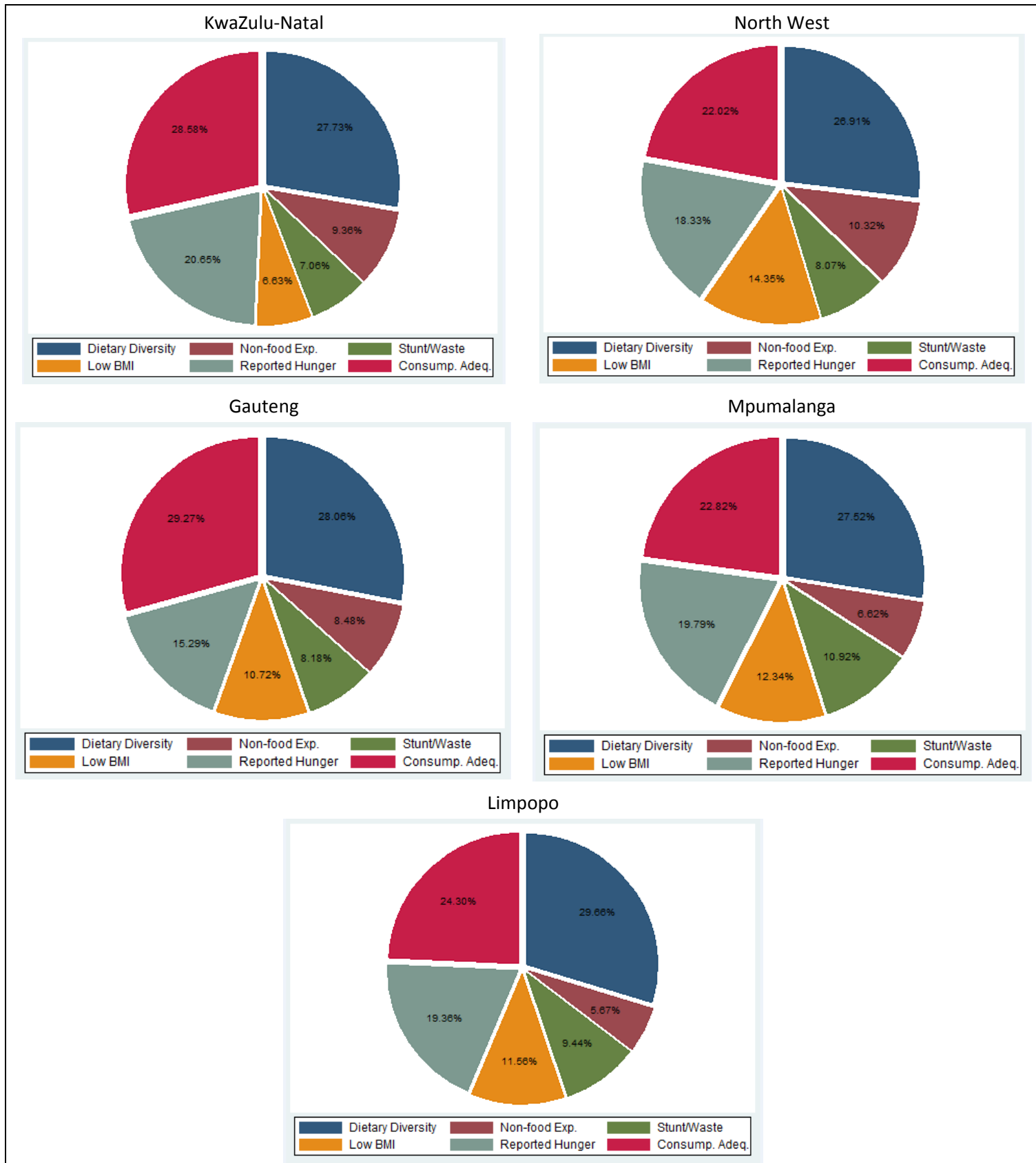
Figure 10: Indicator Contributions to MFII Score by Province

Figure 10: Indicator Contributions to MFII Score by Province (cont.)

Source: Authors' own calculations using weighted NIDS Wave 1 data (2008)

Figure 10 reveals that the comparative contributions of each indicator to MFII by province reflect those for the whole country, with dietary diversity and subjective consumption adequacy being the greatest contributors. The Western Cape is the one exception, with self-reported consumption adequacy superseding dietary diversity as the greatest contributor. The two subjective measures of food insecurity are the greatest contributors to food insecurity in the Western Cape. This is a potentially interesting finding worth investigating further considering the potential differences between subjective and objective measurement. These patterns are reflected in the proportion of the food insecure deprived on each indicator, found in the Appendix.

3. Robustness checks

In general, different methods of constructing food insecurity measures can lead to different conclusions, thus it is necessary to include a number of robustness checks in any analysis (Hendriks, 2005). More specifically the methodology of the MPI is not without its limitations and shortcomings, and it is necessary to discuss and address these criticisms which also apply to the MFII. As noted by Foster (2010) this methodology is best seen as a general framework for measuring multidimensional poverty where most of the hard decisions are left to the user. These 'hard decisions' include the selection of dimensional weights, dimensional cut-offs, and a poverty cut-off. The MFII construction also relies on these decisions, and robustness tests are required to test the sensitivity of the measure to these choices. Alkire, Foster and others, are open and forthcoming about these issues, and promote discussion and debate of these topics[19].

The bulk of the MPI debate is centred on the issue of weights and the imbedded trade-offs. A leading critic aptly puts this concern as "the index is essentially adding up 'apples and oranges' without knowing their relative price" (Ravallion, 2010). This stems from indicators being weighted essentially arbitrarily in the construction of the index. For the MPI this results in equating the death of a child with having a dirt floor and cooking with wood in terms of the weight each indicator bears. The MFII does not include any extreme dimensions such as this. Equating self-reported hunger with under-nourishment is arguably not as problematic as equating the death of a child with cooking fuel. The lack of theory to support the chosen weightings in the MPI does however extend to the MFII, but as pointed out by Alkire (2010) a lack of theory should not mean that no weighting be given at all. Taking Sen's advice (1977), the weightings used are made explicit and are open to criticism. An obvious robustness check then involves varying these weights in order to gauge the sensitivity of the findings to the decision to weight indicators equally.

The cross-dimensional cut-off - the number of dimensions in which deprivations are required for an individual to be classified as food insecure - is another important normative decision that is made by the user. The chosen cut-off of 1/3 is largely based on the same cut-off used in the MPI, but otherwise is an arbitrary choice and requires further examination. Varying this cut-off can either tighten or loosen the requirements for the classification of who is food insecure, resulting in a smaller or greater headcount respectively. This also serves to illustrate how the index can be modified in order to address specific aspects of food insecurity. For example if a policy were aimed at those suffering most severely from food insecurity, the cut-off could be set higher to facilitate identification and analysis of this specific group. As part of the robustness checks the cut-off is increased to 1/2 and it is expected that this will decrease MFII scores. The provincial rankings should

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[19] See Alkire & Foster, 2011, and Alkire & Santos, 2010 for detailed discussions of these issues and how they can be addressed.

however remain the same if the measure is robust to this cut-off. Decreasing the cut-off, to 1/6, seems rather meagre and somewhat defeats the point of a multidimensional measure that considers the joint distribution of deprivation. As such, this option will not be tested[20]. The within indicator cut-offs are closely guided by the literature and as such are less open to the discretion of the user. For now these chosen cut-offs will also not be tested.

An additional issue raised is the requirement of data from a single survey, or at least matched surveys. This can result in sub-standard data being utilised in the construction of the index if this is all that is available. This concern over data quality is not unique to this methodology and is often an issue in quantitative research. However with the scope and quality of surveys, especially multi-topic surveys, constantly improving, this concern is likely to diminish. The NIDS dataset is one of the few nationally representative datasets to include detailed food security related question, and is widely considered a reliable source. The indicators used are well-documented measures of food insecurity and not limited by the availability of data. No obvious measure or concept from the literature has been excluded due to a lack of data. A data concern that does however persist is that subsequent waves of the survey do not include all of the indicators used in the construction of the index. For the moment, this limits the possibility of monitoring food insecurity over time in South Africa with a consistent MFII using NIDS data.

The cross-dimensional cut-off was increased from two to three out of the six indicators. Increasing the minimum deprivation from 2 to 3 indicators results in a stricter measure of food insecurity and it is expected that this will decrease the headcount while increasing the intensity of deprivation.

Table 2: Results of Sensitivity Tests on H, A, and MFII scores for South Africa

	Incidence (H)	Intensity (A)	MFII
Original	0.482	0.400	0.193
Cross-dimensional Cut-off of 1/2	0.285	0.424	0.121
Reweighting Subjective Measures: 0.5	0.482	0.436	0.210
Reweighting Anthropometric Measures: 0.5	0.482	0.355	0.171

Source: Authors' calculations using weighted NIDS Wave 1 data (2008)

Table 2 shows the results of this change for the national MFII figures. As expected, the incidence of poverty, H, has decreased as the number of food insecure individuals has been reduced under the tighter criteria. At the same time, the intensity, A, of the deprivation experienced by those who are food insecure has increased. This again is as expected as the number of indicators in which the food insecure are deprived has increased on average with the higher minimum cut-off. The decrease in the incidence of food insecurity is greater than the increase in the intensity, resulting in an overall decrease in the MFII measure.

Table 2 also shows the results of changing some of the weightings assigned to the indicator variables. If there is an *a priori* reason to believe that subjective indicators of food insecurity are better or more important than other measures, these can be weighted higher. In this instance the two self-reported measures of hunger and food adequacy were allocated a combined weight of 0.5.

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[20] This reasoning and decision reflects that of Alkire & Santos (2010)

The balance of the weightings was equally divided between the remaining indicators, 0.125 each[21]. In this way the index is placing more importance on the subjective aspects of food insecurity than the objective measures. The incidence of food insecurity remains the same, while the intensity increases. In the same way the weighting of the anthropometric measures was increased to 0.5, and the balance allocated equally to the remaining indicators. In this case we see that the intensity of food insecurity has decreased relative to the equal weighting scenario. What this suggests is that of those who are food insecure, the average number of indicators in which they are deprived has decreased when more emphasis is placed on anthropometric measures. The converse is true when we place more emphasis on the subjective measures, where the intensity of food insecurity increases. The indication then is that subjective perceptions of food insecurity are more intense than objective anthropometric measures: people might feel or perceive themselves to be more food insecure than what is indicated by demonstrable physical measurements.

While changes in MFII measures are expected when weights and cut-offs are varied, the real test is whether or not the rankings of MFII scores for different populations or subpopulations are sensitive to these decisions (Alkire & Santos, 2010). The rankings are 1 for the lowest MFII score, or least food insecure, and 9 for the highest score, or most food insecure.

Table 3 provides the original scores and ranking for comparison. Tables 4 - 6 show subpopulation changes in the measures for the different robustness checks. Column 4 of each table shows the MFII ranking in each situation, where significant changes in these rankings would indicate sensitivity of the MFII measure to the selected weights and cut-offs. There is no change in the rankings of the rural and urban subpopulations. It would be somewhat concerning if there was a change here as the difference in MFII scores between the two is great, and this would indicate a heavy reliance on the selections made. The provincial rankings also remain consistent for the most part, with only slight adjustments in each case. Changing the cut-off from 1/3 to 1/2 results in changes at the very top and bottom of the rankings. The Western Cape moves from 1 to 2, and Gauteng moves from 2 to 1, while at the bottom end Limpopo moves from 8 to 9 and KwaZulu-Natal from 9 to 8. Increasing the weight of the subjective measures results in a shift in the middle, with the Northern Cape dropping one position to 5 and the Free State moving up one to 4. Increasing the weight of the anthropometric measures causes this same shift in the middle, and at the bottom end with KwaZulu-Natal dropping one to 9 and Limpopo moving up one to 8.

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[21] This method of increasing the weight of one dimension to 0.5 and splitting the balance equally between the remaining two dimensions (0.25 each) follows the robustness test outlined in Alkire & Santos (2010)

Table 3: Subpopulation Figures and Rankings for Original Weights and Cut-offs

Sample	Incidence (H)	Intensity (A)	MFII	Rank
Rural	0.591	0.443	0.262	2
Urban	0.399	0.338	0.135	1
Western Cape	0.418	0.263	0.110	1
Eastern Cape	0.570	0.416	0.236	7
Northern Cape	0.483	0.377	0.168	4
Free State	0.502	0.357	0.179	5
KwaZulu-Natal	0.569	0.450	0.256	9
North West	0.490	0.423	0.207	6
Gauteng	0.349	0.345	0.120	2
Mpumalanga	0.436	0.374	0.163	3
Limpopo	0.561	0.434	0.243	8

Source: Authors' calculations using weighted NIDS Wave 1 data (2008)

Table 4: Cross-dimensional 3/6 Cut-off Sensitivity Results for Subpopulations

	Incidence (*H*)	Intensity (*A*)	MFII	Ranking
Rural	0.335	0.517	0.173	2
Urban	0.247	0.312	0.077	1
Western Cape	0.326	0.216	0.070	2
Eastern Cape	0.318	0.462	0.147	7
Northern Cape	0.284	0.375	0.106	4
Free State	0.323	0.339	0.110	5
KwaZulu-Natal	0.331	0.527	0.174	8
North West	0.265	0.480	0.127	6
Gauteng	0.168	0.327	0.055	1
Mpumalanga	0.242	0.383	0.093	3
Limpopo	0.378	0.466	0.176	9

Source: Authors' calculations using weighted NIDS Wave 1 data (2008)

Table 5: Reweighting Subjective Measures Sensitivity Results for Subpopulations

	Incidence (*H*)	Intensity (*A*)	MFII	Ranking
Rural	0.592	0.479	0.283	2
Urban	0.399	0.374	0.149	1
Western Cape	0.418	0.297	0.124	1
Eastern Cape	0.567	0.444	0.251	7
Northern Cape	0.483	0.408	0.197	5
Free State	0.502	0.387	0.194	4
KwaZulu-Natal	0.569	0.504	0.287	9
North West	0.490	0.447	0.219	6
Gauteng	0.349	0.374	0.130	2
Mpumalanga	0.436	0.399	0.174	3
Limpopo	0.561	0.470	0.264	8

Source: Authors' calculations using weighted NIDS Wave 1 data (2008)

Table 6: Reweighting Anthropometric Measures Sensitivity Results for Subpopulations

	Incidence (*H*)	Intensity (*A*)	MFII	Ranking
Rural	0.592	0.394	0.233	2
Urban	0.399	0.300	0.120	1
Western Cape	0.418	0.246	0.103	1
Eastern Cape	0.567	0.362	0.205	7
Northern Cape	0.483	0.359	0.173	5
Free State	0.502	0.319	0.160	4
KwaZulu-Natal	0.569	0.384	0.218	8
North West	0.490	0.390	0.191	6
Gauteng	0.349	0.311	0.108	2
Mpumalanga	0.436	0.350	0.153	3
Limpopo	0.561	0.467	0.221	9

Source: Authors' calculations using weighted NIDS Wave 1 data (2008)

There are two further sensitivity checks regarding the anthropometry indicators. As mentioned in the discussion of the indicators in Sections 2.1.3, the issues of the physical consequences dimensional cut-off, and obesity as an indicator of food insecurity, require further investigation.

Table 7: Changing the Physical Consequences Dimensional Cut-off from 1 to 2

	Incidence *(H)*	Intensity *(A)*	MFII	Rank
Rural	0.538	0.437	0.235	2
Urban	0.270	0.414	0.112	1
Western Cape	0.220	0.404	0.089	1
Eastern Cape	0.499	0.423	0.211	7
Northern Cape	0.335	0.417	0.140	4
Free State	0.252	0.401	0.142	5
Kwa-Zulu Natal	0.522	0.448	0.234	9
North West	0.408	0.440	0.180	6
Gauteng	0.236	0.407	0.096	2
Mpumalanga	0.344	0.396	0.136	3
Limpopo	0.485	0.436	0.212	8

Source: Authors' calculations using weighted NIDS Wave 1 data (2008)

Table 8: MFII Including Obesity

	Incidence *(H)*	Intensity *(A)*	MFII	Rank
Rural	0.696	0.478	0.332	2
Urban	0.532	0.383	0.204	1
Western Cape	0.511	0.320	0.163	1
Eastern Cape	0.693	0.465	0.322	8
Northern Cape	0.574	0.414	0.238	4
Free State	0.630	0.399	0.251	5
Kwa-Zulu Natal	0.691	0.494	0.341	9
North West	0.613	0.436	0.267	6
Gauteng	0.505	0.377	0.191	2
Mpumalanga	0.549	0.405	0.223	3
Limpopo	0.632	0.451	0.285	7

Source: Authors' calculations using weighted NIDS Wave 1 data (2008)

Tables 7 and 8 present these robustness tests, with the results being as expected. Table 7 presents the results from changing the physical consequences dimensional cut-off from 1 underweight individual in a household to 2 decreases the MFII scores for the full sample, as well as the urban, rural and provincial sub-samples. This is largely driven by the decrease in the incidence (H), which is intuitive given that a stricter cut-off criteria is being applied. Importantly, the ranking of the

provinces remains exactly the same as in the main specification. Changing the cut-off results in a consistent decrease in the MFII scores across the board, and comparatively the results are the same.

Table 8 shows the findings when obese individuals are considered alongside underweight people in terms of BMI and food insecurity. The MFII scores are larger than the original specification across all the sub-populations, as a result of increases in both the incidence and intensity of food insecurity. Again, this is intuitive as the definition has been broadened to include obese people in determining food insecure households. There is one change of position in the provincial rankings, with Limpopo moving up to 7 and the Eastern Cape dropping to 8. These provinces remain at the higher end of food insecurity, with the change being of little practical significance.

The extensive robustness checks serve to test the sensitivity of the index to certain user-defined decisions. They also serve to highlight the flexibility of the MFII, and how it can be adapted based on the purposes and context of the research. As long as the same criteria are applied to any food insecurity comparisons, the relative findings are not driven by these choices. While there are some minor shifts in the provincial ranking, they do not represent fundamental changes. The indication is that the MFII measure is generally robust to the choices of weights and cut-offs, with minimal deviations in ranking. While these choices can be adjusted by the user based on the question of interest, the MFII does not appear to be heavily dependent on these normative decisions. This is important in establishing the measure as a widely applicable and robust food security measure.

4. Policy Discussion and Conclusion

While there has been considerable work done in developing multidimensional measures for poverty, less has been done in terms of such a methodology for measuring multidimensional food insecurity. One example of a multidimensional measure developed by Maxwell, Coates & Vaitla (2013) constructs a multidimensional indicator, the Multi-dimensional Food Security Indicator (MFI), using an algorithmic approach. The method involves first empirically extracting categories using a network modularity approach, and then refining these inductive results with theory. The MFII is arguably conceptually easier to understand and calculate than the MFI, and has useful properties for analysis that make it a valuable tool for policy development. Furthermore, the methodology has already gained good traction in the poverty measurement discourse.

Some attempts have also been made to aggregate the multiple dimensions of food insecurity into one univariate index. An example of this is the Global Food Security Index developed by the Economist Intelligence Unit.[22] However indices such as these suffer from the same criticism as some poverty indices - that of merely redefining food security while remaining unidimensional. For example a common unidimensional method for creating such a composite indicator is to aggregate across several component variables by multiplying each by some factor, and adding up. Such methods however mean that a shortfall in any one dimension is not of concern, as it can be completely compensated for by gains in another dimension (Alkire & Foster, 2011). This results in the many dimensions being merged into one, and when shortfalls in some dimensions are offset by excesses in others information on the individual impact of dimensions on the aggregate measure is lost. There is further apprehension about the use of a single metric of food insecurity, with Coates (2013) highlighting the following issues: 1) underestimation of food insecurity by overlooking the quantification of dimensions, 2) difficult diagnostics obscuring potential causes and consequences of individual elements of food insecurity, 3) diagnostic errors resulting in "one-size-fits-all" interventions, and 4) biased impact estimation of interventions. These concerns are largely

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[22] Accessible from http://foodsecurityindex.eiu.com/

overcome by the methodology and properties of the MFII, where no information on the various dimensions is lost through aggregation. Furthermore, the decomposability of the index facilitates tailor-made interventions for specific sub-populations, as well as detailed impact evaluation of specific indicators.

In terms of policy analysis, the MFII is a useful tool in both the development of new policies and the evaluation of existing efforts. The decomposability property of the index also makes it particularly valuable in crafting targeted household and individual food security policy. The ability to decompose the MFII by subgroup means that the index score and major contributing indicators to food insecurity can be identified for specific subgroups of interest. The provincial analysis presented above is one example. By examining food insecurity in this way, it is possible to identify those provinces suffering the greatest levels of food insecurity. Not only can polices then be directed at these specific subgroups, but it is also possible to target policies at those indicators that are the greatest contributors to food insecurity. For example, KwaZulu-Natal and Limpopo are the most food insecure provinces, with subjective consumption adequacy and dietary diversity being the greatest contributors. Policies can then be directed at these two indicators in an effort at tackling the most pressing concerns.

Figure 11: District Council MFII

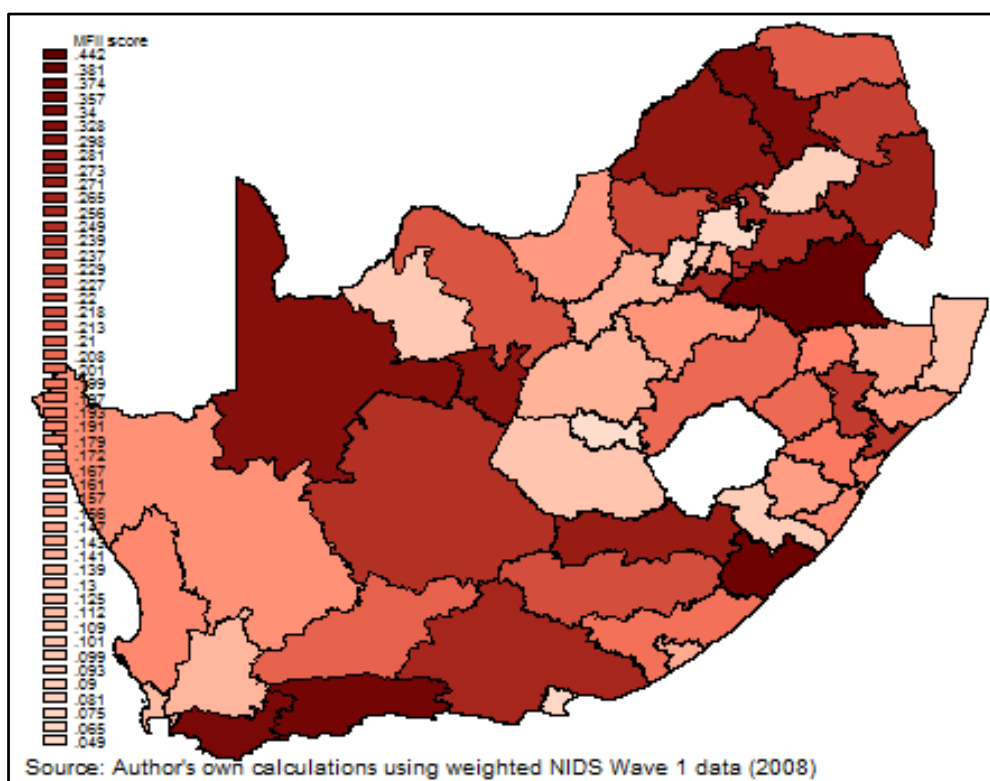Source: Author's own calculations using weighted NIDS Wave 1 data (2008)

Figure 11 provides an illustration of the MFII scores for the 52 District Councils in South Africa. This decomposition provides more detail than the provincial MFII example, and facilitates a more detailed analysis. The versatility of the MFII allows for a flexible investigation depending on the purposes of the research and the questions requiring answers, ultimately facilitating finely tuned policy development.

The decomposability of the index is also beneficial in the evaluation of existing policies. The ability to differentiate across many different subgroups of the population allows for a nuanced evaluation that can identify even subtle changes in the level and composition of multidimensional food insecurity. The impact of policies on rural and urban subpopulations is a level of subgroup analysis that is likely to be useful. For example, land reform policy has rural food security as a primary aim and any progress to this end can be estimated by examining this subgroup. The impact of social welfare policies on household food insecurity can also be explored, such as the old age pension and child support grant. The food security of beneficiaries and non-beneficiaries can be compared and contrasted in a detailed manner that can shed light on the potentially differential impact of the policies.

Target 1.C of Goal 1 of the Millennium Development Goals (MDG) is to halve, between 1990 and 2015, the proportion of people who suffer from hunger (United Nations, 2008). The 2013 MDG country report for South Africa shows that from 2002 to 2011 the percentage of people who report experiencing hunger dropped from 29.9 to 12.9[23] (United Nations Development Programme, 2014). As such, South Africa is reported to have achieved target 1.C of halving the number of people suffering from hunger. However, hunger is a limited measure of food insecurity that ignores a number of other important factors (Battersby, 2012). A promising indication regarding this is that a key recommendation highlighted in the report is the inclusion of additional measures to that of reported hunger. These include dietary diversity, a child food security indicator, and other mixed methods of data gathering such as anthropometric measurement. It appears then that South Africa recognises food security as a multidimensional phenomenon, requiring more detailed measurement than simply counting up the incidence of self-reported hunger.

The multidimensional nature of food insecurity is a given, and the "holy grail" of food security measurement would be "a single measure that is valid and reliable, comparable over time and space, and which captures different elements of food security" (Maxwell *et al*, pp 3; 2013). The MFII presented here not only meets these criteria, but also includes other beneficial characteristics that make it a useful tool for practical food security analysis. When considering the development of a multidimensional measure of food insecurity, a key a consideration is whether or not there is anything to be gained by adopting a multidimensional perspective.[24] Implicit in this approach is that the use of a single indicator is not a suitable or sufficient variable with which to measure the food security status of a household or individual. This paper provides compelling evidence that such a composite multidimensional food insecurity measure contributes to better thinking about food security, and allows for the possibility of more targeted identification and subsequent policies for fighting food insecurity. A theoretical aim of the Alkire-Foster MPI measure was to re-examine the identification step – addressing the question 'who is poor'?[25] In the same vein, answering the question of 'who is food insecure' is a fundamental question in this paper, and the creation of a useful and insightful measure of this has been a key aim. The sensitivity tests, while addressing some of the criticisms of the methodology, also serve to illustrate the flexibility of the index. It can be adapted depending on the motivation, question, context, and prior beliefs, while retaining all of the properties that make it a useful tool for detailed analysis.

The methodology employed here is that of the MPI, a measurement tool that captures the multiple poverty related deprivations experienced, and has been created for more than 120 developing countries (Alkire & Santos, 2010). Using existing data the MPI can be constructed, and updated, for most countries and is used in cross-country comparisons, as well as to track poverty within countries

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[23] Calculated using the General Household survey, Statistics South Africa
[24] As noted by Tsui (2000) when considering a multidimensional approach for the measurement of poverty
[25] Foster 2010

over time (Alkire *et al*, 2011; Finn *et al*, 2013). The phenomenon of food insecurity is analogous to that of poverty in that individuals suffer multiple forms of deprivation when they are food insecure, and any measurement of this phenomenon needs to consider the joint distribution of these deprivations. The methodology applied here is that used for the calculation of multidimensional measures of poverty, an approach that is gaining popularity. The potential usefulness of the MFII is equivalent to that of the MPI in terms of being a single measure that accounts for the multidimensional nature of food insecurity. It can be created for multiple countries, and used for cross country and time series analyses and monitoring of food security. An additional usefulness of the MFII is that it facilitates the design of policies that directly address the interlocking deprivations of food insecurity.

To a large extent the results obtained for South Africa are intuitive, and do not contradict previous findings. They are also significantly more detailed, and allow for more targeted analysis. In sum, 48.2% of South Africans are considered multidimensionally food insecure, and 28.51% are severely so. A further 25.77% of the population is vulnerable to food insecurity. Rural areas suffer greater intensity and prevalence of food insecurity than urban areas, however the roughly equal contribution of each area to national food insecurity indicates that urban areas require as much attention as rural areas. Limpopo and KwaZulu-Natal show the highest levels of multidimensional food insecurity, while the Western Cape and Gauteng show the lowest. South African food insecurity is largely driven by low dietary diversity and self-perceived inadequacy of food. These figures are concerning in light of that fact that South Africa is regarded as having achieved the food security related Millennium Development Goal of halving reported hunger. Clearly there is more work to be done in truly achieving the goal of alleviating food insecurity.

One of the key factors in the creation of this multidimensional measure is that it utilises existing data and can therefore be applied using various data sets. With the quality of data available in South Africa, specifically NIDS in this case, such a measure can be used at little additional cost to gain deeper insights into this phenomenon. The next step would be to measure the changes in household food security over time in South Africa, in part to gauge the temporal impact of food security policies. While one of the key values of NIDS is that it is a longitudinal study, unfortunately not all of the variables used to construct this MFII are available across the waves of the survey. In light of this, future waves of NIDS, or even the General Household Survey, could be adapted at little expense to include the measurement of the indicators required in constructing the index. This would allow for a thorough investigation of the current state of individual food security, the changes in this phenomenon over time, and the impact of various targeted policies on numerous subgroups in the population. A recommendation for future research is the development of more consistent nationally representative datasets that include the multiple indicators required to capture the complex nature of food insecurity. As a national priority, it is important that food security be given the appropriate attention in such surveys.
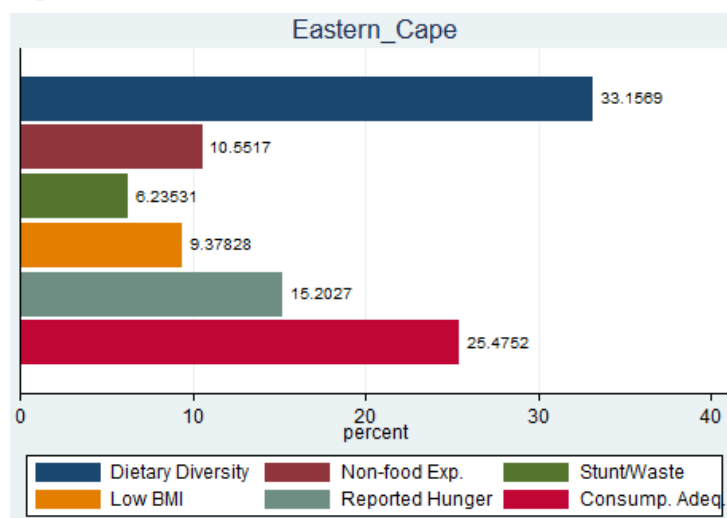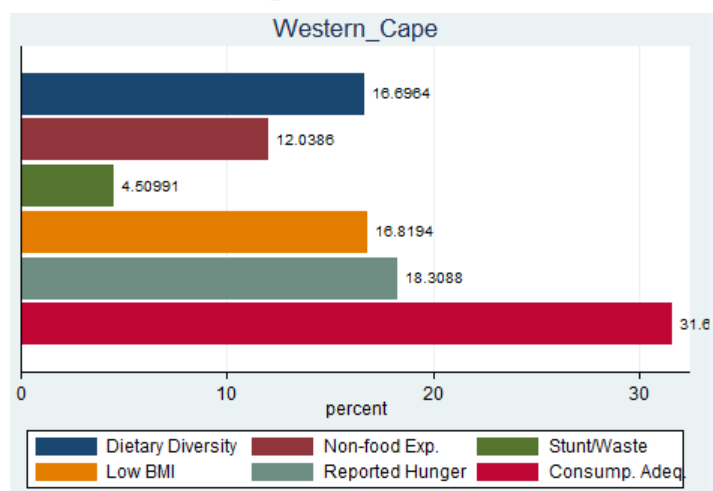
Appendix

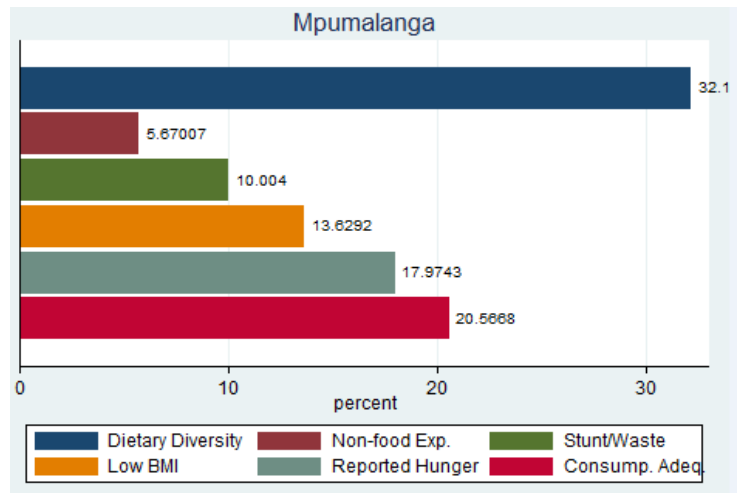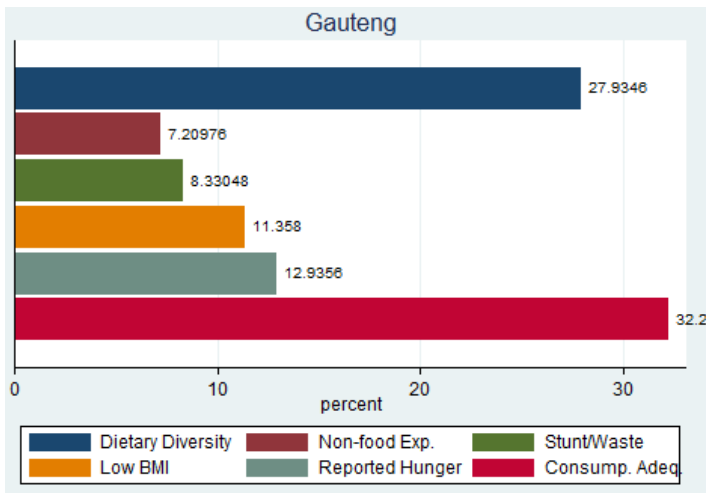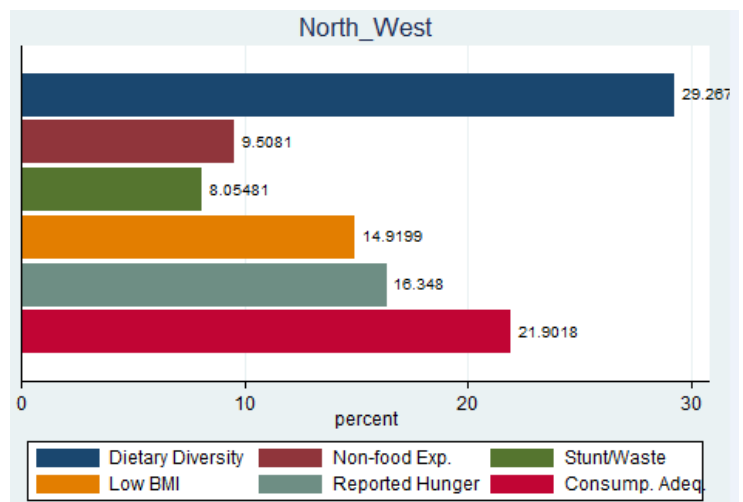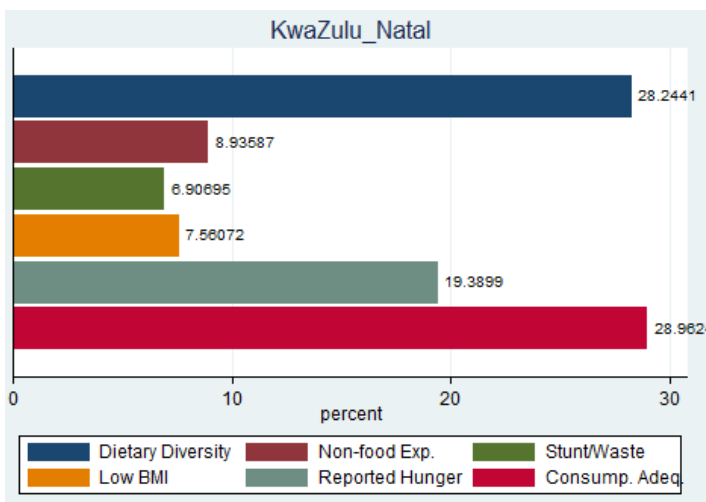## Correlation Table of Deprivation by Indicator

	Dietary diversity	Food expenditure	Z-scores	BMI	Hunger	Food Consumption
Dietary diversity	1					
Food expenditure	0.1403	1				
Z-scores	0.0654	0.042	1			
Low BMI	0.0505	-0.0057	0.1116	1		
Hunger	0.2045	0.019	0.0653	0.0761	1	
Food Consumption	0.2024	0.0468	0.0568	0.0494	0.3855	1

Authors' own calculations using weighted NIDS Wave 1 data 2008

Generally the correlation between deprivations in each indicator is low, and even negative in the case of low BMI and the proportion of household expenditure spent on food. The strongest correlation is between self-reported hunger and the self-reported adequacy of household food consumption. Interestingly, these are the two subjective measures, although the correlation is only moderate.

The Proportion of the Food Insecure Deprived On Each Indicator

Northern_Cape

Metric	Percent
Dietary Diversity	22.4193
Non-food Exp.	7.21666
Stunt/Waste	8.91167
Low BMI	20.8097
Reported Hunger	13.9165
Consump. Adeq.	26.7263

Free_State

Metric	Percent
Dietary Diversity	33.1177
Non-food Exp.	6.31981
Stunt/Waste	5.70751
Low BMI	12.7933
Reported Hunger	16.0783
Consump. Adeq.	25.9834

KwaZulu_Natal

Metric	Percent
Dietary Diversity	28.2441
Non-food Exp.	8.93587
Stunt/Waste	6.90695
Low BMI	7.56072
Reported Hunger	19.3899
Consump. Adeq.	28.962

North_West

Metric	Percent
Dietary Diversity	29.267
Non-food Exp.	9.5081
Stunt/Waste	8.05481
Low BMI	14.9199
Reported Hunger	16.348
Consump. Adeq.	21.9018

Gauteng

Metric	Percent
Dietary Diversity	27.9346
Non-food Exp.	7.20976
Stunt/Waste	8.33048
Low BMI	11.358
Reported Hunger	12.9356
Consump. Adeq.	32.2

Mpumalanga

Metric	Percent
Dietary Diversity	32.1
Non-food Exp.	5.67007
Stunt/Waste	10.004
Low BMI	13.6292
Reported Hunger	17.9743
Consump. Adeq.	20.5668

Limpopo

Indicator	percent
Dietary Diversity	31.1
Non-food Exp.	5.24083
Stunt/Waste	9.75171
Low BMI	12.6425
Reported Hunger	17.0888
Consump. Adeq.	24.1393

Authors' own calculations using weighted NIDS Wave 1 data 2008

Dietary diversity and consumption adequacy are the two indicators in which the food insecure are most frequently deprived, across all provinces. Child stunting and wasting, and the proportion of non-food expenditure are the indicators in which deprivation is the least frequent.

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southern africa labour and development research unit

The Southern Africa Labour and Development Research Unit (SALDRU) conducts research directed at improving the well-being of South Africa's poor. It was established in 1975. Over the next two decades the unit's research played a central role in documenting the human costs of apartheid. Key projects from this period included the Farm Labour Conference (1976), the Economics of Health Care Conference (1978), and the Second Carnegie Enquiry into Poverty and Development in South Africa (1983-86). At the urging of the African National Congress, from 1992-1994 SALDRU and the World Bank coordinated the Project for Statistics on Living Standards and Development (PSLSD). This project provide baseline data for the implementation of post-apartheid socio-economic policies through South Africa's first non-racial national sample survey.

In the post-apartheid period, SALDRU has continued to gather data and conduct research directed at informing and assessing anti-poverty policy.   In line with its historical contribution, SALDRU's researchers continue to conduct research detailing changing patterns of well-being in South Africa and assessing the impact of government policy on the poor. Current research work falls into the following research themes: post-apartheid poverty; employment and migration dynamics; family support structures in an era of rapid social change; public works and public infrastructure programmes, financial strategies of the poor; common property resources and the poor. Key survey projects include the Langeberg Integrated Family Survey (1999), the Khayelitsha/Mitchell's Plain Survey (2000), the ongoing Cape Area Panel Study (2001-) and the Financial Diaries Project.
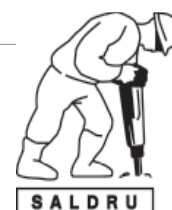
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