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Food Security: A Comparison of Indicators for the United States and the United Republic of Tanzania

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Abstract Developing nations have struggled with the problem of food insecurity thus one of the United Nations Millennium Development Goals (MDG) was to 'eradicate extreme poverty and hunger' with a target of halving between 1990 and 2015, the proportion of people who suffer from hunger. Progress has been made by developing countries in increasing their food security, however a question remains about their status as compared to developed countries; thus this paper sought to devise a methodology to compare the food security status of a food surplus developing country to a food surplus developed country utilizing the four pillars of food security; availability, access, utilization and stability. To test the methodology a comparison was made between the United Republic of Tanzania, a bright spot in the developing world and the United States utilizing indicators for the four pillars from the FAOSTAT Food Security data domain. The results suggest that Tanzania is still deficient with respect to most food security indicators, including the key indicator - the "prevalence of undernourishment". Tanzania's food security status also compares unfavorably to that of the United States, which remains among the leading nations in maintaining a high level of national food security. Finally the paper explores the critical areas needed for the improvement of the food security status of Tanzania.

Keywords: *food security, Tanzania, United States, food security indicators, application of MANOVA*

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1. Introduction

1.1. Problem and Objective

The State of Food Insecurity in the World (SOFI), 2015 has stated that global hunger has continued to decline "to an estimated 795 million undernourished people, or a reduction of 167 million hungry people over the last ten years" and that this decline has been most pronounced in developing countries, "despite significant population growth" [9]. The Report also states that 2015 marks the end of the Millennium Development Goal (MDG) monitoring period and for the developing regions as a whole, the hunger target to reduce the proportion of the world's hungry by 50 percent by 2015 was missed by a small margin [9]. SOFI also reports that some regions (such as Latin America, the eastern and south-eastern regions of Asia, the Caucasus and Central Asia, and the northern and western regions of Africa) and as many as 72 developing countries out of 129 have reached the MDG hunger target, as they made fast progress in reducing undernourishment and overcoming the dire food shortages reported in 2008 [4,9]. However SOFI reports that despite many success stories at country and sub-regional levels, the highest burden of hunger occurs in Southern Asia, where as many as 281 million people are undernourished and in sub-Saharan Africa, where one in every four people, or 23.2 percent of the population, are hungry [9].

Despite the progress made by the developing countries with respect to increasing food security a question still remains as to how their status compares to that of developed countries, thus the objective of this paper is to devise a methodological approach to carry out inter-country comparisons of food security. This approach is tested by a comparison of the food security status of a food surplus developing country, Tanzania, to a food surplus developed country, the United States, utilizing the four pillars of food security, with the specific aim of identifying the dimensions of food security where Tanzania may be deficient, in relation to the United States.

The conceptualization of food security has changed over the years. The current focus is in terms of the four pillars of: availability, access, utilization and stability, consistent with the 1996 World Food Summit (WFS) definition that: "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" [6]. However this multi-dimensionality of food security may

not always be reflected in the popular literature, with an emphasis often-times on the "availability" pillar of food security. For example, in addition to noting that there are serious problems with food utilization and associated factors leading to high malnutrition in the country, a World Food Program (WFP) overview of The United Republic of Tanzania (hereafter referred to as Tanzania) pronounces: "Although the country is self-sufficient in food, reliance on the rain and traditional farming techniques means households, districts and regions may suffer food shortages. While the liberalization of exports has turned Tanzania into a regional grain supplier, domestically, high rates of malnutrition persist". [26].

Tanzanian President, Jakaya Kikwete called for investment to increase Tanzania's food surplus storage and the need to seek additional markets for surplus food products in New York on March 30th 2015. [20] He also stated that for the last three years, Tanzania has enjoyed surplus food production, but the challenge is to increase storage [20].

On the other hand for the USA, recent data from the USDA suggest that "one out of six Americans doesn't have enough to eat," and that this may still conjure up a "depression-era image of the unemployed scavenging for food" [17]. Reference [17] however states that the face of hunger in rural, suburban, and urban America has changed. Despite the reports of food surpluses in Tanzania and hunger in the United States, this paper hypothesizes that the overall food security status of Tanzania is deficient as compared to the United States.

1.2. Overall Approach of the Paper

The paper proceeds as follows: First in the paper, there is a review of recent developments in the food security status of Tanzania and the United States. Attention then turns to methodological issues and in particular, a consideration of the merits and demerits of using composite or aggregate indicators for inter-state comparison of food security, versus the use of MANOVA (multivariate analysis of variance). MANOVA is then utilized as the procedure to compare the food security status of the two countries according to the pillars of food security. The new "Food Security" data domain of the FAO provides readily available data on the pillars of food security that can be used to provide a comprehensive range of indicators of national food security [9]. Hence the dependent variables in the MANOVA are a range of indicators that are used to represent the four pillars of food security, while the independent variable has two possible values: "Tanzania" and "the United States". Multivariate tests of significance (Pillai Trace etc.) are used to test for the overall difference between the USA and Tanzania for each pillar. Then a determination is made of whether significant differences exist between the two countries for individual indicators as individual dependent variables within the four pillars by Analysis of Variance (ANOVA) also referred to in this context as "Tests of Between-Subjects Effects" (utilizing F-tests). Finally the paper discusses recommendations for Tanzania based on the analyses conducted.

1.3. Tanzania's Recent Food Security Experience

According to [15] during the 1961-1966 period in Tanzania, food self-sufficiency was taken for granted as "Tanzania was the only independent African country achieving a growth trend in food production greater than that of its population". This situation continued until the two drought years, 1973-75; when food grain imports especially maize were necessary for relief during these crisis years [15]. A campaign dubbed "Kilimo cha Kufa na Kupona" ("Agriculture as a matter of life and death") was then started and coupled with the World Bank financed 'National Maize Program', Tanzania was once again able to produce enough food and exported maize in 1978 [15].

Reference [15] states that drought and adverse economic conditions caused an unprecedented food crisis from 1981 to 1984 and during this period there was food rationing, characterized by long queues and the provision of 'vibalis' (permits for purchase of essential items). However good rains during 1984-85 and price incentives from structural policy reforms, resulted in a significant increase in food production [1]. As seen in Table 1, the national level food balance data for the period 1984/85 to 1989/90 show that in aggregate terms, Tanzania produced enough food to satisfy domestic food requirements [15]. Thus [15] concluded that for this period "the aggregate level food security was not in jeopardy because of insufficient food production". Even the severe drought of 1992, which affected the Eastern and Southern Africa from Ethiopia to South Africa, did not seriously affect Tanzania, which experienced only pockets of severe food insecurity which were cushioned by internal redistribution of food and modest food aid and imports [15].

Table 1. Annual Aggregate Food Balance, Tanzania Mainland, 1984/85 - 1989/90

Years	Total Production		Total Requirements[1]		Available[2] Balance (% of Requirements)	
	Food '000 mt	Energy m.kcal	Food '000 mt	Energy m.kcal	Food	Energy
1984/85	7,026	24,261	4,543	21,047	131	98
1985/86	6,972	24,100	4,670	21,637	127	95
1986/87	7,048	24,499	4,801	22,243	125	94
1987/88	6,780	23,598	4,935	22,865	117	88
1988/89	7,919	27,355	5,073	23,506	133	99
1989/90	7,819	27,010	5,073	23,506	131	98

[1] Based on Tanzania Food and Nutrition Centre (TFNC) calculations. 1989/90 figures based on 1989 population estimates
[2] Excludes seed and post-harvest losses of 15 percent.
Source: (Kavishe, 1993)

However there has always been concern about the situation of Tanzania with respect to other pillars of food security [7]. Reference [3] for example reviewed the situation in Africa for what he termed "selected indicators

of food security" as provided in Table 2. This table shows that Tanzania fared worse than all regions of Africa, except Central Africa, with respect to the key indicators of "Prevalence of Undernourished (% of Population)" and Dietary Energy Supply (Kcal per person per day). It could also be noted that the percentage of the population undernourished actually increased from 1990-1992 (35.2%) to 1999-2001 (43.3%).

Table 2. Selected National and Regional Indicators of Food and Nutrition Security for Africa

Region/ Country	Under-nourished	Under-nourished	Dietary Energy Supply	Under-5 Mortality
	1999 - 2001	1990 - 1992	1999 - 2001	2002
	Prevalence (%)	Prevalence (%)	Kcal per person per day	Deaths per 1,000 births
Africa	27.4	28.8	2,370	154
North Africa	4.3	4.7	3,210	42
Sub-Saharan Africa	32.9	34.9	2,180	168
Central Africa	58.3	35	1,810	193
East Africa	38.8	44.1	2,020	154
Tanzania	43.3	35.2	1,970	165
Southern Africa	41.3	48.2	2,050	156
West Africa	14.7	20.7	2,590	186
Developing world	16.9	20.2	NA	NA

Source: (Benson, 2004).

Recently quite a favourable picture has emerged about Tanzania's food situation. Headlines point to a grain surplus situation in that nation as indicated earlier. For example, during the month of December 2011, the Tanzanian Ministry of Agriculture Food Security and Cooperatives (MAFC) conducted a Final Food Crop Production Forecast Survey to ascertain the food crop harvest status for the 2010/2011 production season and the corresponding food availability for the year 2011/2012 [22]. The report by the MAFC estimated overall national food crop production to reach 12.972 million MT, comprising of 7.033 million MT of cereals and 5.939 million MT of non-cereals and the report further established the total food requirement for 2011/2012 to amount to 11.532 million MT [22]. A comparison of the estimated production in the 2010/11 with the 2011/2012 food requirement by the report indicated that the country should have attained a Food Self Sufficiency Ratio (SSR) of 112 percent, slightly above that of the 2010/2011 consumption year, which was 111 percent, indicating a general food surplus of about 1.440 million MT.

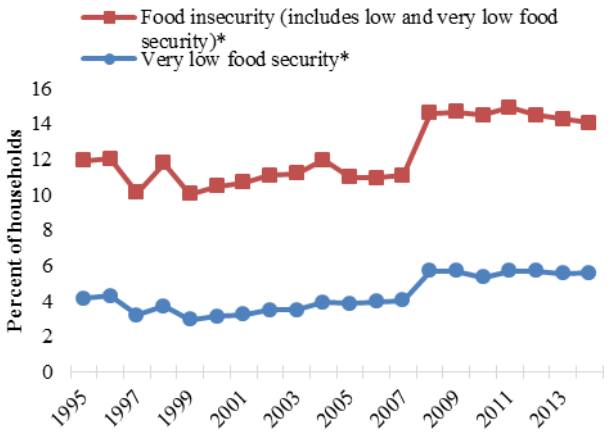
The 2013/14 Preliminary Food Crop Production Forecast for Tanzania predicted a SSR of 125% made up of cereals - 121% and non-cereals - 134%. This represented 3,247,359 tonnes surplus of total food, a cereal surplus of 1,679,933 tonnes and a non-cereal surplus amounting to 1,567,425 tonnes, with the commodities contributing to these surpluses predicted to be: bananas (56%), potatoes (33%), millets (28%) and rice (12%) while a decline was forecasted for wheat (16%) and pulses (10%) [23]. The expected increased production was attributed mainly to the timely onset and fairly good distribution of rainfall over the growing season [23].

The concern for the other pillars of food security in Tanzania has continued however. A nutrition country report states that consumption of micronutrient dense foods such as animal products and fruits and vegetables is infrequent and subsequently micronutrient deficiencies are widespread in the country [22]. The Report also claims the dietary energy supply does not meet average energy requirements of the population and close to 40% of the population live in "chronic food-deficit regions", where rainfall is scarce and irregular [22]. The report also claims that rural households spend up to 66% of their income on food; price volatility is a major concern and the dietary diversification index is very low, as starchy foods provide almost three quarters of the total energy supply, despite the wide variety of food produced in the country [22]. According to this report the primary causes of malnutrition and food insecurity are an inadequate dietary intake (operating at individual level); disease and inconsistent food availability and these are caused secondarily by climatic variability and poor infrastructure, inadequate attention paid to nutritional requirements of the population in terms of vitamins and minerals; limited accessibility to food among the population; limited diversification in the utilization of different varieties of food; widespread poverty; inadequate access to health services; and infant and young child feeding (IYCF) practices that are not optimal [22].

1.4. Food Security in the U.S.A.

A recent review of food security in the United States reported that during the early 1980s, the U.S. economy suffered from a severe recession that left many Americans unemployed and Federal budget cuts weakened many social support programs. These two events caused a dramatic rise in poverty and hunger in the country while homelessness became increasingly apparent in large cities. "America's poor turned to food banks, food pantries, soup kitchens and other charitable programs for help (and) … the size and number of these emergency food programs multiplied over the course of just a few years" [13].

As seen in Figure 1, by 1995 the percentage of households in the United States that were food insecure was about 12% and the rate remained below this level until 2007 (11.1%) Food insecurity increased from 10.5 percent in 2000 to nearly 12 percent in 2004, declined to 11 percent in 2005-07, then increased in 2008 (14.6 percent), remaining essentially unchanged at that level in 2009 and 2010 [25]. Reference [25] reports that the prevalence rates of food insecurity showed a cumulative decline from 2011 (14.9 percent) to 2014 (14.0 percent), which was statistically significant. Reference [25] also states that prior to 2008, the prevalence of very low food security had increased from 3.1 percent in 2000 to 3.9 percent in 2004, and remained essentially unchanged through 2007.

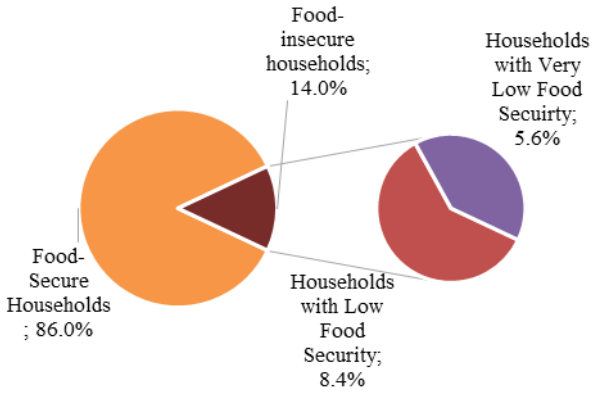


*Prevalence rates for 1996 and 1997 were adjusted for the estimated effects of differences in data collection screening protocols used in those years.
Source: Calculated by USDA, Economic Research Service (ERS) based on Current Population Survey Food Security Supplement data.

Figure 1. Trends in Prevalence Rates of Food Insecurity and Very Low Food Security in U.S. Households, 1995-2014

This prevalence of very low food security was essentially unchanged from 2011 and 2012 (5.7 percent in both years) to 2013 and 2014 (5.6 percent in both years)". The prevalence of very low food security was also 5.7 percent in 2008 and 2009. In 2010, the prevalence of very low food security had declined to 5.4 percent [25].

The USDA has produced an analysis of the food security status of the United States for 2014 [25]. The overall picture for the country is presented in Figure 2 which shows that the percentage of the population that is food secure – that is "These households had access, at all times, to enough food for an active, healthy life for all household members" – was 86.0 percent (106.6 million), which was essentially unchanged from 85.7 percent in 2013 [25]. The "food insecure" in the United States therefore stood at 14.0 percent of the population (17.4 million of U.S. households) and was also essentially unchanged from 14.3 percent in 2013. These were households which at times during the year "were uncertain of having, or unable to acquire, enough food to meet the needs of all their members because they had insufficient money or other resources for food". This category consisted of both groups of households with "low food security" and "very low food security" [25].



Source: Calculated by USDA, ERS using data from the December 2014 Current Population Survey Food Security Supplement.

Figure 2. US Households by Food Security Status (%), 2014

The "low food-secure" households obtained enough food to avoid substantially disrupting their eating patterns or reducing food intake by using a variety of coping strategies, such as eating less varied diets, participating in Federal food assistance programs, or getting emergency food from community food pantries and comprised 8.4 percent (10.5 million) and was also essentially un-changed from 8.7 percent in 2013 [25]. For the "very low food-secure" households, "normal eating patterns of one or more household members were disrupted and food intake was reduced at times during the year because they had insufficient money or other resources for food". These were 5.6 percent (6.9 million) of U.S. households, which was unchanged from 2013 [25].

2. Materials and Methods

2.1. Aggregation versus Non-aggregation Approaches

As has been argued earlier the measurement of a multi-dimensional concept like food security requires the use of a number of indicators of the various dimensions of the concept. Inter-country comparisons of food security therefore require the comparison of the set of indicators for the respective countries. For such comparisons this paper considers the relative merits and demerits of using composite or aggregate indicators versus the use of multivariate analysis of variance (MANOVA) to determine whether significant differences exist among countries for the set of indicators.

Reference [19] has presented the following steps for devising an aggregate or composite indicator for a complex phenomenon like food security from a number of individual indicators:

1. The definition of the phenomenon under investigation.
2. Formulation of the different dimensions of the phenomenon. Such dimensions he states should "convey the different (and possibly unrelated) information" and should be (statistically) independent of each other.
3. Determination of the relative weights across different dimensions.
4. Selection of variables for the different dimensions. He states that obtaining variables of good quality is crucial for constructing composite indicators. Ideally, he states such "variables should be SMART: specific, measurable, accessible, relevant, and timely.
5. Selection of data. He states that this data can usually consist of "a set of heterogeneous indicators: quantitative (hard) data, qualitative (soft) data collected from surveys or policy reviews, or proxies aimed at conveying information on the phenomenon when specific variables are unavailable".
6. The imputation of missing data. This is required he states since most modern statistical techniques assume (or require) complete data, and because of deficiencies in the manner in which existing statistical packages deal with missing data.

7. Normalization of indicators by for example the computation of z-scores.
8. Weighting of the normalized indicators and other measures of the different dimensions.
9. Aggregation of indicators and dimensions using the weighting schemes of Step 3 and Step 8 to form the composite indicator via an aggregation method such as the popular linear aggregation or geometric aggregation.

However the derivation of these composite indicators has major problems [18]. One of these problems is the determination of the relative weights for the different dimensions and for the indicators within the dimensions as indicated in steps 3 and 8. These weights are usually subjectively determined which weakens the scientific nature of the aggregation exercise. Another problem with the aggregation is the interpretation of the values of the composite indicator, in other words what exactly do these numbers mean and does the aggregation actually present an accurate indication or measure of a multidimensional concept such as food security.

Using these composite indicators for comparisons (such as between the USA and Tanzania for food security as in this study) has an additional problem. The use of statistical methods such as tests of differences between the means or ANOVA may be precluded. The statistical properties, in particular the probability distribution, of the composite indicator may be unknown especially if the derivation involves non-linear transformations, such as involved in geometric aggregation, even if it is assumed that the individual indicators are normally distributed. If the numbers of observations of the composite indicators are small then recourse cannot even be made to the Central Limit theorem. Small sample sizes in fact usually characterize such comparisons. Recourse may then have to be made to more advanced statistical techniques such as bootstrapping which require no distributional assumptions.

2.2. Application of MANOVA

This paper proposes and utilizes an alternative approach of multivariate analysis of variance (in this case One-way MANOVA) to make inter-country comparisons of the food security. Here the dependent variables are a range of indicators that are used to represent the four pillars of food security as mentioned above and the independent variable is a "Country" variable with two possible values: "Tanzania" and "the United States", which two countries are usually termed "groups" in MANOVA.

MANOVA has several advantages in that it can test if differences exist for a dimension for the groups taking into consideration (simultaneously) all the indicators for that dimension, without the need to create an aggregate indicator for the dimension. Also, this method can indicate the confidence that can be placed in the test of differences between groups for a dimension via multivariate tests significance based on statistics such as the Wilks' lambda, Lawley-Hotelling trace, and Pillai's trace etc. using relevant tests based on the F statistic approximations to these statistics [12]. In addition if in MANOVA for a dimension differences exist for the groups taking into consideration (simultaneously) all the indicators for that dimension, further follow-up analyses can be conducted for each indicator to determine if differences exist between groups for each individual indicator of a dimension. These individual ANOVA tests for each indicator and the statistical confidence can be obtained from tests based on the F statistic [12].

Using MANOVA therefore, the comparison of the food security status of Tanzania and the United States was carried out in the following manner, within the general framework of [19]. With respect to steps 1 and 2 the concept of food security is well defined as noted above and the four pillars or dimensions of food security were used in the comparison: Availability, Access, Utilization and Stability. Then, given the use of MANOVA Step 3 was unnecessary. In step 4 the indicators that were chosen for each dimension were derived from the new FAOSTAT data dimension on Food Security. A detailed description of these indicators can be found at [8]. Reference [2] in discussing these indicators has stated that they possess the following desirable properties:

(i) Valid in the conceptual representation of the underlying phenomenon they attempt to measure;
(ii) Sensitive to change and unambiguous and easy to interpret;
(iii) Robust and methodologically transparent in construction; and
(iv) Timely – can be produced or updated on a regular basis.

In this application, all the indicators in the FAO data dimension for food security under the different pillars could not be used, since data was not available for some indicators for both countries. So the MANOVA was limited to those indicators for which corresponding data existed for both countries at Step 5 of [19]. No figures are reported for the United States for the indicator "Prevalence of undernourishment (%) - 3 years average (2012-14)" in the FAOSTAT data base. For this important indicator of the "Access" pillar, the figure for Tanzania in the FAOSTAT data base was compared with the "Prevalence of food insecurity" figures reported by the USDA in Section 4 of this paper.

No imputation of missing data was carried out as suggested in Step 6 of [19] and Steps 7, 8 and 9 of [19] were unnecessary as instead MANOVA was carried out for each pillar or dimension of food security using the selected indicators. In the MANOVA, multivariate tests of significance were carried. However the results of the Pillai Trace alone are reported as all the alternative tests gave identical results.

One of the main assumptions of MANOVA is that the dependent variables come from group populations that are multivariate normal distributed [5,11,16,21]. With respect to Type I error rate, MANOVA tends to be robust to minor violations of the multivariate normality assumption [12]. However Doornik-Hansen tests were performed to test for multivariate normality for the group (country) sample data for each pillar [5,11].

Follow-up analyses were done for each MANOVA for the individual indicators, since all tests revealed significant differences between groups for all indicators for a dimension considered simultaneously. These individual univariate ANOVAs were used to determine whether there were significant differences between the two countries for each individual indicator using standard F-tests.

3. Results

The results of the MANOVA carried out are presented in the Tables below. They are presented by the pillars of food security. For the results of the individual ANOVAs carried out, all but one of the F-tests were significant (with a p-value = 0.000) indicating that there were significant differences between the United States and Tanzania for the particular indicator. Hence the one case of non-significant difference is highlighted.

3.1. Availability Pillar

In Table 3 it is seen that the multivariate normality tests for the data for both the United States and Tanzania both fail to reject the null hypothesis of multivariate normality.

Table 3. Comparison of Tanzania and the United States - Availability Food Security Pillar

Availability*	Country	Average	Last Year	N
Average dietary energy supply adequacy (%) (3-year average)	USA	144.9	2014	20
	Tanzania	99.8	2014	20
Average value of food production (I$ per person) (3-year average)	USA	617.3	2012	22
	Tanzania	138.9	2012	13
Share of dietary energy supply derived from cereals, roots and tubers (%) (3-year average)	USA	25.2	2011	20
	Tanzania	64.9	2011	20
Average protein supply (g/capita/day) (3-year average)	USA	111.6	2011	22
	Tanzania	54.9	2011	13
Average supply of protein of animal origin (g/capita/day) (3-year average)	USA	71.9	2011	22
	Tanzania	10.6	2011	13
Tanzania: Doornik-Hansen $\chi 2$ (10) = 12.776; p-value = 0.2365 USA: Doornik-Hansen $\chi 2$ (10) = 12.614; p-value = 0.2461 Pillai's Trace = 0.9991; F (5, 34) = 7937.25; p-value = 0.0000 *All the p-values for the F-tests on the ANOVAs for the individual indicators = 0.0000				

The Pillai's Trace test indicates that there is an overall significant difference in the availability pillar for the two countries. The individual ANOVA analyses carried out support the multivariate result, with all the p-values on the F-tests being approximately equal to zero. The results suggest that Tanzania should increase the production of fresh fruits and vegetables and reduce the share of dietary energy supply derived from cereals to a figure closer to that of the USA (25%). The high energy intake from cereals is matched by low protein per capita intake of Tanzania that is half that of the USA and per capita animal protein intake that is one-seventh that of the USA.

3.2. Access Pillar

In Table 4 it is seen that the Pillai's Trace test indicates that there is overall significant differences between the two countries with respect to the Access pillar. In Table 4 also, the multivariate normality test for the data for the United States fails to reject the null hypothesis of multivariate normality. However in the case of Tanzania the multivariate normality test for the data rejects the null hypothesis of multivariate normality. An examination of the data for Tanzania for "Rail-lines density (per 100 square km of land area)' and "Road density (per 100 square km of land area)" indicates that these variables display only a few fixed values in the data which suggests non-normal distributions. However these values are consistently very much less than the values for the United States giving support to the results of the Pillai's Trace. Again the individual ANOVA tests also support these results with all the p-values on the F-tests being approximately equal to zero.

Table 4. Comparison of Tanzania and the United States - Access Food Security Pillar

Access*	Country	Average	Last Year	N
Rail-lines density (per 100 square km of land area)	USA	2.0	2012	22
	Tanzania	0.5	2006	13
Road density (per 100 square km of land area)	USA	66.0	2011	22
	Tanzania	9.2	2005	13
Gross domestic product per capita, PPP (constant 2011 international $)	USA	45083.5	2013	24
	Tanzania	1185.0	2012	23
Tanzania: Doornik-Hansen; $\chi 2$ (6) = 50.948; p-value = 0.0000 USA: Doornik-Hansen; $\chi 2$ (6) = 6.893; p-value = 0.3309 Pillai's Trace = 0.9999; F (3, 31) = 87421.17; p-value = 0.0000 *All the p-values for the F-tests on the ANOVAs for the individual indicators = 0.0000				

The results in Table 4 suggest that Tanzania's GDP/capita is 2.63% of the USA. Hence for the Tanzanian population to be able to access a greater and healthier household food consumption there is urgent need to increase the country's GDP/capita. A better road and rail network in the country will also help to improve the internal distribution of food in the country also enabling greater household access to food.

3.3. Utilization Pillar

In Table 5 it is seen that the Pillai's Trace test indicates that there is overall significant differences for the Utilization pillar for the two countries. In Table 5 also, the multivariate normality test for the data for Tanzania fails to reject the null hypothesis of multivariate normality.

However in the case of the United States, the multivariate normality test for the data rejects the null hypothesis of multivariate normality. An examination of the data for the United States shows that the variables "Access to improved water sources (%)" and "Access to improved sanitation facilities (%)" remained at more or less the same values given in Table 5 over the entire data period which suggests non-normal distributions for these variables. However these values are consistently very much greater than the values for Tanzania, giving support to the results of the Pillai's Trace. Again the individual ANOVA tests also support these results with all the p-values on the F-tests being approximately equal to zero.

Table 5. Comparison of Tanzania and the United States - Utilization Food Security Pillar

Utilization	Country	Average	Last Year	N
Access to improved water sources (%)	USA	98.8	2012	20
	Tanzania	54.2	2012	20
Access to improved sanitation facilities (%)	USA	99.8	2012	20
	Tanzania	9.2	2012	20
Prevalence of anaemia among children under 5 years of age (%)	USA	7.4	2011	22
	Tanzania	72.0	2011	13
Prevalence of anaemia among pregnant women (%)	USA	14.8	2011	22
	Tanzania	54.9	2011	13
Tanzania: Doornik-Hansen $\chi 2$ (8) = 10.590; p-value = 0.2261 USA: Doornik-Hansen $\chi 2$ (8) = 24.453; p-value = 0.0019 Pillai's Trace = 1.00; F (4, 39) =1.1e+06; p-value = 0.0000				

The results in Table 5 show that there an urgent need for Tanzania to improve the access of its population to sanitation facilities as these were available to less than 10 percent of the population. This compares quite un-favourably to the United States where almost all of the population has access to these facilities. There is also the need for Tanzania to reduce the prevalence of anaemia among pregnant women and children. Again Tanzania compares un-favourably to the United States in this regard since the prevalence of anaemia among children in Tanzania is 10 times greater than the prevalence among children in the USA.

3.4. Stability Pillar

In Table 6, it is seen that the Pillai's Trace test indicates that there is overall significant differences in the "Stability" pillar of food security for the two countries. In Table 6 also, the multivariate normality test for the data for the United States fails to reject the null hypothesis of multivariate normality. However in the case of Tanzania the multivariate normality test for the data rejects the null hypothesis of multivariate normality. An examination of the data for Tanzania does not lead to any straightforward reasons for this non-multivariate normality of the Tanzania data set. Again the individual ANOVA tests support the multivariate results as the means for four of the five indicators in this pillar were significantly different for the two countries with the p-values of the F-tests for these variables being approximately equal to zero. However for the indicator "Per capita food supply variability (kcal/capita/day)" there was no significant difference between the means for the two countries.

Table 6. Comparison of Tanzania and the United States – Stability Food Security Pillar

Stability	Country	Mean	Last Year	N
Cereal import dependency ratio (%) (3-year average)	USA	2.4	2011	20
	Tanzania	9.6	2011	20
Percentage of arable land equipped for irrigation (%) (3-year average)	USA	15.4	2012	20
	Tanzania	1.7	2012	20
Value of food imports over total merchandise exports (%) (3-year average)	USA	4.1	2011	20
	Tanzania	26.7	2011	20
Per capita food production variability (I$ per person constant 2004-06)	USA	18.0	2013	24
	Tanzania	6.3	2013	23
Per capita food supply variability (kcal/capita/day)	USA	36.3*	2014	24
	Tanzania	39.7*	2014	23
*No significant difference between the means. F (1, 45) = 2.170 p-value = 0.148 Tanzania: Doornik-Hansen χ^2 (10) = 20.886; p-value = 0.0219 USA: Doornik-Hansen χ^2 (10) = 12.564; p-value = 0.2491 Pillai's Trace = 0.9970; F (5, 38) = 2492.28; p-value = 0.0000				

The results of the analysis for the "Stability" pillar therefore suggest that Tanzania needs to increase the percentage of arable land equipped for irrigation. The percentage of irrigated land in the USA (15.4%) is nine times greater than the percentage in Tanzania (1.7%). The small percentage of its land that is irrigated is a major risk factor affecting the stability of food security of Tanzania, as poor rainfall over one and especially over several seasons can lead to severe decreases in cereal production in the country and hence rapidly worsen its food security situation, since as noted previously approximately 65% of the dietary energy in the country comes from cereals.

4. Conclusion and Discussion

The study demonstrated the use of multivariate analysis of variance (MANOVA) as a viable technique for making inter-country comparisons of food security status based on the use of a range of indicators. The advantages of

MANOVA were well demonstrated in the study, especially the avoidance of the subjective choices of weights for indicators and pillars as well as aggregation methods. However the problem of attaining the condition of multivariate normality of the data is one that has the possibility of limiting the applicability of the method especially with small samples. The results suggest that Tanzania's status with respect to the pillars of food security compares un-favourably with that of the United States.

The analysis performed in this study showed that Tanzania despite having its grain production exceeding its grain consumption in recent years still has problems with respect to the four pillars of food security. In particular, with respect to the key indicator chosen by the United Nations to measure the achievement of MDG Target 1.C (Indicator 1.9): "Proportion of population below minimum level of dietary energy consumption" measured as the "Prevalence of undernourishment (%) - 3 years average (2012-14)", the figure for Tanzania is 32.7% [10,24]. In 1992 this indicator stood at 24.2% and rose to 37.7% in 2003. Thus Tanzania did not meet the "MDG 1: Eradicate extreme poverty and hunger, Target 1.C: Halve, between 1990 and 2015, the proportion of people who suffer from hunger" by reducing the proportion of its population's hungry by 50 percent by 2015" [24]. Tanzania's figure of 32.7% for the "Prevalence of undernourishment" also compares unfavorably with "Prevalence of food insecurity" figure for the United States in 2014 reported by the USDA of 14.0%.

With respect to the United States, in general, this country was seen to have very favorable food security pillars and indicators overall, but especially with respect to a low "Share of dietary energy supply derived from cereals, roots and tubers" (25%), a high "Average protein supply" (112g/capita/day) and "Percentage of arable land equipped for irrigation" (15.4%) and a low "Value of food imports over total merchandise exports" (4.1%). In addition, almost all of its population has access to improved water sources and improved sanitation facilities.

The study also highlighted the following areas that need urgent attention to raise the level of food security in Tanzania. In the first place Tanzania needs to increase the GDP/capita as Tanzania's GDP is 2.63% of the USA. Increasing GDP/capita appears to be the major long term solution to the country's chronic food insecurity. Also, Tanzania needs to increase its production and consumption of fresh fruit and vegetables to reduce the percentage of the dietary energy supplied by cereals. A holistic value chain approach may be needed to stimulate the production of fresh fruits and vegetables through enhancing productivity, the creation of markets at remunerative prices and by the establishment of enabling policy environments. Tanzania also needs to improve access to sanitation facilities and improved water sources. This is likely to be a major factor in improving health and wellness and reducing communicable diseases in this country. These improvements will lead to a reduction in the prevalence of malnourished persons. Finally, Tanzania needs to increase the percentage of arable land equipped for irrigation as this is a major risk factor affecting the stability of the country's food security with a lack of rainfall likely to quickly increase food insecurity.

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