

# Assessment of Food Safety and Quality Core Issues of Selected Countries as Drivers for Food Security Vulnerability

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**Abstract**— This study assesses the food security vulnerability of 113 countries by their food quality and safety core issues. The countries were clustered according to their food security features and reconnoitered their practices related to the core issues. The relationship of food quality and food safety issues of selected countries was also investigated. Food quality was measured by diet diversification, nutritional standards, micronutrient availability, and protein quality.

Cluster analysis was used to reduce observations and display groupings of countries with similar practices whereas regression analysis was done to investigate the relationship between food safety and food quality attributes as indicators of food security.

Result of cluster analysis generated ten (10) clusters with two clusters having a large number of observations. Cluster 1 which includes Algeria, Angola, Bahrain, Botswana, Kuwait, Qatar, Saudi Arabia, United Arab Emirates, and many others are considered the worst countries while cluster 2 are the best countries. Cluster 2 comprises Australia, Canada, Denmark, Ireland, Germany, Philippines, Singapore, Switzerland, United States of America, etc. Regression equation model in every cluster was generated using a software. In the first cluster, protein quality has a higher effect on food safety while an increase in nutritional standards decreases the safety of food. Cluster 2, on the other hand, showed an increase in protein quality decreases the food safety, and micronutrient availability showed a considerable positive effect on food safety.

Findings identified countries considered rich based on its GDP does not guarantee food security vulnerability. Food security vulnerability may result if the countries do not implement well-planned food safety regulations and nutritional standards, deficient micronutrient availability and protein quality, and diet invariability. Moreover, regression analysis revealed significant relationship between food safety, diet diversification, nutritional standards, micronutrient availability and protein quality as indicators of food security and vulnerability of a country.

**Keywords**— Cluster analysis, food quality issues, food safety, food security, food security vulnerability.

## I. INTRODUCTION

The second goal in the 2030 Agenda for Sustainable Development is about ending hunger, attaining food security, improving nutrition and promoting sustainable agriculture (United Nations, 2015). Food security subsists when people have physical and money-based access to good, enough, safe and nutritive food that meets their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996). Food availability, firm and steady food supplies, access to innocuous food and food use (FAO, 2003a)

will likely be affected by economic status which the end result is the vulnerability of the country if not achieved.

In the context of food security, vulnerability is defined in relation to an outcome, such as hunger or lack of food (Diley, M. & EBoudreau, T., 2001). Although complete and thorough food security and vulnerability analysis surveys were conducted (World Food Programme, 2017), no data analysis has been done for assessing the countries' food security vulnerability. This study assesses the food security vulnerability of 113 countries by their core issues on quality and safety of food.

Various studies make an attempt to evaluate different measures of vulnerability. Chaudhuri (2001), Chaudhuri, Jalan and Suryhadi (2002) and Christiaensen and Boisvert (2000) used an approach to measure vulnerability in terms of expected poverty. Ligon and Schechter (2004) make use of utility-based approach which measures vulnerability as the difference between the utility a household would derive from the consumption of a particular bundle with certainty and the expected utility of consumption from datasets coming from countries Vietnam and Bulgaria. Gentilini and Webb (2005) suggested an interesting addition of the well-known Human Development Index to include hunger indicators. Scaramozzino (2006) improved a rigorous novel approach to the analysis of vulnerability in the context of food security, which incorporates recent developments in the analysis of Risk Management.

The information gathered revealed considerable variables to measure the food security vulnerability. Most studies on vulnerability look at poverty rather than at food security (Scaramozzino, 2006). However, there is no study that encapsulates and emulates the relation of food quality and food safety issues of selected countries. Food quality will be measured by diet diversification, nutritional standards, micronutrient availability, and protein quality.

The gaps can be addressed by generating an equation model to determine the effect of food quality variables on food safety as an indicator of food security vulnerability. Through cluster analysis, the researcher was able to reduce observations and display groupings of countries with similar practices.

The study aims to answer the following: (1) What are the clusters of countries that have the same characteristics related to food security?, (2) What are the food security features of the countries which belong to each cluster? And (3) Is there a

significant relationship between food safety, diet diversification, nutritional standards, micronutrient availability, and protein quality as indicators of food security and the vulnerability of a country?

II. CONCEPTUAL FRAMEWORK

The study is founded on the notion that food safety and quality is achieved by well-planned government initiatives. Economically, when the country is rich, the less vulnerable should it be. However, if the country’s food quality increases, food safety and/or security increase, thus, vulnerability decreases.

According to Osundahunsi, Abu, & Enujiugha (2016), food safety and food security is a factor of the well-being of the people of a country and how it translates to the development and change of the economy in a country. Food insecurity arises from issues on hunger, malnutrition involving micronutrient malnutrition (MNM) and protein-energy malnutrition (PEM), and results of different policies by past and present government. Sufficient micronutrients like iodine, iron, and vitamin A, useful recommendations of enhancing food security and safety, food fortification and supplementation, increased of biotechnology, reduction of postharvest losses and formulation of good agricultural policies can lead to the transformation of the economy and the country towards food insecurity.

This concept presented a valued insight that diet diversification, nutritional standards (based on national dietary guidelines, nutrition plan or strategy, nutrition monitoring and surveillance), micronutrient availability (i.e. dietary availability of vitamin A, animal and vegetable iron), protein quality and food safety (based on agency to ensure the safety and health of food, percentage of population with access to potable water and presence of formal grocery sector) are indicators of food security and the vulnerability of a country (Figure 1).



Fig. 1. Conceptual Framework of the Study

III. METHODOLOGY

In this study, the variables of interest are quality and safety of food in selected countries. Data mining methodology using cluster analysis will be used to reveal the grouping of countries with similar characteristics of these dimensions. This process also includes generating an equation model to determine the effect of one food quality variables to food

safety. For linear regression models, the coefficient of determination  $r^2$  was used to determine the goodness-of-fit of the model. This statistics will tell us how close the data are to the fitted regression line.

The study utilized the data sets from Global Food Security Index of 2017. Global Food Security considers the core issues of food quality and safety, affordability and availability across 113 developing and developed countries. Five unique indicators measure food quality and safety.

IV. RESULTS AND DISCUSSION

Cluster analysis generates ten (10) clusters with two clusters having a large number of observations. Table 1 shows the partition of countries in two clusters. Cluster 1 comprises 45 countries while 58 countries belong to cluster 2.

The clustering of countries is mainly determined by their food safety variable. Countries under Cluster 1 is considered as the most vulnerable to food security by their food quality and safety core issues while cluster 2 countries are considered as less vulnerable (Table 2). Cluster 1 include Algeria, Angola, Bahrain, Botswana, Kuwait, Qatar, Saudi Arabia, United Arab Emirates, and many others (Appendix A). Australia, Canada, Denmark, Ireland, Germany, Philippines, Singapore, Switzerland and United States of America, are some of the countries that comprises Cluster 2 (Appendix A).

TABLE 1. Partition of countries

Clusters	Number of Observations	Within cluster sum of squares	Average distance from centroid	Maximum distance from centroid
Cluster 1	45	135.727	1.620	3.153
Cluster 2	58	167.393	1.540	3.699

Considering the diet diversification of these countries, 21 out of 45 countries in cluster 1 has a score below 50 based on the GFSI data compared to the countries in cluster 2 which has only 14 out of 58 countries. Switzerland (cluster 2) got highest score of 100 while Madagascar has the lowest score of 2 which belong to cluster 1. This affirms to the vulnerability of the countries belonging to cluster 1. The study of Powell et al. (2017) highlighted that agriculture, agrobiodiversity and landscape heterogeneity, along with wealth were some of the most commonly reported determinants of dietary diversity. Household size, livelihood diversity, and gender were also perceived to affect dietary diversity.

As to the nutritional standards, cluster 1 countries score 31-69 and cluster 2 countries on the other hand, all scores 100. Uzbekistan which belongs to cluster 1 has the lowest score of 31. Based on Global Fortification Data Exchange (2018), Uzbekistan does not have food-based dietary guidelines or nutritional standards. The country’s national policies related to nutrition only include mandatory legislation for salt iodization and multi-sectoral comprehensive nutrition plan.

Zambia and Madagascar under cluster 1 has the lowest score (12) while South Korea of cluster 2 has the highest score of 81 in terms of micronutrient availability. Both Zambia and Madagascar are located in the continent of Africa. Since 2010, Zambia experienced insufficiency, poor essential

micronutrients and lack of diversity in food supplies (FAO, 2010). Madagascar also faces the same situation and in 2016 it remains one of the ten poorest countries in the world (World Food Programme, 2016). South Korea, on the other hand, have high-impact, low cost nutrition-related interventions for their people. To name a few, these interventions include prevention and treatment of multi-micronutrient deficiencies including iodine deficiency among children, pregnant and lactating women and actions on acute malnutrition through screening and referral (UNICEF, 2018).

As to the protein quality, cluster 1 has a score ranged from a score of 0 (Laos) to 88 (Israel) while cluster 2 scores 17 (Sri Lanka) to 100 (Portugal). Diet in Laos is based predominantly on rice with vegetables and animal protein e.g. fish, chicken and wild foods are eaten irregularly. This results to the low protein quality in the country. Another study of Lancet Global Health Journal (2015) named Israelis as the healthiest eaters in the world (Shamah, 2015) as evident by their high protein quality score but this cannot deny the fact that the country still belong to the vulnerable cluster due to other variables considered. For clusters belonging in cluster 2, main contributors of protein in Sri Lankan diet are plant sources including rice and pulses (Jayawardena et al., 2014). However, these sources have incomplete protein quality. In Portugal, the country has a nutrition policy concerning food and nutrient intake grounded on the World Health Organization idea of ‘health in all policies’ and on their national data (Graca et al., 2018).

Food safety in cluster 1 has the lowest score of 3 (Congo) while cluster 2 has a score ranging from 39-100 in which Ethiopia has 39 score. Both countries experienced food contamination in both rural and urban areas and is due to environmental pollution, cross contamination and soil contamination. But this is severely undertaken in the Democratic Republic of Congo where hunger is increasingly alarming and severe food insecurity vexes 7.7 million of the population (World Food Programme, 2010).

Cluster 1 are characterized as having low values in all variable while cluster 2 appears to have positive values in all variables affecting food security (shown in table 2). Cluster 1 may have high vulnerability compared to cluster 2 since they have low indicators. Thus, less vulnerable countries are characterized as those which have relatively most appropriate food safety regulations, diversified diet, most useful nutritional standards, high micronutrient availability, and high protein quality.

TABLE 2. Cluster Centroids

Variable	Cluster 1	Cluster 2
Food safety	-0.2825	0.4757
Diet diversification	-0.3264	0.3957
Nutritional standards	-0.6909	0.8253
Micronutrient availability	-0.3231	0.3806
Protein quality	-0.4754	0.4551

A dendrogram (Figure 2 and 3) visualizes a clustering hierarchy and implies an order or relationship between countries. The countries of these categories are similar in some approach or have a number of characteristics in

common. Cluster 1 comprises 45 countries and 58 countries for cluster 2.

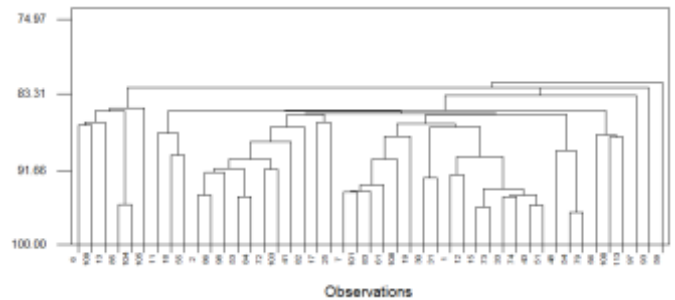


Fig. 2. Dendrogram of Cluster 1

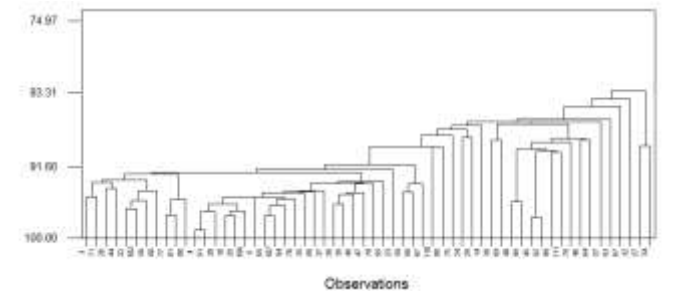


Fig. 3. Dendrogram of Cluster 2

Legend: The number in the X axis corresponds to the number assignment of countries shown in Appendix A

According to the World Bank (2013), most of the Arab states (i.e. Qatar, Kuwait, Bahrain, UAE, and Saudi Arabia) have been the world’s generous donors of aid as a share of GDP. Another report from the International Monetary Fund (2018) showed that Qatar is the richest country focusing on the income and purchasing power parity (PPP) per capita. This implies that food security vulnerability of a country is not only dependent on its economic status.

High dependence on foreign markets because of the lack of local food production could be a factor of high vulnerability. Although Arab states were considered as high-income countries based on their GDP but it remains as the large net importer of food especially with cereals which is the main staple food in the region. They have been also procuring food supplies through mix production and imports (Sadik,n.d.). This heavy reliance on food imports exposes the countries to the vulnerability of food supply chains and volatility of food prices leading to limitation of diversified foods with good quality and safety. At country level, the food self-sufficiency ratio declined in 2011 from its level in 2005 with the exception of Iraq, Algeria, and Somalia countries indicating no progress in their food security policies.

This situation is also true to the southern Algeria. Study of Bouammar et al. (2014), revealed that this region is characterized by an increase dependence on supplies. The region produces only about 5% of cereals, 35% of fruit, 57% of meat and 37% milk. Although production of major vegetables is quite satisfactory with 88% coverage needs, overall, these rates are lower than the national average, reflecting the vulnerability in southern Algeria, in terms of

food security. These limit their access to variety of foods that can provide micronutrients, good protein quality and safe products.

These issues are rooted on the limited access of the agricultural area and resources for ensuring adequate domestic food production as well as the programs and policies relevant to ensuring food security in a country. High-income countries, without these resources and initiatives, will not automatically result to stable food security. Saudi Arabia, for instance, belongs to high-income generating country but actually facing growing challenging risks to its overall food security situation due to its limited agricultural natural resources for ensuring food self-sufficiency, inefficient food consumption subsidies, ineffective food trade and import policies; and relatively high rates of food losses and waste in the country (FAO, 2017).

Another country, Nigeria is experiencing the same situation. The country's agriculture cannot feed its population (Oriola, 2009) and the food supply which grows at 2.5%, cannot meet the demand (grows at 3.5%) of the people (Ojo, 2007). Desertification of the country also unfavorably affected their food production. In this situation, the country is beset by food shortages, hunger and malnutrition (Oriola, 2009; Ojo, 2007). Thus, there is a need for government intervention and actions.

Additionally, another reason in high food vulnerability is the engagement of the country to research and technology for agricultural sustainability and productivity. Ecuador, for example, Oliverio et al. (2010) cited that low productivity in this country is due to lack of investment in research and technology. Agriculture is largely an informal economic activity and financial institutions are ineffective at providing credit to farmers. In addition, the distribution and marketing of foods are deficient (FAO, IFAD, UNICEF, WFP and WHO, 2017).

Another factor that can lead to vulnerability of food security in terms of quality and safety is the conflict. Nineteen (19) countries that belong to Cluster 1 are affected by conflict and protracted crisis. These countries are Uganda, Serbia, Burundi, Rwanda, Kenya, Cambodia, Pakistan, Senegal, Ukraine, Sierra Leone, Cameroon, Sudan, Angola, Guinea, Uzbekistan, Mali, Tajikistan, Algeria and Congo.

Social Finance Incorporated (2010) defines protracted crisis situations as "characterized by recurrent natural disasters and/ or conflict, longevity of food crises, breakdown of livelihoods and insufficient institutional capacity to react to the crises." FAO, IFAD, UNICEF, WFP and WHO (2017) described the effect of conflict as direct and indirect. Conflict impacts can be direct such as, forced population movements, the destruction of food stocks and productive assets and increased health complications including death) and/or indirect in economic, social and institutional changes. Indirect impacts can also include disruptions to food systems and markets, leading to increased food prices or decreased household purchasing power, or access to water and fuel for cooking can be reduced, which negatively affects food preparation, feeding practices and food allocation within the household. Although there are no recent, comprehensive global estimates of the impact of conflict on agriculture and

food systems, a number of food security and nutrition assessments and analyses for countries affected by conflict demonstrate the significant impacts of conflict on agriculture production, food systems and rural livelihoods at national and subnational levels.

Accordingly, in 2016, the unweighted average of prevalence of undernourishment in countries affected by conflict was almost 8% high. A noticeable finding is that 489 million out of 815 million were hungry and chronically undernourished. Almost 122 million or 75 % under age five children were stunted leaving a difference in average prevalence between conflict and non-conflict affected countries at nine percentage points. It clearly shows that conflict compounded by fragility and other stress factors leading to protracted crises substantially increases the likelihood of undernourishment. The weighted average prevalence of undernourishment in the 46 countries affected by conflict is on average between 1.4 and 4.4 percentage points higher than for all other countries. Where compounded by conditions of fragility, the prevalence is between 11 and 18 percentage points higher, and for protracted crisis situations the prevalence is about two and a half times higher than for countries not affected by conflict (FAO, IFAD, UNICEF, WFP and WHO, 2017)

South Sudan also in cluster 1 is an example of how conflict can affect the lives and livelihoods of the population in multiple ways, resulting in a humanitarian catastrophe on an enormous scale and with destructive longer-term impacts on livelihoods, as well as on the agriculture and food systems upon which these depend. Agricultural production and food systems have been disrupted, livestock production has declined significantly, and the spread of ferocity to cereal surplus-producing areas in Equatoria is severely affecting crop production. Food access has been hampered by sharp increases in prices, with inflation driven by shortages, currency devaluation and high transport costs owing to insecurity along major trading routes. The conflict in Juba in July 2016 restricted inflows of imported food through the main southern supply corridor from Uganda, reducing food supplies and further driving up prices. At this time, cereal prices were more than double those of June and almost ten times higher than 2015 levels.

These situations show the factors affecting food insecurity of countries. This may then directly affect the food safety, diversified diet, nutritional standards, micronutrient availability, and protein quality in a country.

On the other hand, looking those countries that belong to Cluster 2, a study was conducted to analyze the government food security policies adopted in countries with different income levels. Accordingly, results showed that programs and policies initiated by the government and various organizations, regardless of the income levels, help solve the food security problem. Vietnam, Ethiopia, China, Malaysia, South Africa, Brazil, United States, Australia and Canada which belongs to Cluster 2, has various programs that promotes food security.

Oliveira et al. (2010) mentioned that maintaining food banks is the main strategy to combat food insecurity in Canada. This initiative resulted to stability in terms of food

security in the country. According to Che and Chen (2003) along with the high standard of living the population and the prospect of famine is remote, the number of food banks continues to increase, and their presence suggests that food insecurity not only exists but persists.

Two strategic guidelines was developed in Australia for achieving food security (Strategic Inter-Governmental Nutrition Alliance, 2001). Australian Public Health Association (2009), SINAL (2001) and National Public Health Partnership (2001) mentioned that the focus of the said initiative is on the improvement of the nutrition of vulnerable groups and; combating structural barriers to a healthy and safe food, such as investment in technology in food production and waste reduction, social inclusion and investment in education. This program is just a few of the many actions, initiated by the Australian government in seeking solutions to attain food security in the whole country.

In U.S. various programs were also implemented in combatting food security. United States Department of Agriculture (2009) enumerated these various programs. There were programs focused to assist low-income families to buy foods. This is called the Supplemental Nutrition Assistance Program (SNAP). Public schools and school-age children were also beneficiaries of the US government initiatives. School Meals and the Summer Food Service Program provides food at cost price in public schools and during the holidays (includes offering food combined with sports activities). Food Distribution Program distribute food to the elderly, indigenous people, pregnant and breastfeeding women and people on low-income. Nutritional support to women, infants and children were also addressed through the Women, Infants and Children program and; the Child and Adult Care Food Program that provides nutritious meals in shelters and poor regions (Oliveira et. al., 2010).

In the same context, Brazil acted to address food security through employing different programs. First is the National School Nutrition Program (PNAE) which focused on offering food support to students at public schools and accredited philanthropic institutions and provide access to better nutrition to this segment (Santos et al, 2007). In 2003, the Zero Hunger Program was created aiming to ensure the human right to adequate food of people who have little access to food, and is active in strengthening family farming, income generation and social articulation, mobilization and control. The Food Acquisition Program was developed by the Brazilian government as a sustainable means of food security, with the aim of encouraging family farming. It is directed towards actions aimed at the distribution of agricultural products to individuals in situations of food insecurity and the formation of strategic stocks (Brazil, 2009 b). Food Security and Local Development Consortia (CONSAD) were also created in the country. These are institutionally formalized, regionally-based organizations made up of a number of municipalities that come together to develop activities, make assessments and execute projects for food security and nutrition and local development, generating jobs and income for the population (Brazil, 2008).

In South Africa, aiming to integrate the various food security programs in the country and eradicate hunger, malnutrition and food insecurity was implemented through a national strategy called Integrated Food Security Strategy. This was formulated in 2000 having main actions to increase the production and distribution of food, improve income and nutrition of the population and food safety and; increase employment opportunities (Department of Agriculture Republic of South Africa, 2002). Another food safety program in South Africa is the National Schools Nutrition Program. This aimed to provide poor children with at least one meal a day, and to promote local development and create jobs by offering school meals (Republic of South Africa, 2009).

School lunch programs, such as the Supplementary Food Scheme and School Milk Program are also implemented in Malaysia. This program was considered as fundamental in the fight against hunger. In addition there is another program realized in addressing the concern on local food production and improve nutritional education, health and basic education by improving the nutrition of mothers, infants and children (United Nations Development Program, 2005). This is called the Applied Food and Nutrition Program (AFNP)

In Vietnam, since there were significant action that has been taken to combat poverty, the rates of poverty fell from 58% of the total population in 1993 to 29% in 2002, with the rapid economic growth (FAO, 2004). However, many people continue to lack physical, economic and social access to sufficient, safe and nutritious food to meet energy needs. Other people are likely to experience food insecurity due to small changes in household production, income or health. With this, Vietnam has developed 5- and 10-year national programs, the Socio-Economic Development Plan [SEDP] (2001-2005) and the Socio-Economic Development Strategy [SEDS] (2001-2010), having the main purpose to eliminate hunger among families and reduce the number of poor families. In 2001, the government enacted the National Nutrition Strategy (2001-2010), which focused on helping disadvantaged regions by reducing food insecurity, improving the food security of vulnerable groups and calls for increased cooperation between sectors and organizations. Other programs that aim to reduce child malnutrition to 20% by 2010 are the National Program of Action for Children and the Strategy for the Protection and Care of People's Health (Gill et al., 2003).

Food Security Program (FSP), is a program adopted in Ethiopia that has led several interventions to change the situation of families from one of food insecurity to food security. This plan was formulated for the period from January 2005 until August 2009, with the aim of combating chronic food insecurity among 5 million people and improving food security for 10 million people (Oriola, 2009).

India is also considered as not self-sufficient in promoting food security. It mainly depends on programs promoted by international organizations such as the WFP, the largest humanitarian agency to combat world hunger (Oliverios, et al., 2010). Nevertheless, this is what makes India different from others making it not vulnerable to food security. Accordingly, the programs offered in India are the most comprehensive in

the world (WFP, 2009, 2007). Among them is the Mid-Day Meal Program (MDM), that provide school lunches for elementary school students, and the Targeted Public Distribution System (TPDS), which subsidizes the purchase of food at lower prices to low- income families. The Integrated Child Development Services (ICDS) is the largest program to promote health, education and nutrition among women and children in India, and is funded by the World Bank, Cooperative for Assistance and Relief Everywhere (CARE), United Nations Children’s Fund (UNICEF) and WFP, the program aims to distribute food supplements, promote preschool education, immunization, health care and growth monitoring (WFP, 2009, 2007).

In the Philippines, food security is addressed across a variety of agencies such as Department of Agriculture, Department of Agrarian Reform, Department of Environment and Natural Resources, National Nutrition Council, and other agencies. The Department of Agriculture implements food policies and production programs covering functional lines, namely: animal and plant industry, agriculture and fisheries engineering, training, agriculture and fisheries standards, fisheries and aquatic resources, research and soils and water management. Department of Agriculture implements Comprehensive Agrarian Reform Program (CARP) and redistributes land to agrarian reform beneficiaries and capacitates them by providing the necessary support services to make their lands productive. Department of Environment and Natural Resources manages the resource base for agricultural production specifically on research, land, forest, environment, and biodiversity management. National Nutrition Council has been the government’s primary policy and coordinating body since 1974. This agency mandates to oversee the implementation of national hunger mitigation program, formulates food and nutrition policies and strategies of the country and organizes the planning, monitoring and evaluation of the national nutrition program.

The different programs adopted in these countries indeed help in ensuring food security. It shows that government and non-government initiatives and interventions are important in sustaining food security. All of these pointed out that economic status is not an assurance for food security but on the different programs and activities in partnership with other organizations in maximizing the natural resources to provide quality and safe product. Thus, to assure food security, countries are required to have dietary guidelines, plan/strategy, monitoring, and surveillance, ensure availability of vitamin A and iron, access to potable water, the presence of formal grocery sector and agency to ensure safe food. Further, agricultural sustainability is a factor to achieve food security in terms of diet diversification, micronutrient availability, protein quality and food safety. Investments on agricultural sector can contribute to the availability and accesability of variety of foods. Quality and safety are, thus, achieved by well-planned and implemented government initiatives. Hence, to assure food security, countries are required to have dietary guidelines, plan/strategy, monitoring, and surveillance, ensure availability of vitamin A and iron, access to potable water, the presence of formal grocery sector and agency to ensure safe

food. Quality and safety are, thus, achieved by well-planned government initiatives.

Regression equation model in every cluster was generated using a software (shown in Table 3). In the first cluster, protein quality has a higher effect on food safety while an increase in nutritional standards decreases the safety of food. Food safety and nutritional quality e.g. protein quality are essential elements and integral part of food security (UNICEF, n.d.). Food safety is about producing, handling, storing and preparing food in such a way as to prevent infection and contamination in the food production chain, and to help ensure that food quality and wholesomeness are maintained to promote good health (WHO, 2015), whereas protein quality is described as the presence of eight essential amino acids in the food. Food safety and protein quality have their collegial meanings but they are vital in the quality of food products. Ensuring high protein quality in food can also warrant food safety.

The concept of food-based dietary guidelines (FBDG) or nutritional standards has been promoted by several international organizations. However, there are no FBDG for the countries in the Arab region. As the Arab Gulf countries share similar a socioeconomic and nutrition situation, an attempt was made to develop FBDG for these countries (Musaiger et al., 2012).

Countries in cluster 2 showed that an increase in protein quality decreases the food safety, and micronutrient availability showed a considerable positive effect on food safety. R-squared conveyed that cluster 2 model explained a higher percentage (by 0.5%) of observations fitted to the regression line. High protein quality food is characterized by high amount of essential amino acids. High number of amino acids is at risk to chemical and microbiological changes e.g. Maillard reaction, proteolysis and protein degradation thus results to a decrease in food safety. Maillard reaction, or non-enzymatic browning reaction, between reducing sugars and proteins (amino acids), is known to cause serious deterioration of food quality during processing and storage. Proteolysis involves the breakdown of proteins in food caused by microbial enzymes to provide amino acids, this causes deterioration and spoilage of protein foods. Nitrogenous compounds (i.e. proteins and amino acids) are necessitated by microorganisms for their growth and production of DNA. Thus, their action in food will also attenuate the safety of food.

TABLE 3. Regression Results

	<b>Cluster 1</b>	<b>Cluster 2</b>
Regression equation	Food safety = 56.1 + 0.097 Diet diversification - 0.376 Nutritional standards + 0.239 Micronutrient availability + 0.697 Protein quality	Food safety = 62.7 + 0.356 Diet diversification + 0.404 Micronutrient availability - 0.221 Protein quality
R <sup>2</sup>	54.8%	55.3%
p-value (ANOVA)	0.000	0.000

Increasing the availability and consumption of micronutrient rich foods can address household food insecurity (Talukder et al., 2015). Meanwhile, ensuring that

people have access to adequate nutrient-rich food including micronutrients availability and safe water is essential for protecting the safety and health of millions of people (UNHCR, n.d.). Thus, increasing the micronutrient availability of food may result to an upsurge in food safety.

V. CONCLUSION

This study found out that those countries considered rich based on its GDP does not guarantee food security vulnerability. Food security vulnerability may result if the countries do not implement well-planned food safety regulations and nutritional standards, deficient micronutrient availability and protein quality, and diet invariability. Moreover, regression analysis revealed significant relationship between food safety, diet diversification, nutritional standards, micronutrient availability and protein quality as indicators of food security and vulnerability of a country.

APPENDIX

Selected Countries and Their Corresponding Cluster

Cluster	Number Assignment	Countries
1	1	Algeria
1	2	Angola
1	6	Azerbaijan
1	7	Bahrain
1	11	Benin
1	12	Bolivia
1	13	Botswana
1	15	Bulgaria
1	17	Burundi
1	18	Cambodia
1	19	Cameroon
1	25	Congo (Dem. Rep.)
1	30	Dominican Republic
1	31	Ecuador
1	33	El Salvador
1	41	Guinea
1	43	Honduras
1	48	Israel
1	51	Jordan
1	53	Kenya
1	54	Kuwait
1	55	Laos
1	56	Madagascar
1	59	Mali
1	61	Morocco
1	72	Pakistan
1	73	Panama
1	74	Paraguay
1	79	Qatar
1	82	Rwanda
1	83	Saudi Arabia
1	84	Senegal
1	85	Serbia
1	86	Sierra Leone
1	93	Sudan
1	97	Tajikistan
1	98	Tanzania
1	100	Togo
1	101	Tunisia
1	103	Uganda
1	104	Ukraine
1	105	United Arab Emirates
1	108	Uruguay
1	109	Uzbekistan
1	113	Zambia

Cluster	Number Assignment	Countries
2	3	Argentina
2	4	Australia
2	5	Austria
2	10	Belgium
2	14	Brazil
2	20	Canada
2	22	Chile
2	23	China
2	24	Colombia
2	26	Costa Rica
2	27	Cote d'Ivoire
2	28	Czech Republic
2	29	Denmark
2	32	Egypt
2	34	Ethiopia
2	35	Finland
2	36	France
2	37	Germany
2	38	Ghana
2	39	Greece
2	40	Guatemala
2	44	Hungary
2	45	India
2	46	Indonesia
2	47	Ireland
2	49	Italy
2	50	Japan
2	57	Malawi
2	58	Malaysia
2	60	Mexico
2	63	Myanmar
2	64	Nepal
2	65	Netherlands
2	66	New Zealand
2	67	Nicaragua
2	69	Nigeria
2	70	Norway
2	71	Oman
2	75	Peru
2	76	Philippines
2	77	Poland
2	78	Portugal
2	80	Romania
2	81	Russia
2	87	Singapore
2	88	Slovakia
2	89	South Africa
2	90	South Korea
2	91	Spain
2	92	Sri Lanka
2	94	Sweden
2	95	Switzerland
2	99	Thailand
2	102	Turkey
2	106	United Kingdom
2	107	United States
2	110	Venezuela
2	111	Vietnam
3	8	Bangladesh
3	9	Belarus
3	16	Burkina Faso
3	21	Chad
3	42	Haiti
3	52	Kazakhstan
3	62	Mozambique
3	68	Niger
3	96	Syria
3	112	Yemen

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